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SELECTED ACTIVITIES OF THE JAWAHARLAL NEHRU ALUMINIUM RESEARCH DEVELOPMENT AND DESIGN CENTRE IN THE FIELD OF ALUMINIUM SEMI-FINISHED/END PRODUCTS AND APPLICATION AFTER PRESENT PROJECT STAGE

DP/IND/88/015/11-53-54 INDIA

TERMINAL REPORT

Prepared for the Government of India by the United Nations Industrial Development Organization, acting as executing agency for the United Nations Development Programme.

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United Nations Industrial Development Organization, Vienna

Abstract

Title of the Project: Jawaharlal Nehru Aluminium Research Development and Design Centre, DP/IND/88/015

The objective of the activity of the consultants: to provide advisory services/expert consultancy on selected R/D activities of the Centre in the field of aluminium semi-products, finished/end products and application after the second project phase.

Duration: 2 months 14 days (commencing 19.02.1994.)

The main conclusions:

- to diminish the surplus of basic materials in India, it would be helpful to organize the information, advisory and marketing activities of the Centre in order to help to explore new application areas, to update technology level of downstream sectors, to implement development and training programmes for small and medium scale industries;
- to improve the quality of products which usually makes difficult their sale at home and abroad, it would be helpful to organize the quality management activity of the Centre.

The main recommendation:

accordingly, to the Government of India and to the management of JNARDDC, to establish the "Department of Semis and Finished Products" with limited staff and facilities at the very beginning.

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Explanatory notes

1.) The value of Indian rupees in US dollars
on 18 Feb., 1994 1 USD = 31.365 INR

2.) In the tables: ... means nil or negligible
- means data is not available

3.) Tons are metric tons

4.) JNARDDC is Jawaharlal Nehru Aluminium Research, Development and Design Center

5.) 1 lakh = 10^5 . 1 crore = 100 lakh = 10^7

6.) NDT = non-destructive testing

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Executive summary

Findings

- Production and consumption of aluminium are not well-balanced -

Until recently, the aluminium industry in India could be characterized by metal shortage, therefore it was not so important to promote the extension of aluminium application and to increase the consumption. In the last few years however, as a result of capacity enlargement in metal production, an excess aluminium quantity came to the market making it necessary to achieve a balance in production and consumption. Obviously, there are two possible ways to achieve this aim, namely to increase the domestic utilization or to find foreign markets for exports. The Indian basic materials are not competitive on the world market, exports are feasible only in the form of semis and finished goods.

- Great differences in the technical level of downstream sectors -

There is a wide difference in the technical level of applied technologies in the downstream industry. As a matter of fact, there are examples of state-of the-art technologies associated with up-to-date machines and engineering background, but a lot of outdated technologies and old facilities are also applied that cannot be used for producing semis with high value added. In this sector, which is dominated by medium and large capacities, development work should be directed to updating facilities and adapting advanced technologies. These activities, as a matter of course, require information management making use of a professional organization that is equipped with all necessary technical and personnel requirements. In the processing sector, contrary to manufacturing side, small-scale factories with rather poor technical level are in majority. Accordingly, the quality of finished products is well below the international standards.

- Involvement of many institutions in the R&D work for the aluminium industry -

In India, lots of institutions are engaged in R&D work for aluminium industry. In general, they are well equipped and able to perform activities in several areas of fundamental and applied research. However, none of them is totally dedicated to tackling all the problems of the industry. At the same time, these institutions were usually organized to deal with particular professional areas and none of them is engaged in the aluminium industry as a whole, dealing with its specific R&D and promotional activities in complex form. Of course, due to rationality and reasonability, such an institution cannot and must not deal with every field of aluminium R&D but, on the basis of an effective information management, its promotional activity should be extended to all sectors of the aluminium industry. That kind of promotional activity seems to be missing now in the downstream sectors.

Conclusions

- Means and methods to increase the domestic consumption should be found -

Considering that the domestic consumption of aluminium finished products is influenced basically by the small capacities, it seems very important to support their quality improvement, product and technology development in organized form with appropriate institutional background.

According to analysis of present status and predicted tendencies in the production and utilization, the domestic aluminium consumption can be considerably increased in building, transportation and packaging sectors by improving attractivity of ordinary products and introducing new challenging ones.

Considering end users' aspect firstly and then working back towards manufacturing side, the major elements in increase of domestic consumption and exports are as follows:

- exploration of new application areas and retention of position of aluminium among competitive materials in the traditional application sectors;
- influence on designers for restructuring their way of thinking towards "aluminium-like" products that can utilize the desirable properties of this metal in every aspect;
- updating the technology level of the processing sector, particularly in small-scale industries, by means of package documentations for development, technology manuals and booklets, training courses for implementing quality-oriented production;
- improvement of manufacturing technologies through well-defined R&D activities for producing conventional semis with better quality and higher value added as well as for making up new types required by new application areas.

All in all, the viable long-term solution is the production of semis with high value added and of good quality that meet the requirements of markets all over the world and are competitive with other materials in respect of both the price and the service functions to be satisfied.

- The efficiency of the information flow should be improved between the interested parties -

In general, the required manufacturing and processing methods are known and occasionally are even applied in defence and other sophisticated industries but their wide-scale use is not common at present. Considering that in the processing sector small-scale capacities are in majority and their importance is likely to increase in the national economy as result of promotion policies of the state, adaptation of up-to-date technologies and quality improvement should be kept in conformity with their technical level and financial background taking into account the principle of step by step gradual progress.

The first important step to be taken in this regard is build up contacts with them in order to create a database

containing all relevant information about their activities, products, markets, etc. Then, on the basis of available data, particular and integrated requirements for quality and technical improvement are to be evaluated and an effective producer-consumer interaction can be organized by means of collection, processing and distribution of required data.
R&D activities of big companies and firms are usually carried out in their own specialized units and external institutions are contacted only when required. Owing to fact that they are more or less confined to production, the weak point in their development system is information management. A professional institution providing all data and information required by their R&D, marketing and quality management activities would be very helpful for them.
A professional unit with sufficient institutional background is needed which is able to organize an effective information exchange within the downstream industry, to collect and provide all necessary data for interested parties and to support small-scale industries mostly in order to improve their performance through advisory work, training programs, quality management and product development.
In this sense, that professional unit is to move along the boundary zone of manufacturing, processing, development and marketing activities as well as to create vital relationships between them through information feedback.

The institution that is able to form this unit should be the JNARDDC where the technical background of information management is practically available and only limited number of experts and some instruments are required to establish a specialized department which is able to provide all services mentioned earlier for promoting the development of the whole downstream industry and, in this way, the extension of aluminium application in India.

Introduction

The immediate objective of the project is to assist the Government of India in setting up a functioning Aluminium Research, Development and Design Centre.

The present mission of

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as consultants in aluminium semiproducts and in application of aluminium is connected with the final stage of the project. Their "Job Description" is in Annex 1, together with a facsimile of the Project Management dated 10 Feb., 1994., to update job descriptions prepared 26 May, 1992.

The activity of consultants commenced on 19 Feb., 1994., lasted 2.5 months, finished on 3 May, 1994. Their duty station was at JNARDDC in Nagpur with travel within the country. The list of senior counterpart staff is in Annex 2, the list of experts met is put in Annex 3. Details of company visits can be found in Annex 4.

At present, there is no department within JNARDDC dealing with aluminium semis and finished products. Due to limited resources at the present time, only some sort of activities in these fields are to be imagined; therefore a report of relevant analyses and recommendations is needed on essential follow-up actions and activities to be introduced for the promotion of economical use of aluminium in the country. Consequently, according to the Revised Project Document of August, 1993 (accepted by the IV. Tripartite Review Meeting), the original objectives were revised in respect to overall downstream R&D work , since the build-up of full-scale activity was postponed for the future.

Recommendations

As shown by analysis of present status and trends of downstream and processing sectors in the Indian aluminium industry, the main objective is to promote extended utilization and application of aluminium in both the traditional and non-traditional consuming branches by means of improving qualities and introducing new products and technologies. Accordingly, it is necessary

1.) to establish the "Department of Semis and Finished Products" within JNARDDC, consisting of Technical Advisory and Quality Management Teams, in order to perform the following functions:
   - to create and regularly update a database that contains relevant data and information on domestic firms, companies and enterprises engaged in the production of aluminium semis and finished products (at a reasonable level of capacity of 100 tons per annum at least) in cooperation with the "Information Center" of JNARDDC;
   - to analyze and evaluate trends and tendencies in the domestic and international spheres regarding new products, technologies, quality requirements and improvements in manufacturing and processing sectors, in order to prepare annual surveys for governmental bodies, institutions and organizations for supporting their management activities and decision making as well as to elaborate selected studies, on the basis of commissions, for firms, companies, etc. for their daily routine ;

2.) to support and promote the extension of aluminium application in India by means of advisory and consulting activities and, as a part of it, to help

development work, technology adaptation and marketing activities of interested firms as well as to have prototype of new products made up and to perform field trial of new technologies designed by firms or developed by its own initiative, using facilities of external partners ;

3.) to organize group training in sectorial and sub-sectorial breakdown for experts of interested firms ; to catalyze imagination and inventiveness of industrial experts for improving qualities of usual products and creating new ones for non-traditional usages by means of inviting them for short-term joint work in JNARDDC as well as to carry out market analysis regularly and to collect consumers' reflections and expectations for aluminium end products as well as to survey new requirements resulting from new and revised old standards at both international and national levels, in order to feed them back to producers and finally to take part in the relevant standardizing activity ;

4.) to organize quality management activity within JNARDDC with appropriate instruments and appliances (detailed in Annex 5) for spot checking of quality requirements and expected properties by means of applying NDT technique mostly. The interested team is able:

- to check nd supervise actual manufacturing and processing operations from viewpoint o f quality assurance as well as to give standards for quality management programs to be implemented in the plants;
- to support advisory and training activities with relation to quality improvement;
- to support firms and companies in the procurement of certification to the relevant ISO 9000 standard.

Details concerning the organization of the Department are given in Annex 10.

CHAPTER I

PRODUCTION AND CONSUMPTION OF ALUMINIUM IN INDIA

The availability of primary aluminium is one but not the only essential prerequisite for the development of downstream industries in the country.

The production of Indian upstream industry and the aluminium consumption in India together with that of Asia and the world are shown by Table 1.

Table 1

Production and consumption of aluminium

'000 tons

	1987	1990	1991	1992	1993*
Production					
World	16 493	18 038	18 665	-	-
Asia	949	1 180	1 288	1 368	-
India	267.5	433.2	503.9	513	483
Consumption					
World	17 055	17 840	17 194	-	-
Asia	3 037	4 148	4 252	4 154	-
India	326	433	420	410	400

(Source: World Metal Statistic, London, monthly)

* preliminary data esteemed for India

The break even point for the production and consumption in India was somewhere in 1990. As of 1990, consumption was higher than production, therefore, in addition to semis and finished products, India had to import basic material. In 1993, primary metal import virtually ceased (see Table 2).

The primary producers were in comfortable position before, because of surplus demand, and they were not forced to follow any marketing activity. Really, it was only merchandizing what they carried out, namely they distributed what was allowed with prescribed prices till 1989.

Table 2

Imports of unwrought aluminium in South and East Asia

'000 tons

	1990	1991	1992	1993*
India	12.7	9.7	9.1	2.3
Thailand	132.6	-	-	-
China	71.8	43.7	229.6	-
Singapore	46.2	55.1	86.1	-
World total	8 252	8 297	8 926	-

(Source: World Metal Statistics, London, monthly)

* preliminary

For the time being, there is some surplus of primary aluminium in India. It seems important to decrease the extra metal quantum by finding outlet or diminishing production. Restriction of production would result in losses and difficulties, therefore the suitable solution of this problem is to find absorbing market for the excess metal in order to keep capacity utilization on the highest possible level.

As a matter of fact, there are two fields where sale increase of primary metal can be realized, namely foreign market and domestic market.

However, it is true, in general, that creation of stocks does not pay out on the long run. The trend of prices shows steady decrease, the average price of primary aluminium was on an acceptable level of 1650 USD/ton in 1990, and since then it decreased with some fluctuation to around

1150 USD/ton. It is remarkable that the six major primary aluminium producers of the world agreed recently to diminish their production in order to keep prices on a realistic level. This action resulted in some sudden increase in metal price and now it seems still too early to predict the level of equilibrium. Figures of global stocks are given in Table 3, the export price indices are shown by Table 4. Unfortunately, the stocking in India cannot be figured for the large number of medium and small scale capacities.

Table 3

Aluminium stocks

'000 tons

	1990	1991	1992 Jan-Sept
World total	1527	1754	1680
Asia total	18	32	20

(Source: World Metal Statistics, London, monthly)

Table 4

Aluminium basic material price indices

1980 = 100

1990	1991	1992	1993/I.	II.	III.	IV.	V.	VI.	VII.	VIII.
93	74	72	69	69	66	64	65	67	69	68

(Source : Monthly Bulletin of Statistics, UN. Nov.,1993.)

According to data and figures, we cannot expect a boom on the world market with respect to aluminium materials. And again, no abrupt changes of imports are to be seen for South Asia either, as indicated by Table 5.

Table 5

Values of basic aluminium materials imported by selected South Asian countries

in million USD

	1989	1990	1991
Thailand	232	238	255
Singapore	81	82	88
Hongkong	111	77	87
Malaysia	95	98	83

(Source: Internat.Trade Statistics, UN. 1993.)

Table 6

Values of aluminium semi-products imported by selected South Asian countries

in million USD

	1989	1990	1991
Thailand	54	72	94
Singapore	167	178	216
Hongkong	272	204	262
Malaysia	57	83	91

(Source: Internat.Trade Statistics, UN. 1993.)

In case of imported semis of the selected South Asian countries (ref. Table 6), values show an increasing tendency while that of the world total is practically unchanged, remaining at the level of about 14.000 million USD per annum.

This is the first reason for it looks more feasible to deal with exports of semis, than that of primary metals. On the other hand, during the whole process of manufacture from

electrolysis to output of finished products, prices become higher and higher as a function of implemented operations. Moreover, price ranges are moving on a wide scale. The price of a plain mass-produced item may be doubled as compared to aluminium ingot's price. In addition, actual production costs play not so deterministic role in prices of finished products, than in case of unwrought metals and extra profits can be realized by extraordinary qualities, novelties and attractive appearances. As a rule, the higher the MVA (manufacturing value added) , the more the profit to be gained.

As regards means and methods of export activity, there is significant difference between basic materials and semis or even finished products. The producers need, in general, more support from the side of information processing and management in terms of existing rules, laws, duties, prices, freight, etc.

The largest possible area where the sale of basic materials can be increased in the form of semis, too, is the domestic market.

As usual, the basic material producers having manufacturing capacity apply the so-called "pull" strategy in their marketing activity in order to increase selling by concentrating on the end-user, striving to win over a relatively wide strata of customers by convincing them of the advantages of application of aluminium finished products and creating fresh demands by "pulling" direct buyers of semis and producers of finished items. This marketing system needs co-ordination among material producers in order to avoid parallel activities and to unite their forces.

Another strategy that can be applied in the marketing is the "push" method. In this case producers are concentrating exclusively on their direct and potential buyers, counting on their loyalty and "pushing" them and their products towards the market and the end-users.

Application of both methods gives the best result if done correctly and activities of partakers are coordinated in order to keep the costs of PR and propaganda to a minimum level.

The breakdown of semis' consumption as per forms is shown in Table 7, while the sectorial breakdown of consumption is given by Table 8.

Table 7

Consumption of semi-finished products

(per cent)

	Rolled products	Extrusions	Wire	Forgings
India	35	15	50	...
Western Europe	54.7	33	11.7	0.6

(Source: National Directory of Aluminium Industries
AAI, Bangalore, 1989)

The tendencies of expected long-term developments in the production of semis can be derived from Table 7. However, there should be some misunderstanding in the interpretation of end-user breakdown of consumption in India, as it is usual in different regions and among people of different professions. Therefore, it is advisable to put once every product into one file and stick to that to get a clear picture and use the same terminology.

Table 8

Pattern of consumption by end uses

(per cent)

	India	Western Europe	World
Building & construction	6 - 8	20	15
Transport	13 - 17	25	25
Packaging	7 - 8	15	10
Electrical	40 - 48	15	20
Mechanical engineering	8 - 10	10	10
Consumer goods	17 - 18	10	15
Miscellaneous	rem.	rem.	rem.

(Source: Magyar Aluminium, 1991. No.7-8 - for World and Europe. As for India, different sources indicate different figures.)

As regards production and consumption forecasts for finished goods, the main tendencies can be predicted from Table 8. Concerning further developments the decisions are likely to follow the basic streams and directions for realizing good results. Therefore, it seems advisable to pay attention to the changes worldwide and to stimulate developments, production and consumption always in accordance with the main stream by means of collecting and distributing proper data and information as well as of giving adequate answers to all questions emerged.

Of course, the structural changes in the pattern of consumption come true very slowly only by themselves as shown by Table 9. Its stimulation can possibly be done by correct PR and propaganda activity providing technical consultancy, advices and support. The proposals about this activity can be found in Chapter IV.

Table 9

Changes in the pattern of consumption during the last 10 years in some European countries

(per cent)

	Switzerl.	Austria	Sweden	UK	Germany	France
Building	+1.1	-2.0	-2.1	+5.4	-3.4	+1.0
Transport	-0.5	+3.1	+3.3	-7.5	+1.8	+2,2
Packaging	-4.0	+1.0	+7.8	+0.7	-1.9	-2.0
Electrical	+1.1	-2.0	-4.8	-2.6	-2.0	-3.1
Machinery	-0.2	+0.8	+4.7	+2.0	-0.2	-0.7
Consum.durab.	-0.3	-1.4	-1.5	-3.0	-0.9	-1.5

(Source: Magyar Aluminium, 1991. No.7-8.)

CHAPTER II.
PRESENT STATUS AND POSSIBLE DEVELOPMENTS OF DOWNSTREAM INDUSTRY

On the basis of factory visits, discussions with managers, experts and technical people engaged in the production and R&D activities (see Annex 4) as well as of available information, the present status and the required or possible developments of applied basic technologies in the manufacturing and processing sectors can be summarized as follows:

A. Manufacturing technologies

Melting and refining

Fuel-fired reverberatory furnaces are most commonly used for melting and holding operations. In several cases heat losses and energy consumption are high because of weak heat insulations. Waste heat recovery systems, computer-based process control and mechanization in material handling are rarely applied in order to improve energy efficiency.

As regards degassing of melts, hydrogen is removed mostly by plunging of chlorine compounds in tablet form. Fluxes containing sodium or potassium chlorides are frequently used to remove oxide inclusions. There are some foundries where gas mixtures comprising chlorine and nitrogen or argon are applied for improving melt purification. It is remarkable, however, that in India the application of chlorine gas has been restricted for its hazardous feature. Some of sophisticated manufacturing facilities like HINDALCO's strip-casting machine are equipped with continuous in-line degassing system.

Ceramic filters for removing inclusions and dross from melts are showing increasing usage as a result of intensive domestic development activities for filter fabrication. Preparations of melt and alloying process require master

alloys, additives and nucleants. The most common types of them like titanium and boron containing materials are now produced in India but further R&D activities are inevitably to be done for improving fabrication technology and enlarging assortment. As regards technology, most of master alloys are fabricated by direct melting route, however, this method is not feasible in the case of some kinds of alloys like Al-Ti or Al-Zr wherein the alloying element is introduced by reducing the oxide compound of the material in molten aluminium using cryolite flux. In this field, R&D activities tend towards the improvement of both direct melting and reduction methods in order to increase purities and decrease production cost. In respect of assortment, R&D work tends to introduce new types of technology and product-oriented master alloys like Al-Be master alloy for Mg containing cast alloys in order to reduce magnesium loss of melts and to avoid non-metallic inclusions.

Casting of billets, slabs and Properzi wire-rods

Foundries of primary aluminium producers cast extrusion billets and rolling slabs as well as ingots by utilizing the liquid metal from their smelter and recycling in-house scrap. Some of the foundries without smelter base, like Orissa Aluminium Extrusion Ltd., use primary ingots and their own recycled scrap as input material for billet casting, the majority of them, however, apply purchased scrap as well, while secondary foundries use almost exclusively scrap as input material. In the case of scrap remelting it is of utmost importance to perform melt cleaning with effective technology, namely to organize quality management.

In general, billets and slabs are produced by conventional DC casting process. It seems likely, that small and medium size foundries will use this method even in the future, the big foundries, however, have introduced or made effort to

introduce hot-top and air-cushion alternatives in order to improve homogeneity and microstructural features of cast products. Sizes of billets and slabs are smaller than the usual international average affecting therefore adversely the productivity and effectiveness. As an example of that is the billet diameter, namely the maximum size of extrusion billets produced commercially in India is 400 mm as against over 600 mm in developed countries.

Wire-rods are manufactured by continuous casting and rolling process on Properzi equipment. The technology level is good and comparable to that of advanced countries in respect of EC grade non-alloyed metal. However, with respect to the production of AlMgSi alloy conductor grade wire rods, the picture is not so bright because some cast-rolling machines are not equipped with in-line quenching unit providing instant and uniform supersaturated solid solution structure of wire-rods so that quality improvement requires further efforts in development.

Facilities and technologies in most of foundries need to be updated in order to create opportunity for the production of higher size billets and slabs which will result in the improved productivity, better quality and higher size of manufactured products. Introduction of update casting technologies is also much to be desired for imporoving surface finish and metallurgical properties. In accordance with demands, further investigations are still required for determining the possibility of effective production of alloy wire-rods from the 3xxx and 5xxx series using the conventional Properzi technology.

Homogenization

Considering that most of foundries apply DC casting method for the production of billets and slabs, homogenization is of utmost importance for eliminating inhomogenities or at least decreasing their quantity and extension in the cast

products because they could cause serious difficulties during the subsequent manufacturing operations and, as a result, deteriorate the quality of end-products. Accordingly, homogenization is a well-established and regularly applied heat treating process in the foundries. Most of treating furnaces are rather outdated in respect of both their energy efficiency and control, therefore further developments should concentrate, first of all, on their modernization. Introduction of new alloys and modification of cast product sizes would require some additional R&D work in the future, in order to determine the most suitable process parameters and to achieve uniform temperature field inside the furnaces.

Rolling

The existing facilities and applied technologies limit the size of products. The maximum sizes to be achieved are as follows:

Hot rolled plates - width 1.620 mm
length 8.500 mm
thickness 25 mm

Hot rolled coils - width 1.500 mm
thickness 4 mm
weight 3 tons

Cold rolled sheets and strips - width 1.000 mm
thickness 0.15 mm
coil weight 4 tons

Productivity is about 60-72 % in the mills of primary producers and only 50 % in the plants of secondary producers as against 70-80 % of the mills in well-developed countries. Consumption of water, air and electricity are much higher than those of advanced technology. Rolled products are produced almost exclusively from DC cast slabs and after that by hot and cold rolling. So far, only HINDALCO and Light Metal Industries (LMI-Calcutta) have introduced the

continuous strip-casting technology by installing thin strip casters. However, LMI cannot utilize the advantage of energy conservation as a whole, because of remelting required for producing liquid metal for casting. The same is the matter at Pennar Aluminium (Dahali) where two up-to-date Pechiney strip casters are being installed with remelting facilities. At present, the most serious problem of Indian rolling mills that most of them are not able to produce sheets and/or strips of hard alloys with high alloy content. Hard alloys mean, in this context, heat-treatable high strength materials like alloys of 2xxx and 7xxx series that are inevitable for enlarging aluminium application.

Except some capacities, like INDAL's, foil rolling mills are rather outdated, therefore in most cases both foil quality and productivity are far from the advanced level.

As regards R&D activities to be done for rolling production, the basic task seems to be the modernization of existing facilities with automatic gauge and flatness control and, in addition, setting-up up-to-date rolling mill(s) with adequate control and stretcher in order to produce wider and thinner sheets/strips of even hard alloys.

Modernization and investment on new facilities could also create further needs for technology development and adoption work. Some R&D activities to be performed in connection with rolled products with high value added are as follows: production of superplastic sheets, can-stock materials, brazeable/solderable sheets, introduction of roll-bond technologies, reduction of foil thickness and porosity. In regard of superplastic sheets it is noteworthy, that attention worldwide has been directed to two possible implementations. One of them is connected with developing alloy compositions that are not so far from commercial types and can recrystallize to give a very fine grain size. On of proposed composition is Al-6Cu-0.5Zr named Supral 100 which is found to be superplastic in the temperature range of 420-480 °C. The production route for the alloy is basically

similar to that used for manufacturing conventional aluminium alloy sheet, although some changes are necessary in order to achieve adequate supersaturation of Zr. Higher casting temperatures are used and DC casting process is modified so that the rate of solidification is increased. Cast slabs are sometimes clad with pure aluminium during the hot-rolling stage for subsequent corrosion protection while the cold-rolling stage is not greatly different from standard practice. The other possibility is to achieve superplastic behaviour in existing commercial alloys. High strength aluminium alloys of the 7xxx series have been thermo-mechanically processed and, as a result of that, very fine grain size (e.g. 10 um) could be achieved in rolled products. As regards can-stock materials, distinction must be made in respect of those used for the body or for the lid, because of their different requirements. Extreme formability with minimum anisotropy and good mechanical strength is required of body sheet as wall thicknesses have been reduced to as little as 0.30 mm. Alloys best capable of meeting these requirements are those based on the non-heat treatable 3xxx and 5xxx series. As a result of intensive development work, the 3004 type alloy containing 1.2 %Mn and 1 %Mg has been established as the best for this purpose. In order to meet the requirements for lids, the alloy coded 5282, containing 4.5 %Mg and 0.4 %Mn, has been introduced. Therefore, R&D work to be performed should not be directed to alloy development but to technology adaptation. As regards the production of brazeable/solderable or roll-bonded sheets, the manufacturing technologies are more or less well-known, thus the problem to be solved is again the adaptation considering facilities and conditions available. In respect of reduction of foil thickness and porosity, the major problem is the levels of elements forming intermetallic compounds and inclusions because they make foils susceptible to pinholing and tearing during foil rolling. Therefore, R&D activities have been directed to

minimizing their quantity by developing more effective methods for purifying and filtering alloy melts.

Extrusion

Apart from production capacities for defence industry even the big aluminium manufacturers possess only medium size extrusion facilities. Their maximum available parameters and those of OFAJ (Ordnance Factory - Nagpur) engaged in defence production are as follows:

	Max.pressing force (tons)	Billet dia. (mm)	Stretcher pulling force (tons)
BALCO	3.500	350	250
INDAL	3.000	315	100
HINDALCO	2.240	300	75
OFAJ	9.000	600	700

The commercial facilities are able to produce only small to medium sized extrusions from low and medium strength alloys. The yield is around 65-70 %, whereas that being achieved in up-to-date extrusion plants is around 70-75 %. Most of the larger extrusion presses are outdated. Accordingly, they do not possess proper handling and control systems as well as on-line heat treating equipment. Stretching facilities are of low capacity, therefore stretching after solution treatment is not feasible except for extruded profiles with small cross section.

As regards R&D activities to be performed in the future, in coincidence with those mentioned above for rolling, the emphasis should be put on modernization of existing facilities and setting-up new machines with high capacity that are capable of carrying out both direct and indirect extrusion operations. Considering the differences in the technical levels of working facilities program packages for

their modernization should be elaborated in terms of the following operations and units:

- cutting to length and preheating of billets
- manufacture of dies for complex and thin-walled profiles
- hardfacing of dies for increasing their service life
- handling system for dies, billets and extrusions
- on-line heat treatment.

In addition to improvement at facility side, further R&D work is to be done with relation to technology. On the basis of available lab-scale facilities for hydrostatic extrusion, technology developments are required for the transition to industrial application. Furthermore, technology also needs to be developed for producing thin walled profiles from high strength alloys.

Forging

Although aluminium alloy forgings are used extensively, forging is made mostly by small and medium size shops with limited technology and equipment. Most of the forging shops, except those interested in defence, do not possess high capacity hydraulic presses required inevitably for high strength alloys and forged parts having thin sections. The largest hydraulic press used for forging aluminium alloys is of 3.000 ton capacity and is not adequate to meet requirements of heavy forgings over 500 kg.

Among forging methods ring forging represents a very peculiar technology especially that of producing large dimension rings up to 4 m in diameter and its application is equipment dependent first of all. Concerning forged pieces with large dimensions made from heat treatable alloys another problem may arise due to non-uniform cooling rate during quenching. The associated internal stresses can develop distortions and other unfavourable effects, therefore an additional treatment should be made to eliminate or at least to decrease these stresses. Stress

relieving treatment of large parts can be done by small degree cold deformation after solution treatment and quenching, but it requires also a high capacity hydraulic press. As regards precision forgings or near net shape forgings, the crucial point can be found in the die design. By means of applying adequate split dies and isothermal forgings the quality of products can be improved essentially. Another way of producing forged parts with enhanced properties is the thermo-mechanical treatment. With relation to this method further work needs to be carried out for industrial realization.

As it seems, R&D activities in this field are strongly facility dependent. In fact, it is of utmost importance to set-up one hydraulic press of 6.000-8.000 ton capacity at least. It could make possible to elaborate technologies for large forgings with extraordinary requirements.

Drawing

A certain part of drawn bars and tubes are produced by some of the big manufacturers using their own extrusions as input material but basically this operation is performed by the small and medium scale capacities which buy the extruded preforms from the extruders for drawing and finishing. The applied technology is well-known and requires no essential improvement . In this field the R&D activities should concentrate to the workpiece-die interaction with special attention to the problem of friction and wear in order to ensure better surface finish of drawn products and longer service life of drawing dies.

Wires of several gauges especially for electrical industry are made by the traditional multi-step cold drawing process. The input material is generally Properzi wire rod because EC grade aluminium and AlMgSi alloy wires are used mainly for overhead transmission lines and conductors. With respect to technical level of wire drawing facilities it does not seem

feasible to realize essential improvement in quality and productivity without modernization or replacement of existing machines.

In this area, the main stream of R&D activities experienced worldwide has been directed to additional technological operations and compositional modifications like thermo-mechanical treatment and microalloying in order to increase thermal stability, creep and stress relaxation resistance of conductor wires without any deterioration or either with slight improvement in tensile properties and conductivity. The applied methods and compositions developed so far are more or less well known, at the present stage the task is to investigate the possibilities and constraints of their applications in India.

B. Processing technologies

Joining methods

Although almost all kinds of joining methods like welding, soldering, brazing, adhesive bonding, riveting, etc. are well known in the Indian aluminium processing sector, their applications are rather limited in the everyday practice. The advanced methods like automated TIG and MIG welding, EB welding, spot welding, ultrasonic welding/brazing, vacuum soldering/brazing, etc. are used only in defence and aerospace industry or are available in R&D laboratories. Industry-wide application of the up-to-date joining technologies is hurdled by, in addition to the lack of adequate facilities, the poor supply of good quality welding wires and rods, suitable fluxes for brazing and soldering as well as of high strength rivet wires with good cold heading properties. Another retarding factor is the lack of skilled welders. The rapidly growing demand for welded structures, brazed aluminium car radiators, adhesively bonded honeycomb structures and laminates together with the requirements for proper filler metals and auxiliary materials show the

importance of R&D activities to be done at this field in the near future already. It should also be underlined that training of welders is of utmost importance, and its institutional support and professional background are to be organized and established as soon as possible.

Heat treatments and thermo-mechanical treatments

Heat treatment of extruded products made from medium strength AlMgSi alloys is usually done in extrusion plants. Solution treatment. Supersaturated solid solution structure is achieved continuously by press quenching using mainly air or rarely water as cooling agent. However, introduction of hard alloys and more complex profiles requires updating of facilities and technologies in order to provide precise control of quenching rates.

As regards rolled products, the old rolling mills are unable to perform on-line heat treatment. As for wire-rods, some Properzi machines producing conductor grade alloy wire-rod are supplied with on-line quenching facility, some of them however, as mentioned earlier, can make wire-rod with hot worked state only which requires additional operations and expensive facilities in the cable factories to achieve the specific properties. It is also noteworthy that the bulk treatment of coils make it very difficult to attain uniform properties.

In the case of commercial products, thermo-mechanical treatments, that combine plastic deformation and heat treatments in order to utilize their synergic effect, are not applied at all for the improvement of properties.

Possible areas of development are in connection with equipment update, manufacture of superplastic sheets, production of hard alloy semis with sophisticated properties and quality improvement of some products like electric conductors mentioned earlier.

Die-casting

A lot of small and medium scale die-casting shops can be found in India. As a result of their limited capacities and rather old facilities, they are not capable to produce large castings of good quality which are increasingly required by different sectors of defence and engineering industry. In general, the applied casting technologies belong to the traditional methods namely sand casting and gravity die-casting. However, some firms have introduced already more advanced technologies like pressure die-casting and, in addition, there is example of application of casting method that represents the state-of-the art solution at this field like squeeze casting demanded by the production of engine castings for cars and other vehicles. Considering that some up-to-date casting methods have been investigated recently in different institutions and their lab-scale applications are in progress, future R&D work should concentrate on the industrial introductions associated with well-defined parts like car wheels, engine blocks, etc.

Sheet metal forming

Technologies like bending, shearing, punching, deep-drawing, spinning, flow turning, etc. are commonly used in the metal forming practice. Small capacities are equipped mostly with simple, outdated machines that are manually operated as usual, therefore their technical background makes them unable to produce products of good quality and high standard. At the same time, lots of medium scale factories and some large capacities that are involved especially in defence and aerospace industry can process sheets and plates with the most sophisticated methods like CNC spinning and flow turning, or either hydroforming.

The production of large thin walled parts like vessels, barrels, paraboloid mirrors, cylinders, etc. requires first of all high capacity presses with special tooling and R&D

activities in order to improve technologies like rubber die forming or superplastic forming. However, the latter must be associated with the development of superplastic sheets having very fine grain size and uniform microstructure.

Surface finish

Although advanced methods and technologies are well known for producing plain and coloured anodic oxide layers, powder and chemical conversion coatings as well as paints of good quality on the surface of different semis and finished items, their applications are more or less restricted to simple and not too expensive processes. The further R&D work in this field should therefore concentrate on the application oriented surface finishing methods, considering that finishing operations are performed basically in small and medium scale factories where opportunities are rather limited in respect of automatization and introduction of sophisticated process control.

On the basis of all mentioned above it may be concluded that the Indian aluminium manufacturing sector, in spite of difficulties resulting basically from its outdated facilities, is able to meet the actual demand of domestic processing sector and some of its products fill even the requirements of foreign markets. Although there are examples of up-to-date machines and equipment, most of them are rather old that require modernization in order to increase productivity and introduce new products with higher value-added. Therefore, R&D works should be focused first of all on the possible solutions of machinery upgrading in the future. On the other hand, it seems also important to investigate the possibilities of introduction of advanced technologies using the new facilities for increasing the competitiveness of semis and promoting wide-scale application of aluminium. Some of required know-hows have

already been elaborated or adopted, some relating work is now in progress and in some areas further R&D activities are needed.

In regard of processing sector, the gap between the levels of knowledge and application is much higher than that of semis' manufacture. Owing to its very diversified nature, the numerous technologies applied and the prevailing feature of small scale capacities with low level of mechanization, process control and quality management, it is very difficult to give uniform solution for the developments to be realized. In this case the first step to be done is to organize an advisory group that is able to elaborate proposals for enlarging product-mix and technology packages for possible improvement for each operation that conform to local circumstances and novel requirements.

C. Existing institutional background on aluminium research

In India, lots of professional institutions dealing with basic and applied R&D work for aluminium industry are to be found. In accordance with a survey made in 1991, there are at least 36 institutions in the country interested and active in aluminium research. Based on technical reports and publications of that year, our survey shows that the number of institutions engaged in R&D for aluminium is over 60 including universities, laboratories and R&D divisions of manufacturing and processing companies. Their activities cover a very wide range from alloy developments to introduction of new products and technologies. The name and location of those institutions are given in Annex 5.

Analysis of R&D activities of different institutions shows that research in the universities is mostly in the area of structure-property relationship, solidification, fundamental

aspects of metalworking, alloy development, composite materials, powder metallurgy and corrosion processes. Special attention is devoted recently to the problem of rapid solidification, alloy-based composites and high strength alloys with lowered density.

Whereas, research work in national laboratories and institutes is basically technology oriented, these institutions are more or less well equipped and many of them have adequate facilities to take R&D process upto pilot plant stage. Alloy development, manufacturing and processing technologies like casting, forging, flow turning, adhesive bonding, powder metallurgy, manufacture of composites, import substitution, surface finishing and corrosion protection are of the main areas where they have already realized significant progress.

R&D activities of companies and plants are basically product and process oriented with special emphasis on quality control, economy through improvement in existing techniques, energy saving measures, scrap recycling, waste utilization, pollution control, import substitution and identification of new application areas.

On the basis of available data and information as of 1991, we have surveyed the aluminium R&D work with respect to their subject matter. The identified activities with short reference to their subjects are given in Annex 6 in an areawise breakdown. Notwithstanding the brief identification of research work, it may be seen that there is a good coverage on nearly all aspects including basic and applied or industrial research. What seems very important is the suitable co-ordination of these activities at institutional level with the aim to avoid parallel work. It is of similar importance to establish vital links between research and production/consumption through both feedforward and feedback ways of information management in order to support the production of products with high value-added and, as a result, to promote the enlargement of aluminium application.

D. Product mix proposals

The production of finished goods fits only partly into the verticum of aluminium industry, but the company visits at the four largest producers proved their general interest in the processing industry.

The big aluminium companies of the world process only a smaller part of their semis to finished products, most is sold to the processing firms. It is their aim, however, to expand their activities also for producing finished goods either in a direct or an indirect way. Among the many reasons of this, the followings are the most important :

- the technology of finished goods production is highly aluminium oriented, which means that manufacturing of good quality final products requires the knowledge accumulated in the aluminium industry ;
- production of finished goods needs cooperation, two ways of information flow with the manufacturers of raw materials and semis ;
- aluminium has a good market in its finished form, the price margin of sales between semis and finished goods is higher than the expenses arising from turning the semis into fully finished goods ;
- finished products of great quantities sometimes can be produced by using the technology similar to that of the semis ;
- considerable benefit may be attained if the scrap originating at processing is rapidly returned to the cycle.

The proposals seem to be feasible because they are not on the market and their use is not widespread, but need to be further investigated are summarized briefly in the following pages. Some of them fit only to the usual activity of large

firms, because they need quite large investments, but some are good for small or medium size of enterprises.

Mass Products

This group of products consist of the usual household utensils, which are produced in great varieties in the small, medium and large scale industries of India, too.

Some other ideas :

- office, camping and garden furnitures
- home equipments, sport goods in general
- street equipments (garbage can, barrier, fence, street mark)
- garden equipments (green house frames, irrigation systems, cordon poles in horticulture).

Electrical industry

The electrical industry uses aluminium for structures which conduct and/or do not conduct current. The electrical conductors represent the greatest among industries consuming aluminium in India.

In case of current conducting structures the application of aluminium is justified by the

- low production cost compared to copper,
- reliability and simple maintenance.

It is the permanent task of the aluminium industry to increase the conductivity of the materials used in cable, power transmission line, busbar manufacturing. There are some possibilities for the processing industry in India to produce beside the existing products such as:

- internal installation lines (building wiring)
- electrical machine windings
- telephone cables.

The most important aluminium structures not conducting current worth for further investigations in India are:

- lamp columns, column's arms
- busbar channels
- cable channels
- aluminium covered switchgears and safety equipments
- measuring and distribution boxes
- transformer houses
- poles of power transmission lines.

Building industry

Advantages and proposals were detailed in a lecture delivered at the seminar of "Aluminium in Building and Architecture" held in New Delhi, March 12, 1994. (See its Abstract in Annex 4)

Just to list a possible product mix:

- roofings
- sandwich panels
- self supporting arches
- renovation materials of old buildings
- rain gutters
- chimney inserts, air ducts
- garbage dropping channels
- garages, garage doors
- combined foils for humidity prevention
- load carrying structural elements (columns, bars)
- factory prefabricated doors, windows
- railings, interior stairs
- container type mobile buildings
- skeletons for masonry, mounting work
- greenhouse frames
- fences
- shutters for windows and doors
- fasteners (screws, nails, etc.)
- false floors.

Packaging industry

About 75% of the aluminium package materials are utilized by the food processing, thus the demands for this branch are of determining character in the consumption as well as in forming the development purposes. The use of cans, boxes, lids, bottle closures, collapsible tubes, packaging of foils, hard foil trays, cups are well known and introduced for some extent in India.

Another large group of aluminium products used in packaging are mainly for non-consuming usage. Those are large boxes, cases, commercial small containers, drums, pallets, applied as reusable packaging materials, the use of which could be largely increased in India. The product possibilities are:

- cases, as
  - = collecting
  - = transporting (collapsible and non collapsible)
  - = cooling cases
- pallets (instead of wood solutions)
- small containers (also used for shop supply)
- drums
  - = for chemical agents
  - = for food industry
  - = beer barrels.

Transportation

The above listed products serve transportation purposes as well as packaging. Beside silos, tanks, transport containers, gas cylinders this field of application of aluminium means the production of passenger and freight cars, car vans, buses, ships, vehicle accessories.

In spite of the high specific cost of aluminium there is a tendency to increase the aluminium consumption in the

vehicle production. The reason of this effort is to reduce the weight, to fulfill the requirements of

- planning of energy saving constructions
- regulations of environmental protections (even if they do not exist yet on this field)
- personal safety's expectations.

The products worth for further investigation are

- castings in general to replace iron and steel
- heat exchangers in cooling systems
- gasoline tanks
- compressed air tanks.

As far as they belong to the transportation sector

- the traffic tables, their poles
- traffic light poles
- road railings
- noise shadows along the roads

are promising applications in the future in India, too.

Machinery and equipment

The possibilities of increasing the application of aluminium on this field in India can be collected in two main groups

- heat exchangers, as
  - = in air conditioners and refrigerators
  - = cooling components of the air condensation system of thermal power plants
  - = collectors utilizing solar energy
- cast components
  - = sand castings up to 1000 pieces
  - = gravity die castings up to 10000 pieces
  - = different pressure die castings for larger series.

E. Factors determining the decision on using aluminium

In the previous para, those application possibilities were listed which are not or not widely utilized in India. What comes into utilization among them depends on many factors.

In the course of manufacture, producer has to choose among structural materials that can be applied for the same purpose. Choice is influenced by both technical and economic considerations. Application of aluminium requires the following aspects to be considered :

- advantageous properties of aluminium in respect of the final utilization
- user's habits, application techniques
- price of aluminium compared to that of other structural materials
- additional economic advantages in application arising from the properties of aluminium
- availability of different materials.

The price of aluminium affects user's decision in connection with the price sequence of structural materials which can replace each other. Comparison of prices as per weight and volume does not supply adequate information. The figures do not indicate all the economic advantages of aluminium such as e.g. painting is not required as in case of steel, higher life span compared to that of wood and plastic.

Taking the present commodity prices into account, an aluminium structure will probably cost more compared to steel structure in many cases. In some cases, however, the price difference between the load-carrying aluminium structure and the steel structure should be compensated by the more advantageous properties of aluminium compared to steel. In some other cases, simple and cheap workability,

low maintenance requirement, elimination of surface treatment, high life-time, high scrap price, low transport costs owing to reduced weight, etc. can compensate the price differences. To forecast user's decision it is imperative to take additional secondary economic advantages into account.

Considering the primary costs only, aluminium structures are in most cases more expensive than steel or wood structures used for the same purpose but they are cheaper than structures of plastic and non-ferrous metals excluding aluminium. Where these metals can be replaced by aluminium, there the application of aluminium would increase considerably. Otherwise, the possibilities for replacement are now nearly fully exhausted worldwide.

Comparison between the purchase prices of products made of different materials for the same purpose does not make basis for decision concerning purchase and application. Beside the prices, most of users consider the advantageous properties of aluminium especially if pieces of proper convincing information are available.

It is not worthy to enforce aluminium application in those fields where the end user does not benefit economically from its application. If we know the user's requirement concerning the base material of the product, we can affect his purchase even in case if the purchase price of the relevant product is temporarily higher than that of the other product.

In addition to technical and economic considerations, the propaganda plays important role by influencing the behavior of users. In people different kinds of subjective feelings may arise in respect with the application of materials and solutions. As a matter of fact, these feelings, behaviors, likes and dislikes can hardly be taken into account.

The calculating method was introduced as an example in the seminar's lecture (see Annex 4).

It is obvious that in such a large country as India having thousands of manufacturers of finished goods should be some organization dealing with the prognosis of the behavior of final consumers of aluminium goods, before introducing any new product to the market, to avoid voluntariness and financial losses emerging of voluntariness. The small and medium size of enterprises can "bleed to death" on a wrong decision starting with a new product would not prove to be feasible.

For the management of a firm that intends to enlarge the activity, the preparation of a feasibility study belongs to the daily routine starting with market research and followed by the usual steps. Nevertheless, it is necessary to minimize risks and, in general, to avoid voluntariness and "wise" advices to be followed. This task cannot be undertaken by anyone, as a gratis. The question is, whether medium size enterprises are prepared to do that ? According to the experience, they are not. They need help, or at least advice, if not more.

The next question is related to marketing.
In the trading activities of the companies of aluminium industry, beside the traditional commercial operations carried out so far (such as accepting orders, contracting, fulfilling, transporting, invoicing, etc.), other rather important activities should be carried out ensuring the permanent development of the enterprises. These are :

- market research based on constant and yearly summarized observations and interpretation of the actual and potential needs and characteristics of the market, in order to satisfy the demand for specific aluminium

goods, thus achieving continuity of work, profits and balanced expansion for the given company. This factor is no less important than the financial, technical and production factors, so this factor is needed to improve even at the 4 big aluminium producers. The public companies so far more or less neglected the real market research and the marketing,

- marketing, which is a management concept, or it should be at least. The marketing is based on the findings of market research and consists of a mix of methods for influencing the market into a direction desired by the concept of the company. The marketing activity starts where the market research ends and the concept of the company is formed by the management.

Real marketing activity doesn't exist in the sphere of aluminium downstream and processing industry. Most companies are or will be privately owned, it is their risk to carry on their activity, one should say. But, the risks of inexperience are usually responsible for the excess capacities, for the unsatisfactory assortment and consequently of imports, the lack of exports, and so on. Finally it is for the sake of the country as well as the individual firms to improve their marketing activity, to decrease the risks as much as they can. Some firms have permanent contacts with some of their buyers, e.g. sheet metal producers with holloware producers and extruders with window-frame manufacturers. In this type of connection the manufacturers of semis depend largely on their counterpart's marketing activity.

Some firms again have offices out of their site with salesmen, who are interested obviously in the day-by-day operative work, but less in the future and development of the firm they are working for.

Visiting companies and organizations it became clear that the past few years since the material shortage ceased and some surplus occurred, were not enough even for some of the larger companies neither, nor the medium size firms to realize the importance of marketing. Training and help is needed on this field from an able organization.

It is true, there are firms having very good experience to carry on market research, they are really good in interview techniques, but not specialized in and not acquainted with the aluminium industry.

CHAPTER III

POSSIBILITIES FOR JNARDDC IN THE DOWNSTREAM ACTIVITIES

In accordance with available information and data as well as our own experiences on aluminium downstream activities, the following conclusions can be drawn with respect to JNARDDC's possibilities in this area:

- in India, lots of institutions are engaged in R&D work on aluminium covering practically the whole area of basic and applied researches. Consequently, it is no use to establish an additional division or research department with facilities that would be able to perform only parallel activities. For a new R&D division therefore it is essential to identify first of all activities and areas where its leading role can be achieved and useful and profitable work demanded by external industrial partners can be done. However, it is remarkable, that required facilities for technology improvement are very expensive in general ;
- the manufacturing sector is to be characterized by a medium level in respect of both the product qualities and applied technologies owing to the rather outdated facilities. In general, the companies with high and medium size capacities are striving to modernize their facilities and to upgrade their technological level by means of the introduction of new, advanced manufacturing methods, but usually they are short of adequate information on technical opportunities, requirements, know-hows, market demands, etc. For them it is of utmost importance to find partner who is possessed of suitable background for information processing including databases, databanks, access to different data sources in India and abroad, etc. and by this way is able to supply them with all data and information required for their decision-makings and developments. As regards their actual R&D work, the companies can manage them using their own background or

initiate the most appropriate institution available to do that effectively ;

- in the processing sector, owing to its very diversified nature and the dominant role of small-scale factories, the quality level of production varies in a very wide range resulting in end-products with very good and rather bad qualities alike. Most of factories are not engaged in R&D work, they try only to meet the market requirements within their rather limited possibilities. They cannot initiate R&D activities but adapt themselves more or less to the main stream of developments in respect of up-to-date technologies and new products. For them it is very important to find suitable partner, let it be the JNARDDC either, which supports their effort to find marketable products, market requirements, technology opportunities, know-hows, etc. through processing and feedback of available information as well as to improve the actual production with adequate advisory activity, quality checking and manpower training.

On the basis of all mentioned above the most viable role of JNRADDC in the aluminium downstream sectors could be described for a short-term period as an advisory institution which supports R&D activities, quality improvement and marketing work basically by acting as information centre which collects, processes and distributes the relevant data and information. In addition, it provides institutional background for trainings, quality management and certification processes.

The company visits strengthened the conviction in the followings:

- creating and updating a relevant database on domestic firms, products, capacities is a must;
- the small and medium size enterprises need consultancy in proper material selection,

= processing technologies,
= marketing;

- the processing industry, in general, needs advice in
  = the development of new products (prototypes, field trials of the designs),
  = technology improvement,
  = training of their employees;
- the whole downstream sector is in need of an expert group which is able
  = to perform tests and quality checking on the spot,
  = to support procurement of quality certifications to the relevant ISO 9000 standard.

On the basis of its own information managing work, JNARDDC should be engaged in supporting and promoting aluminium usage in different branches and application sectors in a short time. In the framework of advisory activity the Institute must be able to analyze and evaluate trends and tendencies in domestic and international spheres in terms of new products, advanced technologies, quality requirements, market demands, etc., that are of utmost importance for manufacturing and processing firms for their decision making processes. With respect to aluminium finished products, JNARDDC is likely to conduct consulting and training work as well. As a part of its long-term activity, the Institute shall be ready to present developments, to make up prototype of new products and to perform field trial of new technologies. All in all, the Institute should be an effective information source for all interested parties in the downstream sectors and, in addition, perform as a link or channel between sectors or tranches in order to catalyze developments, quality improvement and appearance of new products on the basis of mutual interest.

As a matter of fact, JNARDDC cannot undertake this activity free of charge in case when costs arise, but even than to avoid or at least to diminish the expenditures this task should be sponsored as a non-profit oriented activity.
"Since the industry as a whole would be the gainer, a thrust for expansion of activities in this regard (including funds) must be worked out jointly between the industries and the concerned institutions" (citation of the Report of the Technology Advisory Group on Non-Ferrous Metals, Ministry of Industry, Oct.1992)

Thus, how possibilities will become realized depends on several facts. In the following chapter the minimum program is outlined what is inevitably necessary for the sake of all parties involved.

CHAPTER IV

SELECTED ACTIVITIES FOR JNARDDC

A. Information services for the whole of aluminium industry

There is an existing program for establishing an information centre at JNARDDC, what gives the framework, regarding the personnel, hardware and software for the information services of the downstream and processing industries as well as of the upstream, for what the program was originally built up. Accordingly, besides the earlier proposed fields, the scope of information processing should still cover

- semis such as rolled, extruded, drawn and forged products as well as castings
- finished products used in the building industry, in transport, electrical industry, engineering, etc.

In case of processing industry, the most important is to create an information database of firms. In the course of its implementation, a Questionnaire can be used as for opening the databank on firms. From the semiproducers, somewhat more detailed information seems necessary to feed back in order to implement the consultancy services discussed in the following para.

Information database should always be kept at up-to-date level. The economic and technical data for semiproducts can be accumulated very similarly as it was proposed for the upstream industry. For the processing sectors those data listed in the proposal such as

- market (India and world)
- output (India and world)
- capacity (India and world)

have no sense, naturally. But prices, production, standards, patents, transportation costs, suppliers of facilities and know-how are worthwhile to collect.

For the library the list of proposed periodicals may be enlarged with the followings :

- World Metal Statistics (London, monthly)
- Monthly Bulletin of Statistics (UN, New York)
- Metals and Materials (London)

Some manuals from UNIDO, UNCTAD :

- Manual for the preparation of industrial feasibility study
- Manual of Export Promotion Techniques
- Industrial Joint Venture agreements

Since the proposal is thoroughly detailed in the study of "Program for Establishing an Information Centre at JNARDDC" (ALUTERV-FKI, Budapest), here only emphasis can be put on the importance of it.

B. Consultancy services for end users, training

The end users of aluminium materials in the form of semis are the firms of the processing industry. The technical advices (help in proper selection of material, in the technology) are aimed mostly towards them. The final consumers of the metal are the public, in the form of finished products (used in buildings, transport, packaging, household, etc), therefore, the marketing activity should be aimed towards them. (The "Pull" or "Push" strategy of marketing was mentioned earlier).

Any organization dealing with technical advices cannot be divided from those giving economical or marketing advices.

The customers need both at the same time on the same place, and the tasks and responsibilities of the advisers, consultants cannot be strictly (not even slightly) separated as technical or economic matters.

The importance of marketing factor is evident. A development process can last several years, the risk is relatively high. Not only the firms, but the authorities of the economic management of the country participate increasingly in bearing the risk, in order to form an advantageous base material structure and product assortment. The development of aluminium industry is the part of a long term economics developing strategy. It is evident, too, that any organization capable to lessen the risks of authorities could be sponsored at least partly by them, and partly by the firms interested in development.

The growth of aluminium consumption and exploration of new application fields are mainly the interest of producers. To replace traditional structural materials (copper, tin, steel, wood) by aluminium in various application fields and to maintain achievements is just as technical as marketing task. Thus, almost every aluminium industry operates some technical advisory (and research) organization, for which there is a strong need in India, too. It is evident again, that all of the 4 largest producers should not run their own advisory organization just to create parallel activities.

To summarize; there is a need for a techno-economic consulting organization in order to

- promote wide spread economical application of aluminium
- spread new applications
- promote technical advance in aluminium processing by supplying consultancy, documentation and training
- maintain relations with international and domestic organizations

- promote cooperation among aluminium semis manufacturers and processing plants, collecting the present and future demands
- observe international progress
- promote the adoption of them and the indigenous development of new finished goods on the basis of accumulated knowledge to promote designing, constructing and testing of prototypes
- promote standardization.

This list is the actual job description of the advisory organization, as a whole.

Briefly about the standardization and the training. Standards have to assure the customers' safety, uniformity of products, replaceability, environmental protection, etc. It is essential that manufacturing and processing industries as well as users can evaluate the products from the same aspect. In the process of standardization the experts of the technical staff have to take part in order to solve details of questions and to assure the interest of the parties.

Existing international standards and other foreign standards may promote the standardizing activity, but if they are automatically accepted, they often impede progress in the beginning phase of development. It is inevitably necessary to revise and adapt them as own standards, taking the own achievements and capabilities into account. Creating of such standards, somewhat different from foreign ones can help to keep the undesirable competition away from the domestic market.

To form standards is not the task of the producers, but of the authorities. The technical advisory organization should however, take the initiative steps.

The training does not always mean personal connections of those who are involved. In such a large country only regional seminars, lectures can be organized as non-formal training. It should be carefully studied which organization has the best capability to do that. The advisory organization can take part in that but it looks like more useful from the point of view of fast result if they edit booklets on the proper use, proper technologies, applicable in the production of finished goods.

The proposed booklets :

- On the proper use of aluminium
  - = in general, giving the properties, workability in comparison with other materials, what semis can be obtained in India and where
  - = in building industry
  - = in agricultural machinery, appliances
  - = in transport and storage
  - = in packaging
  - = in machine industry
  - = in mass production

with ample examples of foreign and domestic experiences of each field

- on the proper technologies, applicable in producing finished aluminium goods, as
  - = machining (turning, milling, drilling)
  - = cold forming (cutting, bending, deep drawing)
  - = surface treatment (polishing, painting, anodizing)
  - = joining (welding, soldering, riveting, adhesive bonding, screw bolting)
- popular booklet about "do it yourself" methods.

The booklets can serve the basic training of the workers, foremen and technicians, getting them used to aluminium as a structural material (and to serve sales promotion indirectly for semi's producers). The distribution of booklets needs

careful consideration. A part of it can be spread through the marketing networks of the semi-producers (BALCO, HINDALCO, NALCO, INDAL), some others are to be distributed according to the data bank of the information centre and they can also be sold in bookshops, sent to libraries, associations, authorities, technical schools, colleges, seminars, etc.

It is possible that experienced authors cannot be found locally in one, or another subject. Digests and translations can be made or getting foreigners to give the text, until gaining adequate domestic examples.

Organization of Technical Advisory Team

The technical advisory team should consist at the very beginning as a minimum of

- one mechanical engineer, familiar with electrical engineering packaging, transport and storage, mass production as well as with technologies used in finished goods production, and with basic economics,
- one architect, with ample experience in the field of pre-fabricated buildings, civil work , in the field of the building in aluminium windows, doors, portals, partitions, false ceilings, etc., with the ability of designing all these and even of furnitures, with the knowledge of basic economics
- one metallurgist, familiar thoroughly with material properties, manufacturing technologies of semis, the availability of them according to quality, size, price and other terms of delivery in order to help the end users and processors to select the proper material that fits best for their purpose, who is able to organize the material testing of semis, within JNARDDC or elsewhere

- one economist to carry on a continuous market research using secondary sources as so called "desk research", to evaluate the different application possibilities compared with solutions of other materials, to direct team work in preparing value analysis, to prepare feasibility studies according to needs, to manage the edition of booklets,

and the whole staff should be responsible to provide inputs to the databank of the information centre from their field.

It is no use and does not make sense to build up a large Organization before gaining enough experience on the volume of work that should be done. It is evident that to find experienced and able staff is a random. The personnel should train themselves on the job autodidactically. The selection will come automatically.

One can not expect to carry on training by people still not trained. In the first period, therefore the department should be responsible only for the organization of trainings as to find the right lecturers for given subjects, to assure the place, the technical background for the success of training.

It is not advised to get ready with workshops and machinery, people to produce prototypes of aluminium goods. New products can be designed by experienced designers of the given field with the consultancy, or even with the supervision of the staff of Technical Advisory Team (if the order is given by them), and the prototype could be produced at the best firm able to produce that (or the firm, who is interested in the production of the item after trial).

Last but not least, as in the case of any kind of organized activities, the advisory team requires a manager as well.

The manager is not necessarily the best expert, but the best organizer who is able to create good circumstances for work, able to negotiate and to represent the best sake of the centre and his (or her) team.
As a rule, this kind of team needs a "laissez fair" type of leadership.

C. Participation in the R&D activities of the downstream industry

Even a very simple advice means some participation in the development of products or technology of the advised firm. The consultancy supplied usually can not be measured by money, the costs of consultancy can be negligible but the results realized at the aluminium processing partner can be large enough.

When the consultancy is connected with passing over some documentation, that costs money because the preparation or procurement of any documentation needed time and spending, moreover to bear any responsibility and risk for any documentation worth of money, handing over information collected have values; any training assured directly or indirectly was connected to expenses, too.

Designing, constructing and testing of prototypes are not cheap activities at all, the interested parties should pay for it on a contractual basis.

The acting advisory organizations all over the world are

- partly sponsored by the authorities and the basic and semi-finished material producers,

- they are earning some on selling information, pre-processed documentations, not directly for profit, but just to cover the expenses needed to obtain those,
- contracting assignments of work bounding larger capacities, needing larger inputs, such are the designing, constructing, testing prototypes, or running training courses.

From the point of view of JNARDDC it is worth organizing and running a Technical Advisory Team, if

- sponsors can be found,
- it can be proven (by enquiries and some kind of market research, or preliminary agreements) that some assignments can be obtained, and
- the activity of advisers will contribute to the better utilization of existing capacities(instruments and manpower) of other departments of the Centre.

Responds to these questions make it clear how the Technical Advisory Team can participate in the R&D activities of the aluminium processing industry. The feedback of their information collected from their customers of the processing to the downstream can help the R&D plans and imaginations of the lasts.

As for commencing and introducing the activities of the team, it is advised to draft an information bulletin with the list of obtainable services in terms of what are

- free of charge (to whom, what, how, etc.)
- charged (what, how, etc.)
- available on contractual basis.

This leaflet should be spread

- through the marketing branches of basic material and semi-producers (e.g. can be put in addition to invoices mailed)
- by direct mail, the mailing list can be prepared on the basis of

= trade directories

= yellow pages of phonebooks of the main cities,

- through professional associations, chambers, etc.

It is also advised to pay visits at the most important partners in order to

- introduce themselves,
- assure the support and backing of the partners,
- acquire commissions.

Actually, the commissioned participation of the team in the R&D work of the downstream industry should be stated and properly detailed in the contracts.

As a next step, the Technical Advisory Team should prepare the so-called "Small Plant Documentation Packages" in order to draw attention of perspective entrepreneurs. The proposed areas can be found in Annex 9.

D. Quality management services

In respect of both the extension of aluminium application and production of products with higher value added, the quality is of utmost importance. Its key position is underlined by the fact as well that recently international standards have already been specifying the quality assurance and markets tend more and more to absorb products of producers that have already procured the certification to the relevant ISO standard. Accordingly, most of plants with medium or large capacity have already introduced quality management system or are in progress to do that on the basis of their own testing laboratories and facilities. In their case, introduction and adaptation of some new checking methods conforming with technology development may be the task with specific respect to the application of NDT methods for in-process controls. In the case of small-scale industries, the task is more complex. At first, they should be supplied with all necessary information about quality

control possibilities in conformity with their technologies, products and requirements. After, they should be supported in the elaboration of quality management program and then in the introduction of quality management system considering that checking and controls covering the whole manufacture from testing input materials to certifying end products should be performed by simple, quick and reliable methods that do not require expensive instruments and highly qualified staff. In general, these checking methods apply NDT technique mostly.

Considering the importance of quality improvement in the Indian aluminium industry as well as its role in the extension of aluminium application, it seems essential to form a small team consisting initially of two or three persons within the JNARDDC's Department of Semis and Finished Products in order to supply quality management services for the whole industry especially small and medium scale capacities. Within the team a technician should operate the instruments and do the necessary maintenance work, the other one(s) should expertise the actual testings and quality improving activities. Accordingly, expert(s) should be mechanical engineer and/or metallurgist with material testing experience and appropriate knowledge in quality assurance.

A basic requirement for the selection of instruments and appliances is the portability because they should be used mainly at the spot of production. Another main aspect is their principle of operation , namely it seems preferable if they apply NDT technique for checking the actual operation and requirements. Manufacturers of semi finished products are possessed, in general, of all the necessary testing facilities required by the determination of standard properties because they cannot sell their products without quality certification. On the contrary, processing firms especially small ones usually do not have facilities for

checking compositional, mechanical or physical properties because they accept the quality certification of semis and they want to check their operations and suitability of products instead. In this regard, they are interested in doing tests that give information on occurrence of internal defects, temper states, surface imperfections and surface finish features. Accordingly, it seems no reasonable to set up testing facilities for measuring standard properties in short term but to settle down to quality controls using simple instruments and appliances based mostly on NDT technique.

Considering the main manufacturing and processing technologies, temper states, the different mechanisms by which defects can be produced as well as surface requirements, the following spot checking and testings are needed to perform on the spot:

- hardness testing
- conductivity measurement
- ultrasonic flaw detection
- thickness measurement of oxide layers and coatings
- surface roughness testing
- surface gloss and reflexivity testing
- checking of oxide layer sealing.

List of instruments and appliances required by these tests and measurements is given in Annex 5. By using these methods a lot of information can be collected concerning quality management. For example, hardness is a standard property and its value is generally required for the product certification, at the same time, it can be used with certain limitations to assess other mechanical properties like tensile strength. Considering that lots of portable instruments for hardness testing are to be found in the practice from the very simple hardness pliers to the microprocessor controlled instrument with digital display, it is advisable to use this method as a rapid means of materials assessment. That is the case in particular with

quality control procedures or when qualitative evaluations are required for processes and parameter selections. Similarly, conductivity measurements can be used as fast means of assessment for qualitative evaluations on the basis of predetermined relationships between conductivity and other structure-sensitive property.

As regards ultrasonic testing, in addition to radiography, it is one of the most important NDT methods applied to identify defects in products. These defects may form at various stages of production and are harmful in respect of both the success of subsequent operations and quality of final products. For that reason, it is necessary to follow critical technologies and to check the defect-free nature of products. As a matter of fact, it is important to understand the origin and nature of defects in order to devise suitable inspection techniques as well as to modify process parameters for eliminating the causes. On the other hand, surveying manufacturing and processing operations, it is to be seen that there are many different mechanisms by which defects can be produced during the manufacture of semis and finished products:

- defects produced by shrinkage in castings and welds
- defects caused by non-uniform or excessive deformation during plastic deformations
- defects produced by thermal stresses and transformations
- inclusions
- gaseous defects, e.g. blow holes

These defects can be detected by ultrasonic technique, which has the advantage over radiography that it applies harmless sound waves instead of X-rays or gamma-rays with very strict safety measures. It is true, however, that application of radiography is inevitably for detecting peculiar defects occasionally, but in case of necessity it is more reasonable to apply radiography in cooperation with external partner in the first period than to set up facilities for them.

As regards investigation of microstructural features of products, it cannot be implemented on the spot, samples are to taken destructing the actual item then, after suitable preparation, grain structures, phase structures, textures, etc. can be determined using appropriate optical microscope. This technique is now available in the Institute, therefore it can be used for this purpose.

For the assessment of surface quality with special reference to uniformity, roughness, brightness, oxide layers or coatings, there are several portable instruments that supply data and values for the specified properties and features. Anodization processes can checked by measuring the thickness, colour, reflexivity, sealing and homogeneity of oxide layers with purpose-oriented instruments. As regards painted or lacquered surface, coating thickness, uniformity and colour are to be investigated easily with simple portable appliances. In case of as-manufactured surfaces, roughness and presence of cracks, pores and other inhomogenities can be checked by NDT techniques, while textures, anisotropies and other defects are to be tested by applying macro-etching and dye penetrate techniques.

On the basis of all mentioned earlier it can be seen, that the quality management group supplied with some portable instruments and using the existing facilities of JNARDDC is able to support the efforts of plants and factories for their quality developments as well as to help advisory and training activities of the Centre. Of course, after a couple of years, the activity can be extended by applying additional testing and qualifying methods like radiography, acoustic emission, mechanical testings including tensile, compression, fatigue, fracture mechanical and creep tests, corrosion testings, etc., but in that case a new testing department supplied with all required facilities should be established in conformity with the need of Indian aluminium downstream industry first of all.

Using the facilities and instruments already available in JNARDDC and with the addition of equipments listed in Annex 5, it should be possible to carry out the following activities related to testing and quality control.

Manufacturing methods and related products

Melting, holding

Checking of external thermal conditions of furnaces using thermovision in order to determine sources of heat losses.

Billet/slab casting

Identification of defects (flaws, cracks, etc.) in the cast products using ultrasonic technique.
Checking of grain structure by macroetching.
Investigation of microstructure by metallography using optical microscope.
Checking of compositional homogeneity along different directions using Sigmatest and EPMA instruments.

Wire-rod cast rolling

Testing of macro- and microstructural features of rod stock and wire rod by metallography using optical microscope and etching techniques.
Checking of electrical conductivity of rods using Thompson bridge and portable resistivity meters.

Homogenization

Control of heat emission of furnaces using thermovision for determining sources of heat losses.
Checking of macro- and microstructural features of workpieces before and after treatment by metallography using optical microscope and etching techniques.
Checking of compositional uniformity by EPMA.

Rolling/extrusion

Checking of as-worked and tempered states using hardness and conductivity measurements.
Testing of surface quality with roughness tester, macroetching and ultrasonic instrument.
Checking of occurrence of internal defects by ultrasonic technique.
Testing of microstructures and textures by metallography.

Forging

Checking of as-worked state and anisotropy with hardness tester and macroetching.
Identification of internal and external defects using ultrasonic technique and dye penetrate method.
Development of flow lines by etching.
Testing of microstructure by metallography.

Drawing

Checking of specific electric resistance of conductor wires using Thompson bridge and portable meters.

Processing methods and related products

Joining (welding, soldering, brazing)

Checking of occurrence of defects such as cracks, hot tears, porosity and slag entrapment using ultrasound technique and dye penetrate method.
Control of macrostructure of heat affected zone by macroetching with special attention to the possible occurrence of coarse grain recrystallization.
Testing of annealing process in the heat affected zone by hardness measurements.

Heat treatment

Control of tempered states with hardness and conductivity tests with special attention to solution treatment and ageing stages.

Die casting

Checking of internal and external defects such as shrinkage cracks and porosity with ultrasound technique.

Testing of macro- and microstructural features by metallography using optical microscope and etching techniques.

Control of surface quality using roughness tester.

Surface finish

Control of thickness of oxide layers and coatings using the specified devices.

Checking of sealing features of oxide layers by sealing tester.

Checking of aesthetic appearance, uniformity and homogeneity of surfaces with or without treatments by testing reflectivity and colour properties.

Checking of surface roughness with the specified instrument.

Training

The aim of quality management training is to make the whole process of quality assurance known for participants in details, focusing basically on its technical implementation with special attention to testing and checking methods that connect quality as a ranking category with relevant figures, values and levels specified in advance. Accordingly, in general, the training programmes should consist of two main parts. The first one is to be devoted to the overall problems of quality management with special emphasis on the organization of quality assurance system including

standards, specifications and certification to the relevant ISO 9000 standard. The second part should be more specific as to dealing with the technical implementation of quality assurance and concentrating on the practical difficulties of quality control over the whole manufacturing and fabricating processes from checking of input material to the certification of end product. In fact, testing methods and control procedures should be introduced in terms of applied technologies and specific products. With relation to these methods, however, the emphasis is to be put on the information content of them first of all.

A general scheme of a training programme can be considered as follows:

- Quality as ranking category for products
  Notions, specifications, standards
- Process of quality assurance
  Requirements, expectations
- Quality assessment in different stages of production
- Testing/checking methods to be applied for the control of
  - = composition
  - = mechanical properties
  - = physical properties
  - = technological features
  - = metallographical properties
- Examples of application

The theoretical questions of quality management do not require auxiliary materials and facilities but standards and specifications for the discussions. As regards presentation of material testing methods and checking possibilities, the emphasis should be put, as it was mentioned earlier, on the quality related information content of them and the application of NDT techniques, therefore they should be introduced by using simple, well-understandable demonstration tables, models and process simulations, in

addition to the working facilities, instruments and appliances to be found in the Institute after setting up the relevant Department.

Most of instruments and devices required for the proposed checking and testing procedures as well as for the training programmes are portable and they all can be put into a small van for bringing them on the spot, if necessary. Reasonably, these programmes should be implemented in the Institute, however, any other place can also be taken into account in accordance with requirements.

Prior to organizing training programmes, with respect to effective demonstrations and presentations, characteristic samples and test pieces should be collected from manufacturing and processing firms. Preparation of some samples may also be required in order to simulate occurrence of defects, damages and disorders properly.

ANNEX 1

V. Iliev
26 May 1992

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

JOB DESCRIPTION

DP/IND/88/015/11-53 DP/IND/88/015/11-54

J13207

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Post Title: Consultant in aluminium semi-products
Consultant in aluminium application

Duration: 2.5 months

Date required: as soon as possible

Duty Station: Nagpur (India), with travel within the country

Purpose of project: The immediate objective of the project is to assist the Government of India in setting up a functioning Aluminium Research, Development and Design Centre consisting of:

a) Alumina Production Research Department
b) Aluminium Electrolysis Department
c) Analytical Research Department
d) General Services, Instrumentation and Control Department (incl. workshop and maintenance)
e) General Administration and Finance Department

The Centre will develop the capability of carrying out the following main functions on behalf of and in cooperation with the bauxite processing/alumina production and aluminium smelter industries in the country:

a) Assimilation and adaptation of available technologies
b) Providing recommendations and ad hoc or applied and analytical research to local industries in process improvement, transfer of technology, etc.
c) Setting up and operating a data bank
d) Providing training of Indian engineers.

Duties: At present, according to the approved project document for the establishment of the Centre, there is no department dealing with aluminium semis and finished/end-products and their application. However, it was recommended that in the future the Government shall complement the Centre with an appropriate unit for studying the production of aluminium semies and finished products, process development, products promotion/diversifica-

TPR and PAC meetings and it was agreed that some of the above areas could be selected and introduced in the frame of the follow-up project stage. Due to limited resources at present, full-scale activities in this field are not applicable, therefore a report of the relevant analyses and recommendations on sustaining follow-up actions is needed.

The consultant will be required to provide advisory services/expert consultancy on selected R/D activities of the Centre in the field of aluminium semi-products and application after the current project phase (The consultant 11-53 is supposed to work in tandem with consultant 11-54 in aluminium application).

His main duties will be to:

1.) Review the final report of the UNIDO Subcontractor Aluterv-FKI "For setting-up an Aluminium Research Development and Design Centre in India", prepared in August 1983.

2.) Review the revised Centre design, prepared in 1990 and analyse the Centre's capabilities at the stage of completion of the current project from the point of view of possible utilization of the existing facilities, infrastructure, personnel, etc. in case of expansion of the activities in the field of aluminium semi-products technologies and application.

3.) Contact the main aluminium producers and consumers in India and identify their development problems and needs.

4.) Deliver lectures, provide consultancy and technical information on the latest development and achievements in the field of aluminium semis production (bars, sections, shapes, sheets, strips, tubes, etc.)

5.) Prepare a report with recommendations on "selected activities of the Centre in the field of aluminium semi-products and application after present project stage" and discuss it with the counterpart/project management.

The consultant is expected to prepare and submit a technical mission report with attached report as per para 5 above, upon completion of his mission. The report should be prepared in line with the UNIDO standard requirements.

Qualifications:

University degree (preferably PhD) in mechanical/metallurgical engineering; with extensive practical experience in aluminium semi-products production, design and application.

Language: English.

The Indian aluminium industry looks back to a history of 44 years. The first aluminium smelter (in Alumpars, Kerala) was put into operation in 1943. At present there are five alumina plants in operation and six aluminium smelters with an overall capacity of about 587,000 and 580,000 tonnes per year, respectively. These facilities belong to five aluminium companies, namely Bharat Aluminium Company Ltd. (Balco), Hindustan Aluminium Corporation Ltd. (HINDALCO), the Indian Aluminium Company Ltd. (INDAL), the Madras Aluminium Company Ltd. (MALCO) and the National Aluminium Company Ltd. (NALCO).

With the commissioning of NALCO the share of the public sector in aluminium smelting is more than half of the total installed capacity of India. This indicates the decisive influence of the public sector on the future of the industry. The sustained growth and development of the aluminium industry in India, apart from requiring the adoption of suitable long term policies in relation to production management, output, pricing, and fiscal levies, is also in need for technology and market development, which will gradually be handled by the proposed Centre.

During the past years, India became one of the leading countries in the world having substantial bauxite resources, after the discovery of large deposits in the Eastern Coast in the nearly 1970ies. The total bauxite reserves of India are estimated to be of the order of 2,650 million tonnes, which places India on the fifth place in the world list.

With the vast reserves of bauxite and coal in India, the aluminium industry has ambitious plans for a faster growth rate keeping in view the future demand in the foundry and export potentials.

The existing alumina/aluminium plants in India are based almost entirely on technology imported from various sources. Both in the areas of production of alumina and aluminium, a number of technological improvements have taken place in advanced aluminium producing countries. Import of improved technology is not always possible, also its introduction is not feasible in the existing plants. Import of technology necessitates proper assessments to determine its suitability under Indian conditions, the available raw materials, product demands, state of engineering developments, etc. Though research and development work is being carried out by the major aluminium producers in the country, these are mainly directed towards solving their day to day process problems in the plants. No work is done for the development of process know-how and basic engineering. The technologies followed in the existing plants are from various countries/suppliers - KAISER, ALUTERV-FKI, VAMI, ALCAN, MONTECATINI and ALUMINIUM PECHINEY. Apart from the strategic importance of having an indigenous Research, Development and Design Centre for Aluminium, the Centre is expected to save substantial hard currency payments to the foreign partners.

For meeting the estimated demand of aluminium by the turn of the century, substantial additional capacities for alumina and aluminium will have to be set up in the 1990ies. Additional demand for aluminium by the turn of the century, which is in excess of the currently available capacity would be of the order of 440,000 tonnes per annum which at the current selling price of aluminium amounts to Rs. 1180 crores. Considering the payment for know-how, basic engineering and royalties for this additional follow-up stage this would mean an expenditure of at least another Rs. 1.2 billion equivalent to US$ 95 million.

It is to be pointed out that the cost for Establishment of the Aluminium Centre in Nagpur (both Indian Government and UNDP contribution) is of the order of US$ 12.5 million. The financing of operations and further development of the Centre is envisaged by the Government to be secured through a collection of Rs. 100 per tonne of aluminium for aluminium research and development, added to the price of aluminium (established now by the State in India). The funds so generated would serve as financial basis for operation and further extension of the Centre.

When the new aluminium capacity will be established the Centre will be fully functioning and if it contributes to savings of only ten per cent of the expected expenditure for project engineering and royalties, apart from rendering other useful services, its establishment would be fully justified.

It is to be noted that all the leading aluminium producing countries have their own R and D centres. Close interactions among these Centres' Research and educational institutions and industry has enabled numerous technological advances - this example is needed to be followed in India.

In the light of the above, a co-ordinated effort in R and D will be essential for the development of know-how and basic engineering to self-reliance in alumina and aluminium technology needed for the establishment of future plants without need to go for foreign consultancy. Future development of aluminium industry in the country based on indigenous expertise demands the immediate establishment of a self-reliance full-fledged and independent research, development and design centre for aluminium at the national level.

The development objective of the project is to aim at self-reliance in alumina and aluminium production technology and to achieve faster growth of the Indian aluminium industry to meet the domestic demand for aluminium products. This goal will be achieved by setting up of an Aluminium Research, Development and Design Centre at the national level which will be in a position to carry out research and development in the field of bauxite processing, alumina and aluminium production leading to improvement in the existing plants and creating new production facilities. Thus, the output of the project will be physical facilities of an Aluminium Research Development and Design Centre, adequately equipped with specialized research and testing equipment and trained professional staff to render research and development technology in the existing plants and for setting up of new alumina/aluminium production facilities based on indigenous raw materials and natural resources.

In addition, the Centre will handle related projects such as dealing with the use of by-products, design improvements for saving of energy and materials, development of new products and alloys. Another particular problem that the Centre is expected to address is emanating from the lack of adequate and uninterrupted power supplies which has led to poor utilization of capacities in the recent past. Investigations into energy saving technologies of alumina and aluminium production will be one of the important tasks that the Centre will have to tackle.

It is expected that once the Centre is established it will meet the fast growing technological service needs of the aluminium industry in India. The Centre will consist of the following departments:

- Aluminina production research department with four laboratories and one pilot plant;
- Aluminium electrolysis research department with four laboratories;
- Analytical research department with three laboratories;
- General services, instrumentations and control department with four sections;
- General administration and finance department with three units.

The civil construction works for the Centre started in Nagpur in 1990 and will be finished by 1992-1993. The centre is planned to fully operate/function by 1994-1995.

The assignment of the national staff and procurement of equipment started in 1989-1990. The first R/D works are expected to start in 1991-1992. Training of the staff will be carried out in India and abroad.

For a more detailed information reference could be made to the Project Document and the Detailed Centre Design.

Facsimile Cover Sheet

To: DR. T. KALMAN
Company: ALUTERV-FKI
Phone: 00-36-1-161-1837
Fax: 00-36-1-181-2967

From: RAMACHANDRAN/ZAMBO
Company: JNARDDC
Phone: 00-91-712-386894
Fax: 00-91-712-386802

Date: FEBRUARY 10, 1994
Pages including this cover page: 3

DEAR DR. KALMAN.

KINDLY FORWARD THE FOLLOWING INFOMATION TO DR A. EVA AND / OR MR S. FULOP:
THANKS AND REGARDS

WE WERE INFORMED THAT YOUR ARRIVAL IN NAGPUR IS EXPECTED AROUND FEBRUARY 25, 1994. PLEASE FIND BELOW COPY OF OUR PREPARATORY ACTION IN CONNECTION WITH YOUR PROGRAMME, WHICH MAY BE USEFUL FOR YOUR PREPARATION.

PREPARATION FOR THE VISIT OF EXPERTS IN ALUMINIUM SEMI-PRODUCTS AND APPLICATIONS

The following preparatory work is proposed:

1. Review of production and consumption of semi-fabrication and products from aluminium and its alloys is to be prepared during the mission, therefore
   - List of main producers of aluminium somis and consumers is being collected / updated.
   - Statistical data on production and structure of consumption are being collected

- Names of companies to be contacted / travel programme for the team is being finalised

2. Role of Aluminium Association of India is being considered and their co-operation is being requested.
3. Questionnaire for collection of information from the companies is to be prepared . International experts are requeted to prepare the same.

Also considered the following points, while preparing for your visit:

1. One of the main problems of development / extension of production capacty for the primary aluminium and semi-products of aluminium and its alloys in India is the limited indigenous market requirements; therefore the activities which may be introduced in the Centre are to be concentrated on the promotion of economical use of aluminium in the Country.
   Export of primary aluminium seems to be incompetitive but the export of more value added products to the neighbouring countries is to be considered
   Quality and assortment of the products and special indigenous conditions are also be considered carefully
   Possible role of the Centre to be defined.

2. Selected activities to be introduced :

- Information services / review and analysis of the production and consumption in the world and India
- Consultancy services / market analysis, quality improvement, introduction of new products
- R&D activities in selected fields
- Participation in the implementation of selected development projects

3. EXCERPT FROM JOB DESCRIPTION FORWARDED TO UNIDO BY THE PROJECT:

According to the Project Document for establishment of Jawaharlal Nehru Aluminium Research Development and Design Centre the Government should consider to complement the Centre with a department dealing with the production of aluminium semis and finished products, process development and product promotion. Sustainability and and follow up actions after project phase have also received attention in the II TPR and a report on sustaining activities and maintaining technological currency is to be brought before the next TPR. Recommendations on completion of the activities of the Centre with the field of semis and finished products should also be the part of the report for III TPR. Addition of a department dealing with aluminium semis and finished products was discussed on the III PAC and after careful consideration it was agreed, that at the present stage it is not possible to find fresh resources required for the introduction of full scale activities in this field. However, on the basis of the present needs of primary producers it is felt, that some areas could be selected and introduced in the frame of a follow up project. This expert will work in tandem with another in aluminium application (11-54) to :

1. Review the final report of UNIDO subcontractor AUTERV-FKI " For Setting -up an Aluminium Research, Development and Design Centre in India", prepared in August 1983.

2. Analyse the capability of the Centre at the stage of completion of t he present project from the point of view of possible utilisation of the existing facilities, infrastructure etc. in case of expansion of the activities

3. Contact the main aluminium producers and consumers in India to fix the present needs

4. Prepare a report with recommendations on "Selected activities in the field of aluminium semi-products and applications in JNARDDC after project phase"

WE ARE LOOKING FORWARD TO SEE YOU IN NAGPUR

ANNEX 2

Senior counterpart staff:

Dr. T.R. Ramachandran, Director
N.G. Sharma, Deputy Director
Dr. J.Zambo, Chief Technical Advisor

Travels in the country:

07.03. Korba (Bilaspur)
09.03. New Delhi
14.03. Renukoot (Varanasi)
16.03. Bhubaneswar
18.03. Angul
19.03. Balasore
20.03. Calcutta

ANNEX 3

LIST OF PEOPLE MET

Dr. L.Moller - UNDP, New Delhi
Dr. E.A.Yanko - VAMI, Russia (UNIDO consultant, Nagpur)
S.K.Mehrotra - Director, BALCO, Korba
P.N.Sharma - General Manager, BALCO, Korba
Dr. P.K.Maitra - Dy.Gen.Manager, BALCO, Korba
A.K.Roy - Smelter Manager, BALCO, Korba
P.Banerjee - Dy.Manager, BALCO, Calcutta
V.K.Vasudeva - Regional Manager, BALCO, Calcutta
S.K.Roy - General Manager, Asian Group, New Delhi
V.K.Chhabria - Sr.Manager, Asian Group, New Delhi
B.K.Agrawal - Vice President (Fab.Prod.), HINDALCO, Renukoot
P.Singh - Vice President, HINDALCO, Calcutta
R.N.Gupta - General Manager, HINDALCO, Calcutta
S.Baberwal - Sales Engineer, HINDALCO, Bangalore
S.K.Tamotia - Chairman, NALCO, Bhubaneswar
R.K.Maheshwari - Dy.General Manager, NALCO, Angul
M.M.Seth - Chief Manager, NALCO, Bhubaneswar
S.Acharya - Executive Director, NALCO, Bhubaneshwar
G.S.Panda - General Manager (Smelter), NALCO, Angul
C.B.Agrawal - Chief Manager, NALCO, Bhubaneshwar
B.S.Pani - Chief Manager, NALCO, Bhubaneshwar
R.P.Panda - Manager, IPICOL, Bhubaneswar
S.M. Sundaram - Managing Director, Orissa Extr.Ltd. Balasore
A.Sen - General Manager, Orissa Extr.Ltd., Balasore
TNM Balagopalan - Chief Technical Officier, INDAL, Calcutta
G.D.Binani - Vice-President, Orient Ind.Ltd., Calcutta
P.Jain - Manager, Mohamir Aluminium, Calcutta
V.Misra - President, Pennar Aluminium Co.Ltd., Dahali
S.Mohinta - Gen. Manager, Pennar Aluminium Co.Ltd., Dahali
M.Todi - Mg.Director, Alfa Aluminium Pvt.Ltd., Calcutta

C.S.Madan - ECA Products Pvt.Ltd., Madras

C.S.Pradipak - Mg.Director. Krish-Viman Ltd., Secunderabad

S.Sanghvi - Corp.Off., ORBIT, Pune

S.C.Chokhani - Mg.Director, Sudarshan Al.Ind.Ltd., Bombay

ANNEX 4

Details of company visits
(Synopsis)

Bharat Aluminium Company Ltd.

Korba / Calcutta

Counterparts: S.K.Mehrotra - Director (Commercial)
P.N.Sharma - General Manager
dr.P.K.Maitra - Dy.Gen.Manager (Quality Control)
A.K.Roy - Smelter Manager
P.Banerjee - Dy.Manager (Marketing)
V.K.Vasudeva - Regional Manager
and their staff members

Products

Rolled products - hot rolled coils and plates, cold rolled coils, strips and sheets, patterned sheets, corrugated sheets, circles, foils

Extruded products - solid and hollow profiles (about 1500 standard types), seamless rolled and drawn tubes

Conductors - EC and alloy grade wire-rod, AAC/ACSR/AAAC conductors

Billets - size: 100-400 mm in diameter
max. 6.000 mm in length

Casting alloy ingots

Experiences of discussions and plant visit can be summarized as follows:

Melting, holding and melt treating operations are carried out by using conventional methods and furnaces as well as traditional degassing/cleaning additives, grain refining nucleants and master alloys. Billets and slabs are produced by DC casting technique, application of hot-top method is to be expected by the end of this year. In the case of hard

alloys or on specific request, soundness of cast products is checked with NDT (ultrasonic) method. In addition to solid billets, their hollow form is also produced especially for the manufacture of semis of hard alloys. As regards commercial production, hard alloy means, in this context, some kinds of AlMg, AlCuMg and AlMgSi types with medium alloy content. Wire-rods are produced on Properzi cast-rolling machine without any extraordinary filtering and checking operations. Hot and cold rolling facilities, as well as extrusions presses are rather outdated and, in spite of their time to time updating and modernization for improving capacities, controls and auxiliary equipment, they are unsuitable for manufacturing sophisticated products like can-stock material or high strength thin walled profiles of larger size. No surface finish such as anodization or painting is applied, products are sold out in their as-manufactured state.

In Korba plant, rather well-equipped quality testing and R&D laboratories are available to carry out prescribed tests for checking actual manufacturing processes and to conduct development work that is basically technology-oriented and concentrates on the manufacture of semis with higher requirement. However, occasionally they deal with the development of new product as well, as it was presented by the prototype of an all-aluminium truck body. They are ready to co-operate with external partners to conduct R&D work as joint effort on the basis of mutual interests. Procurement of the certification to the relevant ISO 9000 standard is in progress.

The company has four regional marketing offices which operated so far mostly as merchandizing organizations and marketing activities (market research, propaganda, public relation) have not been at too high level as a result of supply oriented market conditions. Recently, the circumstances have changed, the marketing work, as they have realized already, has to be strengthened and enlarged. It

seems also necessary to create a healthy information exchange system in order to feed market-induced requirements back to the engineering side as well as to feed information on technical opportunities forward to consumers. In this process the information system to be established at JNARDDC can give very effective support.

Asian Group

New Delhi

Counterparts: S.K.Roy - General Manager (Projects)
V.K.Chhabria - Sr.Manager (Projects)

Group companies: Asian Consolidated Industries Ltd.
Rajasthan Breweries Ltd.

Since 1986 they have been involved in the production of cans. So far they have produced 3-part tin cans for Nestle Co., but as they are possessed of a large capacity brewery, it is a must to start beer-can production.

Their plant is under construction and its expected capacity is 18.000 tpy of 2-piece cans for beer and softdrinks. According to their assumption, the capacity will be utilized fully if aluminium cans substitute for bottles used in India for beers and softdrinks as high as 15 and 5 per cents of the total, respectively.

At the beginning, in order to introduce the product to the market, the Metal Box (UK) will supply cans, but by the first quarter of 1995 they will start the domestic production with a possible output of 1.200-1.800 pieces per minute using imported can-stock material. They requested both INDAL and HINDALCO as possible Indian manufacturer of can-stock strips to produce samples for testing. However, in respect of domestic supply of required material quality, it seems more feasible to import hot-rolled coils for the can stock production and to perform cold rolling operations on

them in the first period. The estimated quantity is about 12.000 tons per annum for the beginning. Problems to be solved are as follows:

- to organize recycling of used cans
- to obtain necessary certificates
- to find a solution of using the same alloy for the body and the top as well as to apply it indigenously.

With relation to Indian semis production and its expected development, it was also mentioned that the "Climate Systems India Ltd." - a joint-venture company with Ford Motors was set up in 1992 to manufacture aluminium radiators for Maruti automobiles - requires solderable aluminium strips and sheets but this quality is not available yet in the domestic market.

Hindalco Industries Ltd.

Renukoot / Calcutta

Counterparts : B.K.Agrawal - Vice President (Fab.Prod.)
P.Singh - Vice President (Sales)
R.N.Gupta - General Manager (Exports)
S.Baberwal - Sales Engineer
and staff members

Products

Rolled products - hot rolled plates and coils, cold rolled coils, strips and sheets, patterned sheets, corrugated sheets (with and without ribs), circles, slug stock

Continuously cast wide strip in coils

Extrusions - solid and hollow profiles

Wire rods - EC, AlMgSi and AlFeSi grades

Aluminium ingot - high grade, master alloy, alle boron free qualities

Experiences of discussions and factory visit can be summarized as follows:

For the melting, holding and melt treating operations the conventional methods are used applying the usual, self and indigenously made degassing/cleaning additives, nucleants and alloying materials. In the foundry, vertical and horizontal DC casting machines can be found, the maximum billet diameter is about 300 mm. Surface quality of billets made by horizontal casting technique is rather unfavorable. No NDT technique is applied to check the soundness of cast slabs and billets. There are four Properzi machines of smaller size to produce wire-rod for conductors and rod stock for subsequent extrusion process on the Conform machine. Concerning wire-rod quality, cable factories complain time to time for the occurrence of high number of breakages during wire drawing process. Extrusion presses are rather outdated, the maximum pressing force to be achieved is around 2000 tons only and that is not enough to produce large size extrusions of hard alloy with complex geometry. Because of tooling problems and occasional billet inhomogenities, the surface quality of extrusions is sometimes not so good as required. The Conform extrusion press is used for producing simple profiles with no specific requirement.

The working hot and cold rolling mills together with their auxiliary equipment require modernization in order to meet requirements of up-to-date production in respect of both the process control and uniform product quality. Now, a new Davy 4-nigh cold rolling mill with advanced control is being set up for the production of strips of extraordinary quality, for example to produce can stock material. With relation to the improvement of heat treating processes, there is now a project to invest on a new solution treatment furnace. An up-to-date continuous strip casting machine made by Fechiney is also available for the manufacture of wide strips in coiled form. These coils are subjected to subsequent cold rolling operations on the new Davy mill. A part of the cold rolled sheets are used for producing circles and corrugated

panels. Testing laboratories and quality controls are equipped with facilities that are necessary for checking actual manufacturing processes, therefore possibilities of own R&D activities are rather limited. Procurement of the plant certification to the relevant ISO 9000 standard is in progress. In the future, in accordance with their intention, they want to deal with the development of manufacturing processes and technologies that are closely connected with market-induced requirements. Accordingly, their development work is to concentrate on the extension of alloy range, namely the manufacture of semis from extra hard alloys of 2xxx and 7xxx series, free machining alloy and AlMg alloy with magnesium content over 5 per cent. The modernization of old cold rolling mill will be implemented by the Davy Inc. At present, some areas of analytical work, quality checking and R&D activities seem to be promising where they are ready to co-operate with the JNARDDC.

The organization of "market development cell" is in progress, its activity starts with the short-term plan in April. They have four of zone offices that (will) carry out merchandizing, market research and customer service as it is stated. Although the company has no representative anywhere, their export activity shows an increasing tendency. Their partners are the traders, they obtain the prices off them, because they have access to LME prices only, thus they are in need of a database containing actual prices, demands, partners, etc.

National Aluminium Company Ltd

Bhubaneswar / Angul

Counterparts : S.K.Tamotia - Chairman-cum-Managing Director
R.K.Maheshwari - Dy.General Manager (Operation)
M.M.Seth - Chief Manager (R&D)
S.Acharya - Executive Director (Planning)
G.S.Panda - General Manager (Smelter)
C.B.Agrawal - Chief Manager (Proj. & Tech.)
B.S.Pani - Chief Manager (MR & BD)
and staff members

Products - ingots of different type and size from non-alloyed and alloyed metal, wire-rod of EC and alloy grades

Experiences of discussions and factory visits can be summarized as follows:

At present, NALCO's downstream activity is confined to foundry practice. They produce ingots from pure and alloyed metal including cast alloys and wire-rod with Properzi technology. Melting and melt treating operations are carried out by using conventional methods and facilities. The Properzi machine is equipped with in-line quenching unit, therefore AlMgSi wire-rod in solution heat treated and quenched condition can also be produced. As a part of their development activity, hot-top billet casting and homogenization of cast billets are in the setting-up phase and installation of facilities is in progress. Concerning manufacturing technology of alloyed ingots with high Zn content used for sacrificial anodes in corrosion protection systems, they should like to obtain some additional information on advanced methods and novel compositions.

Quality controls and testing laboratories are equipped with adequate facilities, however, application of new technologies should be accompanied by the application of advanced testing methods based on NDT technique. For this reason, they would like to obtain specifications for different NDT methods and processes to be applied in terms

of their sensitivity, detectability of defects, determinableness of macro- and microstructural features, etc. In the future, on the basis of available molten metal base, they want to extend their activity to die-casting sphere as well in order to produce castings with high quality and complexity especially for automotive industry. For that reason, in order to support their decision making process, they should also like to acquire additional information on possible technologies, required facilities, attainable quality, etc. For the time being, as an integral part of their development program, they have been dealing with the idea of application of welded aluminium vessels for railway transport of alumina. In fact, it is rather difficult task to make large welded structure without distortions and internal stresses, therefore both product and technology designs require much of experience and expertness that are not available at NALCO at the moment, thus they would like JNARDDC to find the right person for them to expertise the problem. In their opinion, it is very important to make an advisory activity commence in the Indian downstream aluminium industry and to develop technology packages for updating facilities and improving production in plants and factories having different technical level.

In respect of merchandizing there is no network of distribution. As regards market research, they depend on specialist agencies. Desk research is prepared by own staff and customers consuming more than 1.000 tons per annum (there are 10-15 of them) are directly by interviews. For out of the rest, that means actually 1200-1500 customers, they carefully create a panel and their questioning is a task of outside help. Studies and reports are usually prepared by themselves. They do not use any product promotion and some parts of media are used for PR activity only.

Orissa Extrusion Ltd.

Balasore (It is an enterprise promoted in the joint sector by INDAL and IPICOL.)

Counterparts: S.M. Sundaram - Managing Director
A.Sen - General Manager

Products: aluminium extrusions of various forms in as-manufactured and anodized states

Experiences of discussions and factory visit can be summarized as follows:

The plant has its own billet casting unit supplied with conventional facilities. Remelting, holding, melt treating and DC casting operations are carried out as usual, by using ordinary cleaning agents, Al-Ti-B grain refiner and alloying additives. After having homogenized, billets are cut to length then heated and extruded using a Japan-made 2.000 ton press with sophisticated process control, linear motor puller, automated run-out and in-line quenching. The maximum diameter of circumscribing circle of ordinary extrusions and flat profiles is 210 and 260 mm, respectively. There are special ageing furnaces to complete heat treatments of cut-to-size profiles. Extruded pieces may be subjected to anodization as well. An up-to-date anodizing line is available by which, at present, plain electrolytic anodization of different kinds can be carried out. However, as the required area with power supply is available, there is opportunity to set up some additional tanks for implementing colour anodization.

The plant has a computer controlled quantometer for precise analysis of alloy composition. Die design, tooling and manufacture can be made in the plant's die shop where state-of-the-art CAD/CAM process is applied to provide exceptional accuracy for die cutting.

The rated capacity is about 10.000 tons per annum. In 1993, the production was around 5.000 tons and for 1994 it is expected to reach 6.000 tons, that is roughly 8 per cent of the consumption of extrusions in India. Ingots for remelting

are supplied by INDAL and NALCO with appropriate quality certificate, no secondary metal is used for the billet casting, however they are remelting their own process scrap after appropriate preparation.

For the time being, output products are basically absorbed by the domestic market especially the building sector, export markets take only a limited quantity of about 400 tons per annum. In addition to their own sales and marketing activities, customers are served through INDAL's own sales and service network. As regards products' quality, except some cases concerning surface features and damages caused by transportation, there are no complains and reclamations from customers.

At present, concerning further development, they have not any particular plan. Documents for the procurement of ISO certification are ready. In the areas of manpower training, quality management and information service, after having become acquainted with available possibilities, they are ready to cooperate with JNARDDC.

Garrison Engineering Ltd.

Calcutta

Counterparts: Executive Manager

Product: aluminium bodies, space frames and superstructures for buses, lorries, trucks, firefighter vehicles

Experiences of discussions and factory visit are as follows:

The small-scale factory employs 25 workers all in all and produces bodies and superstructures for different types of heavy vehicles especially for buses. The steel chassis with engine is supplied to them for installing bodies and all necessary units on it to complete the vehicle. Major part of structures can be made from aluminium, however, there are some transition elements and internal pieces like seat frames or supporting arms, that are manufactured from steel.

Aluminium extrusions are used for skeletons and frames, while covers, decks and platforms are made up from plain and patterned sheets. The required shapes of elements and parts are formed by ordinary plastic deformation processes with simple facilities based on manual work mostly. For mounting and assembly work they apply mechanical joining processes like riveting or bolting. Manual gas and arc welding methods are used only in connection with bonding of steel parts. Welding apparatus for aluminium is not available. There are a lot of steel-aluminium contacts in the structures as result of the application of steel bolts in the joints. In the presence of humidity an electrochemical corrosion process may develop at these contacts causing serious damage and decrease in service lifespan. Therefore, it seems reasonable to modify the construction and to apply unimetal solution with diffusion bonding technique like welding for example. It requires only a not too expensive welding apparatus for aluminium and some skilled employee for this field. The last phase in the manufacture is the surface finish when selected parts of the superstructure are painted by spraying method.

The output is about 12 buses monthly, input aluminium materials are bought from INDAL and BALCO. Their consumption of extrusions and sheet as per month is about 900 and 550 kg, respectively. Quality control is restricted to visual checking, testing instruments or appliances even of the most simple ones are not available.

Utkal Factory

Calcutta

The firm was established by [illegible], My.Director [illegible] as an average [illegible] plant working [illegible].

Co-operants: [illegible] Madras

Products: Aluminium [illegible] product of small size

The small-scale factory produces some type of holloware products such as pots, kettles, pans, etc. in the small size range. In the foundry, there are coke-fired shaft furnaces with crucibles to prepare melt for die-casting rectangular thick plates using permanent molds. A mixture of primary ingot bought from BALCO or HINDALCO and some scrap is applied as input material for remelting. Melt treatment is carried out by putting chlorine-containing tablets and fluxes in to the melt and by skimming the surface prior to casting. Molten metal is poured into molds manually. These cast plates are subjected to hot and cold rolling using two old duo mills and a coke-fired furnace to anneal work-hardened material between passes if required. Having reached the final gauge, sheets are cut into circles. These circles are transported to processing shop where old spinning machines, excenters, riveting presses and other facilities are available to produce holloware products. The whole manufacturing process is manually operated, the technical level of production is very low. Quality control is confined to visual checking.

Narayani Metals

Calcutta

Counterparts: Executive Director

Products: aluminium holloware products such as pressure cookers, pots, kettles, utensils as well as cast granules and pellets (deoxidizers) for steel metallurgy

The medium scale factory can be characterized by a fully integrated structure covering almost all processes and technologies that are required to produce finished product from basic material. Accordingly, the main manufacturing and processing methods applied for holloware production are as follows: cutting of rectangular plates using coke fired

shaft furnace with crucible melting and permanent molds, hot and cold rolling with intermediate annealing if necessary, circle cutting, spinning, deep-drawing, necking, ironing, bending, punching, riveting, machining, pickling and polishing. It is noteworthy, that welding technology is not applied at all. Most of facilities and machines, except some excenters and deep-drawing equipment, are rather outdated. The applied technologies are based mostly on manual work. Notwithstanding the poor technical level, products are of acceptable quality. The basic checking method is the visual observation, although some simple testing procedures are available. They are in need of advisory activity and kindly receive any help for improving surface finish and quality.

Century Aluminium Extrusion

Calcutta

Counterparts: Managing Director

Products: aluminium extrusions, drawn wires, secondary ingots and pellets (deoxidizers) for steel metallurgy

The extrusion plant is some 300 km far from Calcutta so that its visit cannot be arranged for the limited time available, but supposedly it is similar to that of Orissa Extrusion Ltd. in respect of machinery and facilities with the only exception that anodization is not available in this plant.

In addition to that, they have a small-scale factory in the suburb which is engaged in wire drawing, ingot casting and pellet manufacture. As it was seen on the spot, wire drawing is used to produce medium gauge wires from Properzi wire-rod. The factory buys the wire-rod coil and performs wire drawing with some passes down to the final diameter of 4 to 5 mm and these wires are sold out to other firms for further processing. Drawing operation is carried out by a simple machine without any auxiliary equipment. Ingot casting is based on secondary metal input. Simple, rather outdated facilities are used for producing ingots with various shapes

as required by buyers that are involved mostly in die casting business. From a certain part of molten metal they make up pellets and shots by means of using permanent molds for regular shape and rotating table method for irregular form. Quality checking is not applied at all.

Indian Aluminium Company, Ltd

Calcutta

Counterparts: TNM Balagopalan - Chief Technical Officer

INDAL is one of the largest private sector companies in India. An associate of ALCAN of Canada, INDAL is vertically integrated through every stage of the industry including bauxite mining, alumina refining, smelting, manufacturing and processing. Among its products ingots, plates, sheets, coils, foils, extrusions, pastes and powders of different quality can be found. As a private company, the management considers manufacturing technologies and quality assurances as confidential matters, therefore only some discussion could be organized. Its conclusions are as follows:
INDAL is interested in the utilization of information databanks and databases. They consider advisory service as an important means for supporting end-users and processing industries in their activities to explore new application areas and products, however, it is not clear if they could sponsor advisory work at all. At present, INDAL tries to acquire information on aluminium gas-bottles from different sources as they consider this product very promising in respect of future application in India. With relation to some new application areas proposed by us, mobile buildings with modular units are regarded most attractive for them and they should like to get more information about these products.

Orient General Industries Ltd.

Calcutta

Counterparts: G.D.Binani - Vice-President (Executive)

Products: fans and ventilators for homes, offices, etc.

The medium-scale factory is engaged in the production of various fans and ventilators. They conduct basically assembly work using parts, sub-assemblies and units made by subcontractors. They are interested in the substitution of aluminium for cast iron or steel in certain parts for achieving weight or size reduction as well as for improving fans' performance and attractiveness if the substitution proves advantageous from point of view of cost-effectiveness, too.

At the first sight, some cast iron parts can be replaced by aluminium pressure die-castings, but the problem requires more intensive analysis using database that contains all relevant information on die-casting shops available in India.

Pennar Aluminium

Dahali, Dist.Nagpur

Counterparts: V.Misra - President

S.Mohinta - General Manager (Operations)

Experiences of discussions and plant visit are as follows:

The Dahali plant consists of two factories. One of them is a cable factory where stranded conductors of various types are produced from Properzi wire-rod. The basic processing technologies applied are wire drawing, stranding and heat treatment. Technical level of facilities is satisfactory. Most of products are absorbed by the domestic market, however, owing to the good quality and well organized marketing activities, export markets are also open for them and a certain part of output is bought by foreign firms

mostl, for Middle East region. The major problem to be overcome is resulting from the assurance of uniform properties for alloy wires in the case if the basic wire-rod has not been subjected to on-line quenching during its manufacture, therefore the solution heat treatment and quenching operations are to be carried out subsequently using appropriate furnace and cooling facility. However, at this stage of fabrication, wire-rods or wires are in form of tightly wounded coils with quite a large mass and treatments have to be done by them. Apart from energy loss resulting from reheating of coils in order to achieve solid solution condition , instead of utilizing their warm-worked state in the cast-rolling process, the most serious problem is that uniform cooling rate cannot be achieved within coils as a result of non-uniform temperature field caused by the variation of heat transfer condition inside the bulk, therefore properties may vary considerably in terms of location. The factory management would kindly cooperate with JNARDDC in order to determine possibilities for achieving uniform or almost uniform quality for alloy wires.

The other factory will be engaged in the production of sheets and coils. Facilities including two continuous wide-strip casting machines made by Pechiney and an Achenbach cold rolling mill are being set up. The input aluminium ingots will be supplied by NALCO. The up-to-date facilities going together with the state-of-the-art technology make it possible to produce sheets and strips of the highest quality level. Otherwise, in accordance with quality expectations, about 40 per cent of production is booked in advance by foreign firms. After having finished the installation work, they should like JNARDDC to help in setting about activities of their quality testing laboratory.

Seminar on Aluminium in Building and Architecture
March 12, 1994. New Delhi, Lodi Road, Scope Convention Centre

The seminar was organized by the Aluminium Association of India. Number of participants was about 200. In the technical session there were four presentations, two of them had the similar title of "Role of aluminium in Buildings" and dealt with door and window frames mostly. The last presentation introduced the redmud as a filter in resins for utilizing the resulting composition to produce thick tables. Mr C.S.Madan, Managing Director of ECA Product Ltd., Madras, put emphasis on the need of training for fabricators, R&D facilities and laboratories for testing finished products for realizing "certified qualities", and last the necessity of a permanent display and information centre.
Mr R.Shukla, HINDALCO, introduced a system of light structure building, the feasibility of which is yet questionable. The copy of the No.3 presentation is attached.

ALUMINIUM IN BUILDING AND ARCHITECTURE

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Nagpur 440 023

Abstract

Aluminium and aluminium alloys have an attractive combination of properties - low density, medium to high strength (and hence favourable strength to weight ratio), excellent corrosion resistance, good workability, easy fabrication and aesthetic appearance which favours their use in the building - architectural sector. The alloys used contain Mn, Mg and Si as the main alloying constituents. The world wide consumption of aluminium is expected to rise from about 25 million tonnes in 1990 to about 29.8 million tonnes by the turn of the century with the major fields of applications confined to construction, transportation and packaging. The annual consumption in India is about 500,000 tonnes with the electrical sector accounting for a significant amount of the metal consumed (~40%). The estimated consumption in the building industry, about 30,000 tonnes, is considerably lower than that in the developed countries (2-3% of that in USA and 4-5% of that in Japan).

The reasons for the low level of consumption in India are related to inadequate design techniques and methods, habits and training, lack of proper standardization, financial constraints and tradition. There appears to be a good correlation between per capita income and consumption in electrical and building sectors - the lower income countries have predominant application in the electrical sector and the higher ones in the building - architecture sector.

More extensive use of aluminium in the construction industry requires the need for revision of conventional architectural thinking particularly related to tolerances, fabrication of elements (ready made mobile blocks, module system of building, and the decision of the builders to use aluminium taking into account the advantages of substitution and prices and costs during life time compared to other traditional materials. A list of possible uses which needs to be considered seriously for the rolled products includes corrugated sheet roofing, heat insulated panels (ready made in factory and mounted on site from prefabricated elements), curtain walls, renovating old buildings using surface treated materials, rain gutters, chimney inlets, garbage dropper pipe systems, garage and garage doors. Possible applications of extruded products include load-bearing structural elements in place of wood (helping to conserve forests), factory prefabricated doors, windows, railings and interior stairs, small mobile

buildings such as stands and kiosks, mobile platforms (skeleton) for mounting and renovation work and plastic covered green house frames.

While considering the use of aluminium in the building and architecture sector, the Development Committee on Aluminium Utilisation of the Aluminium Development and Promotion Council (meetings held in 1991) recommended the need for early compilation of a brochure on aluminium in building and architecture, review of the existing standards and introduction of new ones where possible, provision of fiscal incentives for the use of aluminium and evolution of standard designs for the use of the metal in furniture. It is necessary to review the progress achieved with regard to these recommendations and put in dedicated efforts to encourage more wide spread use of aluminium and aluminium alloys in building and architecture.

THE USE OF ALUMINIUM IN THE BUILDING INDUSTRY

Introduction

The attractive properties of aluminium and its alloys, e.g. medium-high strength, low density (favorable strength/weigth ratio), excellent corrosion resistance, aesthetic appearance, good workability, easy fabrication, made it advantageous to use them as basic material in the building-architectural sector.

The widespread application of aluminium in the building industry of the world started in the late 40's, although the first roofing is dated back to 1897 and it is still in excellent condition.
At the beginning of this decade, the aluminium consumption of building industry in India as well as in some selected countries shares out of total according to the followings:

Country	Percentage share
India	6
USA	17.1
UK	17.7
Japan	32
Sweden	26.7
Hungary	20
Austria	16.6

The reason of the low level of consumption in India, according to experts engaged in building industry, can be summarized as follows:

I. Products made of rolled semis mostly

1.) Roofing

a/ trapezoid corrugated (waved) sheets made of hard AlMn1 or Al99.5 materials with thickness of 0.6-0.7-0.8 mm. Beside roofing, they can be used for side walls as well, with or without heat insulation;

b/ sandwich panels made from corrugated sheets with polyurethane foam between armaments;

c/ self-supporting arches made from profiled sheets with multilayer structure, prefabricated in sizes of modules up to span width of 40 m. Some version need columns on the sides, some can be used without them, latest ones allow usually resettlement;

These products are usually fabricated in lose co-operation with rolling mills.

2.) Renovation of old buildings and houses

a/ industrial and agricultural halls - designs and implementations apply waved sheets generally that are available on the market. Occasionally, narrow, channel-like roll-formed strips are used, too;

b/ communal buildings, dwellings - design requires more aesthetic solutions, using surface treated, anodized or lacquered finish on the formed sheets.

3.) Rain gutters - made of strips with commercial quality

4.) Chimney inserts, air ducts - made of strips with 0.5 mm thickness, wounded into spiral form.

5.) Garbage dropping system - made from rectangular or circular tubes that are prepared from sheets, installed with fittings.

6.) Garages, doors for garages - made from extrusions and corrugated sheets. Design provides easy resettlement.

7.) Humidity preventing foils - combined with plastics, tar, bitumen, etc.

II. Products made of extrusions mostly

1.) Load-carrying structural elements - to substitute for wood.

2.) Factory prefabricated doors, windows, railings, interior stairs - to provide all advantages of prefabrication.

3.) Mobile buildings - container types, as mentioned above. In addition, some other small buildings and structures with temporary purposes like newspaper stands, booths, etc. are to be investigated.

4.) Skeletons for masonry, mounting and renovating work - ready for resettlement (some types have got wheels even).

5.) Plastic covered greenhouse frames.

6.) Fences - two types seem feasible; wire cloth (mesh) solution and grids in panel form using frame and vertical rods.

7.) Shutters for windows and doors.

8.) Screws, nuts, rivets, nails, locking elements and other fasteners.

The possible role of JNARDDC in the promotion of aluminium application

On the basis of its own information managing work the Institute is engaged in supporting and promoting aluminium usage in the different branches and sectors, especially in building industry. In the framework of advisory activity JNARDDC can analyze and evaluate trends and tendencies in domestic and international spheres in terms of new products, up-to-date technologies, quality requirements, market demands, etc. that are of utmost importance for manufacturing and processing firms in order to support their decision making processes. With respect to aluminium semis and finished products, the Institute will likely be able to conduct consulting and training work as well in the near future . As a part of it, JNARDDC will be ready to present developments, to make up prototype of new products and to perform field trial of new technologies. All in all, the Institute wishes to be an effective information source for firms and companies of aluminium downstream and processing sectors and, in addition, to be a link or channel between sectors or branches in order to catalyze developments, quality improvement and appearance of new products on the basis of mutual interest.

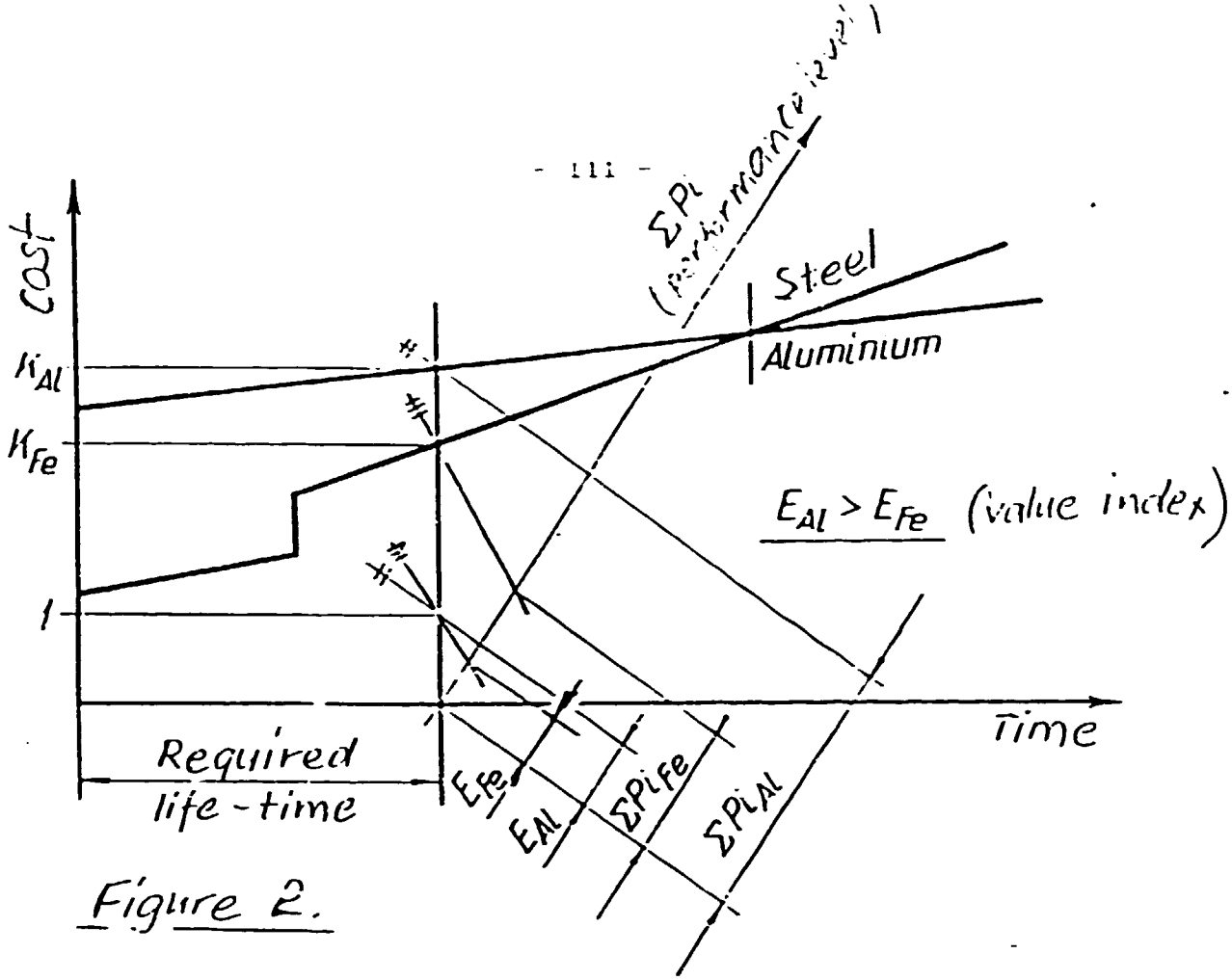

Figure 2.

$$F = K - V = M + A$$

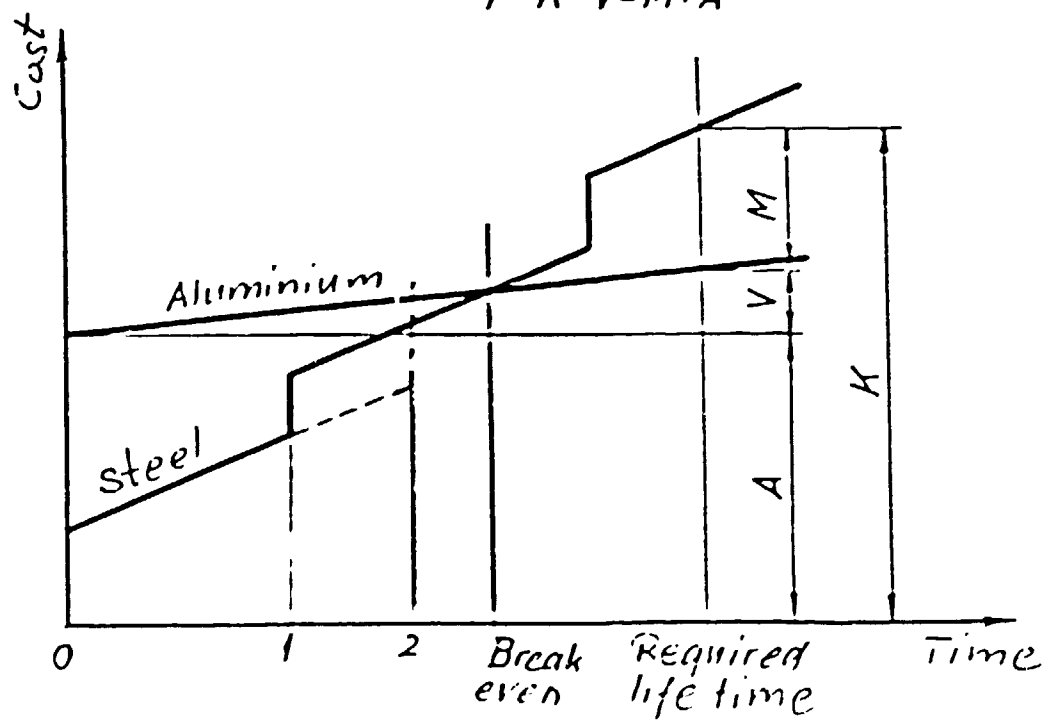

Figure 1.

ANNEX 5

List of instruments and appliances for the quality management services

	Estimated costs
Portable Brinel hardness tester with digital display	5.000 USD
Webster hardness pliers	500 USD
Ultrasonic testing instrument with a variety of probes	20.000 USD
Sigmascope (conductivity meter) with digital display	4.000 USD
Thickness meter for anodic oxide layer	3.000 USD
Thickness meter for non-metallic coatings	3.000 USD
Sealing tester	2.000 USD
Colourmeter	4.000 USD
Glossmeter	3.000 USD
Optical surface roughness tester	5.000 USD
Estimated total cost	49.500 USD

ANNEX 6

Institutions engaged in aluminium R&D

Universities

Bengal Engineering College, Howrath
Indian Institute of Science, Bangalore
Indian Institute of Technology, Bombay
Indian Institute of Technology, Kanpur
Indian Institute of Technology, Kharagpur
Karnataka Regional Engineering College, Suratkal
Maharaja Sayajirao University of Baroda, Baroda
Malaviya Regional Engineering College, Jaipur
P.S.G. College of Technology, Coimbatore
Punjab Engineering College, Chandigarh
Regional Engineering College, Durgapur
Regional Institute of Technology, Jamshedpur
Banaras Hindu University, Varanasi
Bangalore University, Bangalore
Rashtriya Vidyalaya College of Engineering, Bangalore
University of Roorkee, Roorkee
Regional Engineering College, Rourkela
Indian Institute of Technology, Madras
Kakatiya Institute of Technology and Science, Warangal
Regional Engineering College, Warangal

Laboratories and Institutes

Bhabha Atomic Research Centre, Bombay
Central Electrochemical Research Institute, Karaikudi
Defence Metallurgical Research Laboratory, Hyderabad
National Aeronautical Laboratory, Bangalore
National Metallurgical Laboratory, Jamshedpur
Naval Chemical and Metallurgical Laboratory, Bombay
Reactor Research Centre, Kalpakkam
Regional Research Laboratory, Bhopal
Regional Research Laboratory, Trivandrum
Vikram Sarabhai Space Centre, Trivandrum/Thiruvanthapuram
Indira Gandhi Centre for Atomic Research, Kalpakkam
SERC, Madras
IIT, New Delhi/Madras
Aeronautical Development Agency/Establishment, Bangalore
National Physical Laboratory, New Delhi
Defence R&D Organization, Bangalore
Aircraft Design Bureau, Bangalore
Central Glass and Ceramic Research Institute, Ahmedabad
Regional Engineering College, Rourkela
ISRO Satellite Centre, Bangalore
Welding Research Institute, Tiruchirapalli
Indian Association for Cultivation of Science, Calcutta

Companies, industries

BALCO, Ltd., Korba
Bharat Heavy Electrical Ltd., Tiruchirapalli
Ennore Foundries Ltd., Madras
Galada Continuous Castings Ltd., Hyderabad
Hindustan Aeronautics Ltd., Bangalore
HINDALCO, Ltd., Renukoot
Honeycomb India Pvt.Ltd., Bangalore
INDAL, Ltd., Calcutta/Kalamassery
India Pistons Ltd., Madras
Jindal Aluminium Ltd., Bangalore
MALCO, Ltd., Mettur Dam
Patel Aluminium Pvt.Ltd., Bombay
Ordnance Factory, Medak
Grindwell Norton Ltd., Bangalore
Greaves Foseco Ltd., Pune
Metallurgical Engineering Consultants Ltd., Ranchi
NALCO, Ltd., Bhubaneswar
KLAS Engineering Ltd., Bangalore
Research and Development Establishment (Engineers), Pune
ECIE Pvt.Ltd., Bangalore
L&T Ltd., Bombay
IDL Chemicals Ltd., Bangalore/Hyderabad
Travancore Titanium Products Ltd., Trivandrum
Plasmatherm System Pvt.Ltd., Ahmedabad

ANNEX 7

Areas of R&D activities for aluminium downstream sectors in the 1990-91 period

Fundamental research

Structure-property correlation in AlLi alloys

Diffusion of Zn along grain boundaries and boundary migration in polycrystalline Al

Effect of preaging on precipitation in 8090 Al alloy

Lattice imperfections in cold worked FCC AlLi alloy

Alloy development

Rare earth additions in Al alloys for conductors, superplastic sheets, PM parts

Development of Al alloys for armored vehicles

Manufacture of AA 2219 alloy (AlCu6MnZr) including processing technologies (ring rolling, welding)

Development of a high strength AlMgSi alloy for aeronautical applications

Modification of AlSi casting alloys with Sr and P

Influence of Cr, V and B on the microstructure and ductility of Al-Ti

Correlation between mechanical and wear properties of leaded Al plain bearing alloys

Wear characteristic of leaded AlSi alloys

Dry sliding wear behaviour of AlLi alloy sheet (8090-T6)

Melt treatment

Developments in Al melting and processing technologies - degassing, filtering, grain refining, rheocasting, squeeze casting, Be addition

Preparation of binary alloys of Al with Ti and Zr for nucleants

Development of SiC filters for melt treatment

Ceramic foam filters for Al casting

Mg loss during melt treatments in Al alloy 356 and its effect on the mechanical properties

Casting/cast-rolling

Al alloy casting technology - AlLi alloys, composites

Production of Al alloy wire-rods for all Al alloy conductors

Casting and extrusion of high strength alloys for aircrafts

Metalworking

High strength Al alloy extrusions for aerospace applications

High strength Al alloy extrusions for defence

Formability of AlLi alloys - forming limit of AlLiCu sheets

Technology development for aerospace grade Al alloy rivet wires

Optimisation system for cold rolling mills

Development of large diameter Al alloy extruded bars for aircraft application

Effect of Mg on the superplastic deformation of AlSi alloys

Manufacture of AlLiCuMgZr alloys

In-process failures of ring rolled/forged parts made from AlCuMg alloy

Heat treatment/thermo-mechanical treatment

Energy conservation in preheating furnace

Development of superplasticity in AlLi alloys by TM treatments

Effect of annealing temperature on the rolling texture of cold rolled AlCu alloy

Effect of TM treatment on residual stresses in AlCuMg alloy forgings

Effect of Mg and Fe contents, solidification rate and Cd trace additions on the [illegible] of AlSiMg cast alloy

Heat treatment of hypoeutectic Al-Si alloy - effect of [illegible]

Surface finish

Effect of burnishing on surface properties of Al components

Enhanced [illegible] resistance of coated Al alloy (LM9)

Prevention of exfoliation corrosion in AlZnMg alloy

Electrochemical behaviour of an AlLi alloy

R&D efforts towards producing stain-free Al surfaces

Electroless nickel plating on anodised Al

Development of chromate conversion coatings on Al alloys for space application

Development of gold plating on Al alloys for space application

Plasma-sprayed Al deposit on glass-epoxy substrate

Influence of Cl ion concentration on the corrosion behaviour of medium strength Al alloys (8090, 2091, 2014)

Rapid solidification

Rapidly solidified Al alloys (AlZnMgCu+Ni,Zr,Fe) for aircrafts

Elevated temperature ductility of rapidly solidified 7091 PM alloy

Composites/Powder metallurgy

Particle-matrix interactions during synthesizing of AlZnMg-TiO_2 particulate composites

[illegible] reinforced Al matrix composites

Cast Al alloy [illegible] ash composite

Processing of Al composites by [illegible] random rotation technique

[illegible] and properties of Al-SiC particulate composites

Processing of chopped carbon fibre dispersed HMS 2117 Al alloy composites

[illegible] of Al-[illegible]-MgO particulate composites solidified [illegible] pressure

[illegible] properties of Al alloys

Dielectric behaviour of Al-polyester composite

Characterization of a pressure die-cast Al alloy-graphite particle composite

Fabrication and fracture toughness of Rheocast SiC particulate reinforced Al alloy composite

Al_2O_3 slurry layer and AlZn-SiC composite strip on mild steel substrate

Effect of SiC dispersoid on the corrosion behaviour of squeeze cast Al alloy-SiC composites

Material/quality testing

Non-destructive testing of Al in explosives and propellants

R-curve evaluation of AlLi alloy (8090) sheets

Failure analysis of aircraft components

Fracture behaviour of AlLi alloy sheets (8090-T6)

Cracking of Properzi rods

Wear of rapidly solidified AlMn alloys under dry sliding

High strain cyclic fatigue and fracture behaviour of Al alloy (7150)

Low cycle fatigue and fracture behaviour of Al alloy (2090)

Corrosion fatigue studies on AlMgSi alloy (6061)

Stress corrosion fracture of high strength Al alloy (5044) angle bracket

Environmental assisted cracking behaviour of an AlLi alloy (8090)

Joining

Explosive-clad Al-steel transition joints

Resistance spot welding of AlMg alloys

[illegible]

New casting methods (squeeze casting) for automotive part[illegible]

Squeeze casting of long freezing range AlMg all[illegible]

[illegible] investment casting of Al alloys

[illegible] Al alloy casting

Porosity sealing of Al alloy casting by vacuum impregnation
Spray deposition of Al alloys
Cast-forming methods for Al - rheocasting, thixocasting, compocasting and squeeze casting
Centrifugally cast Al tubular products
Dendritic arm spacing and mechanical properties in LM4 and LM25 alloy castings used for automotives

Metal forming/cutting

Processing of Al flats on CNC machines
Broaching of Al and its alloys
Fabrication of Al alloy airframe structures by flowforming process
Al impact extrusion

Applications

Al applications in the nuclear industry
New aluminium products in defence
Al in packaging industry
Al alloy conductors for transmission and distribution lines
Al alloy overhead conductor systems
Spin-offs of defence research in Al to other sectors - bridges, tredways, fuel carriers, structures)
Al collectors for solar thermal energy conversion
Role of Al in bridge design and rehabilitation - portable bridge constructions from Al extrusions
Al in building and architecture
Al alloy pressure vessels
Al clad Al matrix dispersion fuels for nuclear research reactors
Application of Al alloys in corrosive atmospheres for textile [illegible]
Development of some new Al based alloys and alkaline electrolytes for use in Al-air battery
Investigation of boride film lubrication for Al alloys for [illegible]

ANNEX II

QUESTIONNAIRE

to be asked by AAI (from firms of down stream and processing sectors except NALCO, BALCO, HINDALCO and INDAL)

1. Name and address
   Particulars of location
   Parent company (if any)
   Managers - names, titles, phone, fax

2. List of aluminium products with basic specification
   (and parts, items, etc. containing aluminium basically)
   Quantities
   Catalogues, printed materials, descriptions, price list
   (if any)

3. Specification of input materials
   Quality, size range, quantity, etc.
   Source, origin (domestic, imports)

4. Basic manufacturing and/or processing technologies
   applied (or available)

5. List of major machines and facilities
   (with capacity utilization)

6. Quality specifications and quality control used
   Control of input materials and technologies
   Check of end products (output materials)
   Quality assurance system (if any)
   Testing methods and equipment available
   Certification

7. Marketing activity

Merchandizing (based on own staff, agents or representatives)

Market research (domestic, foreign trade)

Media used for propaganda

8. Difficulties (if any) concerning

input materials (quality/properties, size, terms of delivery)

technologies (know-how, equipment, etc.)

quality management

development activities (personnel, partner, technical, financial, training, etc.)

customers' service

PR activity

ANNEX 9

Documentation packages for small-scale industries

As it is proposed, the Technical Advisory Team should prepare some pre-feasibility studies in order to draw the attention of perspective investors or entrepreneurs.
Applied technologies, facilities, required material input, manpower and utilities are the basic elements of these studies in the form of brief description and specifications.
Proposed areas are as follows:

- Household utensils
- Transport milk-cans
- Barrels
- Heat exchangers
- Lamp-poles, arms
- Rain gutters
- Ladders, scaffolds, furniture skeletons
- Facades, portal frames, pavilions
- Containers, tanks, bunkers
- Sandwich panels
- Die cast parts.

As a result of this kind of documentation activity, a pre-feasibility study for a die-casting shop was prepared and handed over to the interested parties. The reason of selecting this item was the interest of UNIDO in this matter.

ANNEX 10

ORGANIZATION OF THE DEPARTMENT OF SEMIS AND FINISHED PRODUCTS

The Department will consist of two teams, namely the Technical Advisory Team and the Quality Management Team, in addition to the Head of Department and administrative personnel.

OUTPUT 1: Technical Advisory Team

1. Set-up:

The team consists of mechanical, architectural, metallurgical and economic consultant posts with output of operation as follows:

i. Advices on the proper selection of materials, technologies and quality assurance systems to be used in the production of finished goods.

ii. Preparation of feasibility studies, proposals for new products and documentation packages for the establishment of small and medium-scale factories in order to promote widespread application of aluminium.

iii. Development of training programmes for qualified staff of small and medium-scale industries in the field of downstream technologies especially processing methods; organization of the programmes by assuring the best lecturers, the most appropriate place and background in order to achieve the best result; edition of booklets and preparation of short video films for educational purposes.

iv. Promotion of cooperation among manufacturers of aluminium semis and processing factories; collecting information on actual and future demands; observing international trends and tendencies concerning semis and finished products.

v. Promotion of designing and constructing processes of prototypes to be made from aluminium by means of assuring the best designer and fabricator for that purpose; testing the prototype and organizing the start-up of production and the sale of the product.

vi. Promotion of standardization of aluminium products.

2. Qualified staff

Four highly qualified staff members, as a minimum, are necessary at the very beginning of the activity.

OUTPUT 2: Quality Management Team

1. Set-up:

The Team consists of a mechanical engineer (or a metallurgist) and a technician, with outputs of operation as follows:

i. Supervision of actual production processes from point of view of quality improvement in small and medium-scale industries; promotion of the application of conventional quality checking methods.

ii. Introduction and adaptation of new testing and checking methods in accordance with technology development; organization of training programmes for qualified staff of downstream industries.

iii. Application of portable NDT instruments for in-process control.

iv. Advices on the selection of instruments and appliances; elaboration of quality management programme and quality assurance system for small and medium-scale factories.

v. Promotion of procurement of certification to the relevant ISO standard.

2. Qualified staff

One highly qualified staff member experienced in material testing and quality assurance as well as one technician skilled in instrumentation and measuring technique, as a minimum, are necessary at the very beginning of the activity.

INPUTS

1. Buildings, infrastructure, supplies

The headquarter of the Department is to be put into the existing buildings of the JNARDDC where excellent facilities and infrastructure can be found.

2. Instruments

The list of instruments and appliances is in Annex 5. The estimated total cost is 49.500 USD at the very beginning of the activity.

3. Assignment of staff

The minimum staff at the very beginning:

1 as the Head of Department
3 highly qualified experts
1 qualified technician
2 support personnel.

4. Training of staff

On-job training of indigenous personnel including autodidactical self-training.

TIME TABLE

Step	Description of activities	Duration	
		Starting month	Finishing months
1.	Decision (Approval)	0	-
2.	Appointment of Head of Dept.	0	1
3.	Employment of staff members	1	4
4.	Fielding of staff	2	5
5.	Establishment of rules and procedures	3	6
6.	Procurement of instruments	3	6
7.	Training of staff	2	continuous

1.) Inadequate technique in design

This fact is strongly connected with the traditions sticking to the applied materials and methods. But, first of all, the buying power of people is the basic point. The sectorial breakdown of consumption shows some correlation to the per capita GDP of countries. In the last 10 years, as a function of per capita GDP, the consumption shares of building and electrical industries shows the following rough picture

GDP/PAX, USD	100-400	500-1200	1300-4000	Over
Electrical (%)	40-60	20-30	10-20	< 15
Building (%)	5- 6	5-10	10-15	< 25

2.) Lack of proper standardization

There are some Indian Standards on roofing (IS:1254-1975), aluminium doors and windows (IS:1948-1961, IS:1949-1961), hinges, handles, door stoppers, latches. These are fairly old ones.

3.) Financial factors

The firms, engaged in the production of finished goods everywhere in the world, are complaining on high prices of input materials while, on the contrary, producers of basic materials and semis are doing the same about low prices. In what they both agree is to comp'ain on excise and other duties.

4.) Lack of adequate facilities

As regards extrusion presses, there are only small to medium size machines in the everyday routine that can produce small to medium size profiles as well from low to medium strength alloys. Therefore, in general, large extrusions and high strength profiles for load carrying structures and frames have to be imported. In the case

of rolled products, an essential limiting factor is that the existing facilities cannot produce cold rolled sheets and strips with width greater than 1.000 mm, and thickness less than 0.15 mm. Further constrains are resulting from the lack poor process control and lack of proper auxiliary equipment at both technologies.

Feasibilities of enhanced use of aluminium

The well-known advantageous properties of aluminium, as lightness and strength, should get special emphasis in the light of comparison to steel as one the most competitive metallic materials. According to this, it is remarkable that specific weight of aluminium is one-third of that of steel. At the same time, strength of particular Al alloys reaches practically the level of structural mild steels. The variety of shapes and forms is larger, the workability is easier than that of steels. Contrary to ordinary steel, aluminium is corrosion resistant, weather proof and possesses good electrical and heat conductivity as well as light reflection. Further on, aluminium structures require little maintenance during their life-time and are fire-proof.
However, aluminium has got some disadvantageous features compared to steel, like lower modulus of elasticity, higher sensibility for fatigue, creep and stress relaxation as well as its welding needs special equipment.

[illegible] of aluminium application in the building industry must concentrate on

[illegible]

The application of aluminium requires some revision of conventional architectural thinking. In the traditional architecture, the tolerances are to be measured in inches and left to the judgment of bricklayers, carpenters and to the masters, in general. Working with metal, accuracy has got extraordinary emphasis, dimensions and tolerances are to be measured in millimeters or 1/32 inches.
In the conventional building process, design of a building (if required any) consists of a layout and some drawings concerning facade and critical sections, if necessary. For permission processes, the authorities usually do not need more details. In fact, these are far not enough for constructing a building made of aluminium, or either designing aluminium building elements.

Working with aluminium, the architects should get accustomed to more sophisticated building techniques, like
- prefabrication and
- light construction.

General advantages of prefabrications are as follows:
- prefabrication can be located in areas where industrialization has reached a certain stage and the infrastructure exists;
- large series can be produced from items in organized form, with highly skilled manpower, using only one or some operation(s). The results will show up in lower prices, as connected to the higher productivity;
- the built-in volumes of materials may be reduced (comparisons show more than 10 % save against on-site production);
- assembly and installation work on the spot require fewer skilled labor (thus it is cheaper);
- the completion period of a project may be short cut.

As regards "light construction" in this context, we understand the solution, where the whole building is made of prefabricated elements using entirely or partly aluminium units and items. As usual, the base is made of concrete, the load-carrying structure and the skeleton or frame are made of steel, while coverings (roofings), side walls with doors and windows are made of aluminium. There are two possible forms of prefabricated light constructions

- the so-called container houses for dwelling, office, sanitary, etc. purposes, that are prefabricated completely with installed piping, wiring and so on, and delivered in ready-made status to the site of setting up. Moreover, they can be used in single or multiple (joint) form ;
- the module building system, where building process is reduced to on-site mounting of prefabricated framing, roofing, side panels, partitions with doors and windows (the sizes are in fixed modules). In this context prefabrication means manufacturing.

Factors determining user's decision

In the course of manufacture, producer has to choose among structural materials that can be applied for the same purpose. Choice is influenced by both technical and economic considerations. Application of aluminium requires the following aspects to be considered:

- advantageous properties of aluminium in respect of the final utilization
- user's habits, application techniques
- price of aluminium compared to that of other structural materials
- additional economic advantages in application arising from the properties of aluminium
- availability of different materials.

The price of aluminium affects user's decision in connection with the price sequence of structural materials which can replace each other. Comparison of prices as per weight and volume does not supply adequate information. The figures do not indicate all the economic advantages of aluminium such as e.g. painting is not required as in case of steel, higher life-span compared to that of wood and plastic.
Taking the present commodity prices into account, an aluminium structure will probably cost more compared to steel structure in many cases. In some cases, however, the price difference between the load-carrying aluminium structure and the steel structure should be compensated by the more advantageous properties of aluminium compared to steel. In some other cases, simple and cheap workability, low maintenance requirement, elimination of surface treatment, high life-time, high scrap price, low transport costs owing to reduced weight, etc. can compensate the price differences. To forecast user's decision it is imperative to take additional secondary economic advantages into account.

Considering the primary costs only, aluminium structures are in most cases more expensive than steel or wood structures used for the same purpose but they are cheaper than structures of plastic and non-ferrous metals excluding aluminium. Where these metals can be replaced by aluminium, there the application of aluminium would increase considerably. Otherwise, the possibilities for replacement are now nearly fully exhausted worldwide.
Comparison between the purchase prices of products made of different materials for the same purpose does not make basis for decisions concerning purchase and application. Beside the prices most of users consider the advantageous properties of aluminium especially if pieces of proper convincing information are available.

Calculating method for user's decisions endeavors to take all the effects into account. The essence of the calculation is that all the additive and subtractive costs calculated for a desired life-time, such as purchase price + erection costs + transport costs + maintenance and other costs like additive ones, and returns arising from scrap sale like decreasing factor, of the product made of material to be replaced, should be reduced by the time-varying costs summarized for the same period of the product made of aluminium. The difference gained has to cover the buying and installation costs of the product made of aluminium.

If this coverage is higher than the fix, or non-recurring cost (purchase price or production cost + erection cost + transport cost - returns deriving from scrap sale) of product made of aluminium, the resulting cost difference constitutes savings i.e. profit owing to the use of aluminium. (Costs used to be discounted in the beginning of the period.)

It is not worthy to enforce aluminium application in those fields where the end user does not benefit economically from its application. If we know the user's requirement concerning the base material of the product, we can affect his purchase even in case if the purchase price of the relevant product is temporarily higher than that of the other product. If he has money for it, if he can afford it, etc. These influencing factors, however, cannot be followed by calculating methods.

The calculation above seems to be complicated only at the first sight. What it covers is shown in Figure 1, as an example of flat iron and galvanized steel roofing.
At the time of installation, refer to it as point 0 in the life time, the aluminium version costs more than the steel one. However, aluminium does not need any maintenance,

but the owner has to pay, let us say the interest after the loan on what base the investment was arranged. Interest is paid for the investment costs of steel roofing, too, but it is less than in the case of aluminium version. When corrosion appears on steel roofing, it is advised to do something against this process, e.g. to paint it (shown by point No.1 in the life-span line). However, painting costs money. When painting is neglected, steel roofing dilapidates and needs to be replaced (point No.2), what costs more money than painting does at the proper time. Anyhow, the cumulated costs for steel roofing rise higher than those for aluminium. In addition, steel as structural material is competitive, but there are other solutions made of ethernit, cementasbestos, polyesther, too, for industrial and agricultural buildings. In fact, they all should be taken into account and shown by the finure so as to determine the most feasible solution among them for a required life-span. As a matter of fact, the method is simple and it takes only time to apply. It costs almost nothing, much less than to make a wrong decision. Prior to spending any money on investment or starting any action , e.g. propaganda, it is advised to use this method in case of every proposed new application.

In addition to technical and economic considerations, the propaganda plays important role by influencing the behaviour of users. In people different kinds of subjective feelings may arise in respect with the application of materials and solutions. As a matter of fact, these feelings, behaviours, likes and dislikes can hardly be taken into account. Another evaluating method which can also be adapted for this purpose is the well-known value analysis. The advantage of aluminium may prove even in such case if the cumulated costs of its application are higher than that of steel as shown by figure 7.

Its application requires the knowledge of preference factors that can be worked out by the usual way together with the determination of levels of fulfillment for preferences of competing solutions. These levels are to be figured, as usual, too. When the value indices are counted, the results of previous calculations could be used.

It is not difficult to prepare the recommended and outlined calculation and value analysis before any effort is made and money spent on the development and introduction of any new or modified aluminium product. The question is, therefore, who will do that ?

For the management of a firm that intends to enlarge the activity, the preparation of a feasibility study belongs to the daily routine starting with market research and follow by the usual steps. Nevertheless, it is necessary to minimize risks and, in general, to avoid voluntaries and "wise" advices to be followed. This task cannot be undertaken by anyone, as a gratis. The question is, whether medium size enterprises are prepared to do that ?

In the followings some "wise" advices as mentioned above will be given, like a flash without details but worthwhile for further investigations.

List of perspective applications of aluminium in the building industry of India

The present status of aluminium consumption was outlined in the introduction. The comparative low level indicates the difficulties but, at the same time, surmises great opportunities.