OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

M Publ

Restricted 21341

November 95-December 95

Original-English

Recommendations on future programme
for the
Aluminium Electrolysis Department
of
JNARDDC, Nagpur

Technical Report

on expert mission carried out from

19th November to 15th December 1995

DP/IND/88/015/11-68

Prepared by : J.D. Hamilton

Backstopping officer : Dr. T. Gróf DIO/T/MET/

United Nations Industrial Development Organization

EXECUTIVE SUMMARY

This report on the "Directions for Future Activities of the Jawaharlal Nehru Aluminium Research Development and Design Centre, Nagpur Electrolysis Department" follows an expert mission DP/IND/88/015/11-68 carried out between 19 November and 15 December 1995.

According to Job Description for the mission the following activities were undertaken:

1. Discussion were held with JNARDDC staff and UNIDO experts as to the present capabilities of the Centre
2. Visits were made to three primary Aluminium smelter, BALCO, NALCO and INDAL to identify and discuss areas of co-operation between the companies and JNARDDC
3. Recommendation of programmes and tasks for the Centre in the light of discussions with smelter managers and technologists is made in this report.
4. In addition assistance in the preparation of training material was given.

The smelters have very different technologies and a number of operating problems. Their need presently and probably for the next year or two is for Technical Services and not Research and Development. A number of areas of co-operation were agreed. The staff of the electrolysis department are skilled in using sophisticated mobile equipment to measure the electrical, magnetic and thermal parameters of the reduction pots.

The Centre has excellent operating analytical facilities which are available to the aluminium industry. The electrolysis section has two well equipped laboratories for work on the reduction process and on the production of carbon. These are not yet functioning routinely. Their services are needed, they should be brought into reliable operation as soon as possible.

The opportunities available in the plants visited indicate that help in analyzing and improving the performance of existing equipment is required and in the modernizing the older facilities by introducing new technologies.

In the light of the needs of the aluminium plants the Electrolysis Department needs to get all its laboratories functioning routinely and staff to carry out the programmes required by the plants.

In the long term skills in mathematical modeling need to be developed if a capability in the design of reduction cells is required.

As the industry in India is widely dispersed seminars and workshops for exchange of information and dissimilation of knowledge are needed and should continue to be organized at the Centre or at smelter locations.

CONTENTS

INTRODUCTION

The JAWAHRALAL NEHRU ALUMINIUM RESEARCH DEVELOPMENT AND DESIGN CENTRE is in the process of being established by the Government of India with assistance from the UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION beginning 1989. The project would be completed by the end of December 1995. The Centre is located on the outskirts of the city of Nagpur in central India.

The Centre presently has a staff of fifty five people, thirty five of whom are science and engineering graduates. From time to time the staff are supported by aluminium industry experts provided by UNDP/UNIDO.

There are four major divisions of the Centre. These are Alumina research, Aluminium Electrolysis, General Services and Analytical research departments. It is the purpose of this report following a visit to the Centre and three Indian smelters to review the capability of the Aluminium Electrolysis Research Department which has been developed to provide professional technical assistance to the smelter. In addition in co-operation with scientists of the Centre and Dr. Horvath (a UNDP/UNIDO expert) areas and projects for future, medium and long term co-operation with the smelters have been identified.
The job description provided for the mission is included as Annexure-1.

Organization of the Aluminium Electrolysis Department

The Department comprises three sections:

1. The Electrolysis Section

The section staff are M/s U.B. Agrawal, S. Dasgupta and K.G. Deshpande. All are graduate engineers seconded to JNARDDC from BALCO.

The laboratory is equipped with instruments, furnaces etc. to carry out work on the physical chemistry of the aluminium reduction pot. A report which demonstrates the capability of the electrolysis laboratory entitled "The rate of reoxidation process determined by gas bubble forces in aluminium electrolysis" has recently been prepared. All the staff have been employed on plant studies using the Mobile Van equipment (see below).

Mr. Deshpande has recently prepared a report on the disposal of spent pot lining and the recovery of useful materials from them.

Mr. Agrawal has received training in UK in the economic evaluation of R & D projects and modernization feasibility studies and has recently published paper on greenfield mining operations.

2. The Carbon Laboratory

The carbon laboratory is staffed by M/s A.K. Basu and P.K. Bid. Both are graduate engineers and Mr. Basu is seconded from BALCO.

The laboratory is fully equipped with sophisticated modern instruments capable of the complete testing of coke and pitch and anode mass. Anode mass can be tested both in green and baked state. Anode mass can be received from the plants or prepared in the laboratory for testing.

3. The Process Monitoring and Modeling group

The laboratory is staffed by M/s G.S. Senger and A. Agnihotri both graduate engineers. Mr. Senger was previously employed at BALCO. They are assisted by two technicians.

The laboratory has the following equipments

1. A sixteen channel automatic data acquisition system for continuously measuring electrical parameters on group of pots
2. Magnetometers to determine the strength and disposition of magnetic fields in and around pots

3. A multichannel heat flow meter to determine heat transfer through various surfaces of the reduction pot
4. A thermovision system capable of producing high quality infra red images of reduction pots and other items of the plant

The equipment is all transportable in the Mobile Van and has been used at three smelters with considerable success. It is available for use when any change in operating conditions is considered.

This group may be required to develop skills in mathematical modeling at some time in the future.

In addition to the Electrolysis Department there is at the Centre a superbly equipped analytical laboratory. There are facilities to chemically analyze all raw materials, intermediates and products of a smelter. The X-ray diffraction and fluorescence equipment was particularly impressive in that it is capable of rapid and accurate bath analysis. This service is being used by the plants to check their own analytical results and to provide support when they have equipment problems.

Capabilities of the Aluminium Electrolysis Department

The Aluminium Electrolysis Department is still settling down and there is not yet a great deal of routine work in progress. The well equipped facilities are not yet in full operation. Some staff have yet to familiarize themselves with practical procedures.

The area where the greatest capability has been developed and demonstrated is in the use of Mobile Van to measure the electrical, magnetic and thermal parameters of the reduction pots at BALCO, INDAL and NALCO. This work has involved all the staff of the department in an attempt to provide training and experience in this type of activity. The work has been managed by Dr. Horvath, a UNDP/UNIDO international expert. He has analyzed the data and issued reports. The capabilities of this equipment could be usefully applied to support test pot operation at BALCO or NALCO.

A concern in the electrolysis and carbon laboratories arises from the fact that although they are well equipped there is very little through put of samples. Thus staff are not getting practical experience of operating a wide range of sophisticated instruments. This is unfortunate since at BALCO and to a certain extent at NALCO there is real need to examine all the aspects of carbon electrode production and performance. With such a need for assistance at the plants and such a useful and costly facility at the Centre it is essential that these laboratories begin to operate efficiently and routinely. It may be that more staff are required at the technician level to carry out practical work in these laboratories. They need to demonstrate their abilities to the operators of smelter so that their services are in demand.

The skills of the Centre do not yet permit the modeling of reduction pots to the extent that models can be used to confidently make changes to a pot nor does the capability to support the design of a new cell exist. This capability will be required in future but will take time to develop.

The Aluminium Electrolysis Department held a successful electo - chemical workshop at the NALCO smelter at Angul in 1992 and in 1993 a training programme was held at

BALCO for operating management prior to a plant revitalization programme. A technical seminar has been requested by the INDAL plant and is presently under consideration.

It is felt that the activities of the Aluminium Electrolysis Department are at this time, to some extent, dependent upon the ability and enthusiasm of Dr. Horvath. His involvement with JNARDDC is soon to cease. An acceptable replacement should be considered to maintain the momentum of the department.

STATUS AND REQUIREMENTS OF THE PLANTS FOR TECHNOLOGICAL ASSISTANCE

1. Bharat Aluminium Company Limited (BALCO)

BALCO is a Government of India enterprise which comprises an alumina plant and aluminium smelter located at Korba in the state of Madhya Pradesh. The smelter uses Russian (VAMI) technology. There are eight pot rooms each of 51 pots. The pots are of the vertical stud Soderberg type.

The present operating parameters of the plant are as follows:

Current-	99.270 kA
Cell Voltage-	4.79 V
Current Efficiency-	81.69 %
kWh per ton of aluminium-	17.39
Cell life-	1448 days

In earlier times large parts of the plant have operated much more efficiently achieving current efficiencies of 87%. It is the desire of the operating management to improve all aspects of operating efficiency by returning the physical plant to its original condition. by solving certain process problems and by investment in modernization. In recent years the plant has been supported by international experts and scientists of JNARDDC who have carried out extensive measuring programmes on the BALCO pots and provided plans of action to modernize and improve the performance of the plant. This work has contributed to the recent modest but steady improvement to the BALCO pot lines and increased the technical knowledge and awareness of BALCO management.

Physical status of the plant

Carbon plant

The carbon plant is clean and well managed and was producing adequate quantities of paste during the visit. There is however a possible quality problem associated with the use of a high viscosity pitch (see below).

Pot rooms

A modern system of automatic control of the pots (CELTROL) has recently been installed and is operating at present to control the voltage of pots and to provide information to management and operators as the condition of each pot. To take full advantage of this expensive equipment it is intended to add automatic crust breakers to each pot to enable this system to control the feed to the pots and to extinguish anode effects. Managers and operators are enthusiastic about this system and over the past year the operation has improved considerably. However the technology provider's performance guarantees have not yet been fully achieved.

A number of factors are affecting the performance of the BALCO pots adversely. These include:

1 Lack of reliable crust breaking equipment.

This means results in pots being fed infrequently and with larger amounts of alumina than specified. Since the solubility of this alumina is already low a sludge forms in the bottom of the pot which affects the performance and adds significantly to the work load of the operators.

2. Defective studs.

The condition of the 20,000 studs in the plant has been allowed to deteriorate seriously over a number of years. In consequence the distribution of current within the anode is very uneven leading to poor operation. A major programme to repair studs is under way. Stud welds are being remade and short studs are being extended. The result is not perfect but it is much improved. The studs are not tested prior to installation in the pot.

3. Variable clamp condition

It appears that many anode stud clamps are defective after years of use and occasional abuse. These add to the problems of anode voltage drop and poor anode current distribution.

4. Cathode flexible

Since installation all cathode flexibles have been cut and an extra weld inserted. This has introduced an extra voltage drop of over 20 mV to each pot. The drop between flexibles is variable adding to problems of uneven current distribution in the cathode.

5. Lack of gas hoods

Many gas hoods are missing or damaged. This leads to serious air burning of the anode and the discharge of noxious fumes to the pot room atmosphere. Fume burners do not operate consistently.

6. Condition of Anode Bus bar

This bus bar needs to be cleaned at points where the stud is clamped to minimize the contact resistance between stud and bus bar.

7. Alumina Quantity and Quality

Supplies of alumina have been intermittent in the past although the situation has now improved. The alumina is excessively fine at times 50% less than 45 microns size. This leads to pot sludging.

8. High Viscosity Anode Pitch

Recent supplies of anode pitch have been very viscous and may be affecting the flow of paste in the anode. In addition the anode is soft and generating large amounts of carbon dust into the electrolyte. This increases bath resistance, reduces anode cathode distance and leads to much extra effort in skimming the pot.

9. Erratic metal tapping

Normally two pots are tapped together and in the absence of a weighing system the metal tapping is erratic and as a result of this there is variation in the metal pad.

Actions Recommended to Improve the Performance of the Plant

Carbon Plant

From an operating point of view the carbon plant was operating well. It was clean and producing and shipping adequate supplies of anode paste to the pot rooms. In the pot however the paste was not performing well. Dust was being generated and it was necessary from time to time to scrape the bottom surface of the anode and skim the pot. Frequently paste drained from stud holes into the pot. The plant was using a new source of pitch which was unusually viscous.

The equipment of JNARDDC should be used to address this problem. Tests should be undertaken to find the most compatible combinations of coke and pitch for use at BALCO. There should be discussions with coke and pitch suppliers when BALCO's quality requirement could be explained.

The quality control of the paste plant should be improved with frequent quality checks during operation. JNARDDC should carry out all the tests necessary to determine the quality of anode paste and may then recommend a minimum of test procedures to be established at the plant to maintain paste quality and anode performance. In this way any doubts about the quality of paste would be eliminated

Pot Rooms

JNARDDC should conduct a full technical and economical analysis of the problems now facing the pot rooms. It should determine how much the rectification of each problem will cost, how long rectification will take, the financial reward for solving a problem and the consequences of not solving a problem. Priorities can then be realistically assigned to the problems and request for the funds justified in terms of the financial returns on the investment. The problem will include:

Stud Repair

Studs are being repaired at the rate of about twenty studs per day. The repaired stud is not as good as new stud and is not being tested before delivery to the pot rooms. Stud repair should be stepped up and testing should be established. Even at 100 studs per day it will take over six months to complete the programme.

Clamp repair and Anode Bus bar cleaning

All clamps should be inspected and where necessary repaired or replaced. A programme to carefully clean the anode bus bar should be put in place. Prior to starting a pot the pot room management should check that all the clamps are working and that the bus bar is clean and flat at all contact points. A full check of the condition of an anode and associated equipments should be made prior to its acceptance by the pot rooms.

Cathode flexible and Anode Riser Bus bar

The extra weld placed in the cathode flexible should be eliminated when a pot is being relined and work undertaken to eliminate the extra joint in the anode riser bus bar.

Gas hoods

All missing gas hoods should be replaced as soon as possible and all pot burners cleaned and recommissioned.

Crane weighing system

A metal weighing system should be put in to the cranes so that the metal can be tapped accurately.

Alumina Quality and Quantity

Work should continue to ensure a supply of good quality alumina to the pot rooms and two new crust breakers should be procured to ensure pots are fed regularly at the correct intervals, since the decision to install crust breakers on each pot is not likely to be taken soon.

The above work is required to bring the plant back to good operating condition. It will take many months of continuous efforts by the pot room management and maintenance management to complete the above job.

Establishment of a Test Section

It is strongly recommended that six adjacent pots are identified and as far as possible all the necessary measures taken to restore them to good operating condition. This group of pots could be operating in a matter of weeks with good studs and clamps, a full compliment of gas hoods, regular crust breaking, close tapping and metal level control. Frequent quality control checks of bath chemistry, temperature, voltage drops, liquid levels etc. could be undertaken. The pots would be used to demonstrate at an early stage the value of the proposed remedial work. The pots as far as possible should not be under the control of pot room management. The pots would provide an example of how the whole plant could perform if maintained and operated properly.

The pots could be used to test changes to operating practices. The operation of these pots should have a very high profile throughout the plant as they represent BALCO's future. Thus it is vital to ensure that this test pot demonstration succeeds and therefore it is recommended that four outside VSS experts familiar with this technology are employed to manage this test group. One expert should be in attendance at all times.

When the pots have achieved excellent stable performance the experts should assist the local management in achieving similar results throughout the whole plant as the refurbishing programmes are gradually completed.

When these test pots have been operating properly for some months it is strongly recommended that they are fitted with crust breakers and the CELTROL system used to feed them and extinguish anode effects. To do this it will be necessary to acquire proven cell operating strategy from a company operating a similar pot with automatic side breaking system, so that KAISER can programme the installed CELTROL automation to control the pot. A possible supplier of this information would be HUNGALU who operate similar computer controlled side break VSS pots at INOTA.

The operation of these pots will provide reliable information as to the value of further modernization of the BALCO pot. This will be required to justify further expenditure. It will allow any problems with the new technology to be eliminated prior to the full conversion of the whole plant and allow the operating strategy to be refined to give best performance under BALCO conditions.

This is a substantial programme. The plant has to be brought back to its original maintained condition following some years of deterioration. It then has to be provided with good carbon and alumina and brought to operating excellence. It then has to be modernized if this is proved to be a good effective measure.

2. Indian Aluminium Company Limited (INDAL)

The INDAL plant at Hirakud in the state of Orissa is a privately owned enterprise which comprises a small HS Soderberg pot line, a paste plant and a rolling slabs casting shop.

The smelter which was built in 1958 uses 55 kA ALCAN technology. There is at present one pot line of 160 cells. A second line consisting of relocated pots from the Belgam plant will come in operation in March 1996. The smelter has a captive power plant. The rather ancient equipment is operated superbly at

Current efficiency-	88.5 %
Net carbon-	503 kg/t
kWh/Kg-	15.03

The cells are well hooded and pot fume is scrubbed by wet caustic scrubbers. A number of managers were in discussion with us and all were very well informed on the performance and operating technology of the pot. There is great safety awareness in the plant. Helmets, safety goggles and safety boots were the norm in work areas. There was an awareness of the environmental consequences of poor control of the operation. This plant is not in need of help to maintain its present excellent performance but might use some JNARDDC support to move yet further forward. This is a world class operation.

Discussions with the Technical Manager at the plant revealed the following potential areas for co-operation with JNARDDC.

1. The plant presently has a locally developed system of automatic voltage control of pots. Serious consideration is being given to the possibilities of installing point feeders and a new pot control system. If this is done support of JNARDDC using the Mobile Van to determine and analyze the magnetic, thermal and electrical status of the pot would be useful.

2. Although the anode at INDAL is performing well it could be to the mutual benefit of JNARDDC and INDAL for JNARDDC to carry out a full audit of carbon production. JNARDDC would gain valuable experience of auditing a process that is performing well.
3. The facilities of the Carbon laboratory could be used to optimize cathode life with particular reference to sodium penetration.
4. The mathematical modeling of the cathode to define the shape of the ledge and to determine theoretical voltage drops within the pot.
5. The use of analytical facilities within JNARDDC to carry out check analysis or unusual non-routine analysis.
6. Energy audit studies at the Hirakud works. JNARDDC would submit proposals to INDAL in this regard.
7. The organization of a technical seminar at Hirakud works.

JNARDDC will make INDAL aware of all services available from the Nagpur Centre. At present there are no urgent requirements for assistance from this plant. However co-operation between the plant and the Centre could be to the advantage of both organizations.

3. National Aluminium Company Limited (NALCO)

NALCO is a Government of India enterprise which comprises a captive power plant and large modern smelter at Angul in the state of Orissa. The smelter uses the Pechiney AP 18 pot. This is a large modern pre-bake pot fully automated with point feeders. The potential production of the plant is 230.000 tones per year.

The present operating parameters of the plant are:

Current-	180 kA
Cell Voltage-	4.30 V
Current efficiency-	89 %
kWh/t-	14.3
Net Carbon-	450 kg/t
AE/day-	0.6

This is relatively poor performance since the average performance of this pot in the other plants around the world (an average of 2600 pots)

Current-	180 kA
Cell Voltage-	4.26 V
Current efficiency-	94 %
kWh/t-	13.35
Net carbon-	416
AE/day-	0.17

The plant was commissioned in 1987 and has in the past operated rather better than it is now.

This is a facility with excellent equipment which is not achieving its potential at this time. The management are keenly aware of this.

Carbon plant

The carbon plant and rodding room housekeeping was not good. The bake furnace was better and is presently being extended by 10 sections to ensure full availability of anodes to the pot rooms. All equipment was working well in the rodding room but the pour of cast iron into the anode studs hole was excessive. Many returning butts were severely air burned. Butt size was very variable. There are piles of carbon scrap lying around the plant which must be consumed as soon as possible.

Pot room

The pots are not performing well with relatively low current efficiency and a high frequency of anode effects. Many pots contain carbon dust which is difficult to remove from a point fed pre-bake pot. Pot life was said to be in excess of 2000 days. The positioning of the pot hoods was not good. Recently started pots were completely unhooded.

Actions Recommended to improve Performance

Work needs to be done to clearly identify the factors which are stopping this plant from achieving its potential. Two major investigative programmes are proposed:

Evaluation of Carbon quality

JNARDDC are well equipped to carry out a full survey of the carbon manufacturing process at this plant. All raw materials, process intermediates and products should be thoroughly tested to ensure conformance with the Pechiney specifications. Quality control procedures should be assessed to ensure process and product quality are under control at all times.

There is a severe air burn problem in the plant which may arise from a number of factors. The first is lack of ore cover in the pot rooms and there could be oxidation catalysts such as vanadium, nickel and sodium in the anode. The physical properties of the anode such as porosity also influence oxidation rates. A complete determination of all anode physical properties and anode impurities is highly desirable at this time.

Determination of Temperature Profile of Baking Furnace Pit

The final baking temperature of a pre-bake anode is of critical importance in determining its behaviour in the pot. Occasionally the temperatures reached in a pit are not uniform and parts of the pit may not reach to the final desired bake temperature. To ensure there are not problems with the NALCO pit a number of thermocouples should be installed in a pit and results recorded over the life of a fire to ensure all parts of a pit reach the required temperature. JNARDDC are fully equipped to undertake this survey.

Establishment of a test section

This was proposed to senior management at Angul. It is recommended that five adjacent pots are operated on a test section. The recommended operating procedure provided by Aluminium Pechiney should be closely followed as they are well proven in other identical locations. The pots should quickly demonstrate operating excellence and indicate what plant wide changes are necessary to return the whole plant to high productivity and to stable operations.

CONCLUSIONS

The assistance and support that the smelters need and could benefit from differs from plant to plant. This is to be expected since the technological differences between the plants are wide. BALCO uses a Russian design 100 kA Vertical Stud Soderberg pots commissioned between 1975 and 1984. INDAL uses a Canadian designed 55 kA Horizontal stud Soderberg pots commissioned in late fifties. NALCO uses modern French design 180 kA pre-bake pots. Only the INDAL smelter is presently achieving the full technological and operating potential of its equipment.

All the plants could benefit from an in-depth study of the carbon manufacturing process. This should include:

1. Raw material Analysis and Characterization
2. Process intermediate Analysis and Characterization
3. Final product Analysis and Characterization
4. Check of process parameters such as
    - Final bake temperatures
    - Aggregate granulometry
    - Pitch levels
    - Mixing times and temperatures
    - Voltage drop within anode assemblies etc.

These studies would require close co-operation between the local management and carbon experts of JNARDDC. The full range of analytical and test equipment of the carbon laboratory would be required. Recommendations to improve the product quality should be tried and then tested. All the smelters agreed that such a programme would be informative and helpful.

If the programme is carried out successfully it will lead to continuous co-operation in the area of carbon manufacture between the plants and the Centre. The major problem however is that the carbon experts are in post, the carbon laboratory is equipped but it is not yet functioning in a reliable and routine way. To be of value all this equipment needs to be commissioned and staff trained in its routine operation. The range of equipment available is excellent and capable of providing valuable information to the smelter but it needs to be brought into regular and routine operation by skilled laboratory technicians as soon as possible.

A similar situation exists in Electrolysis laboratory. Reliable information on the solubility of BALCO alumina in pot electrolyte is needed but the laboratory is not operating the available equipment routinely.

The most useful and successful work done by the department has been the studies at smelters using the Mobile Van and its range of test equipment. The cell conditions at BALCO, NALCO and INDAL have all been studied and report issued. This equipment will be valuable in the future to monitor the progress of BALCO's efforts to improve performance and to monitor the effects of introducing bar breakers and controlled feeding. There will be a similar opportunity to assist in the conversion of INDAL smelter to point feeding.

In addition to the above programmes discussions with the smelter management revealed a number of other areas where JNARDDC support would be welcomed.

At BALCO a full analysis of the programmes to restore the pot lines to their original condition is required. One of the strengths of the electrolysis department is that it is staffed by people of considerable smelter operating experience. One of them should be seconded to BALCO to analyze the programme from both a technical and financial point of view.

In addition BALCO management have requested helps in solving their problems of sludge formation and high aluminium fluoride usage.

At NALCO temperature profile of the baking furnace pits have been requested. This can readily be undertaken when next the Mobile Van is at this plant or, as the requirement is quite urgent in view of NALCO's anode problems. plant equipment might be used to do the work.

At INDAL requirements are less urgent but an energy audit has been requested plus a reduction process technical seminar.

There are therefore considerable opportunities for the Electrolysis department to support to three smelters visited and other not visited. Some of these opportunities can be taken immediately but there is a major requirement to get the carbon and electrolysis laboratories functioning on a reliable and routine basis.
The electrolysis section has demonstrated its ability to organize workshops and seminars in recent years and should continue to do so.

Skills still need to be developed in modeling if the Centre is to become capable in cell modification and design and the Centre will need to maintain co-operation with both Indian and International modeling experience.

The present needs of the primary Aluminium industry are for Technical services rather than Research and Development as the plant performances are brought to their full potential. This is likely to change as day to day problems get solved and the need for R & D projects will start to be recognized and defined.

ANNEXURE-I

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

JOB DESCRIPTION

DP/IND/88/015/11-68

Post Title: Expert in aluminium production processes

Duration: 1 months

Date required: asap, October 1995

Duty station: Nagpur, 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.

The Centre will develop 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; and (d) providing training of Indian engineer.

Duties:

1. Review the capability of the Centre developed for the evaluation of the present status in and assimilation/adapation of available technologies to the Indian aluminium smelters.

2. In close co-operation with scientists of the Centre and international experts review the aluminium prodcution process in BALCO, NALCO and/or MALCO's aluminium smelters and identify areas/projects for the medium and long-term cooperation between the companies and JNARDDC.

3. Prepare a report with recommendations on main directions and programme for future activities of the Centre in the field of aluminium production.

Qualifications: University degree in chemistry or metallurgy, at least 20 years of experience in aluminium smelter operation and development.

Language: English

Background Information:

The Indian aluminium industry looks back to a history of about five decades. The first aluminium smelter (in Alupuram, Kerlaa) 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 660,000 and 362,000 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). The latter plant was commissioned in 1987.

In the commissioning of NALCO the share of the public sector in aluminium smelting was more than half of the total installed capacity of India. This indicates the decisive influence of the public sector in 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 aluminium producing countries in the world having substantial buaxite resources, after the discovery of large deposits in the Eastern Coast in the early 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 and the one under construction 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 in alumina/aluminium technology which is expected to be covered by the Aluminium Research Development and Design Centre. The technologies followed in the existing plants are from various countries/collaborators - 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 collaborators. The most recent example to be quoted is the case of the aluminium complex of National Aluminium Co. Ltd., their payment for know-how basic engineering, royalties, etc. to M/s Pechiney, amount to about Rs. 700 million in foreign exchange for a plant of 800,000 tonnes alumina and 218,000 tonnes aluminium per annum capacity.

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 (incl. NALCO plant), would be of the order of 440,000 tonnes per annum. Considering the payment for know-how basic engineering, royalties for the 218,000 tpy NALCO aluminium smelter, for this additional follow-up stage this would mean an expenditure of at least another US$ 95 million.

It is to be pointed out that the cost for the establishment of the Aluminium Centre (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 was envisaged by the Government to be secured through a collection of Rs. 100 per ton of aluminium for aluminium research and development, added to the price of aluminium (established now by the State in India).

It is to be noted, that all the leading aluminium producing countries have their own R&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 above, a coordinated effort in R&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-sustained full-fledged and independent research, development and design centre for aluminium at the national level.

- 6 -

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 an 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 assistance and assistance in design for the continuous improvement of 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 similar to those covered under UNDP projects. Another particular problem that the centre is expected to address is emanating from the lack of adequate and un-interrupted 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.

Annexure-II

The Operation of Test Pots in Aluminium Smelters

The operation of a small group of pots to define and resolve problems or to prepare for process changes has been used effectively in a number of plants. The best procedure for setting up and operating test pots is as follows:

1. Select a small group of pots adjacent to each other which are not likely to have cathode failure during the test period
2. Install a small temporary office in the courtyard near to the pots
3. Install and equip a small tool store near the pots and keep it properly stocked
4. Provide desk, chair, stationery, files etc. for good record keeping
5. As the pot rooms are likely to be in difficulties the pot room management should not be deflected from their responsibilities to run the test pots. Appoint a senior operating technologist to run the pots and to report to the plant manager. Keep pot room management informed of the progress at a weekly meeting
6. Put an experienced supervisor and an operator on each shift to attend to the section at all times
7. As far as possible assign all operating decisions to the people running the pots
8. The pot room management must ensure that these pots receive ore and anode when required and are tapped correctly. In times of difficulty in pot room operations e.g. crane break down the test pots receive priority over the rest of the room
9. In most Test Pot situation the object is to show that when operated properly the performance and productivity of the pots improve. On five or six pots it is relatively easy to make process changes and replace or repair damaged or worn out items quickly. The effect of the improvement is soon apparent
10. The effect of the equipment improvement and good work practices can then be demonstrated to the pot room management and work force. The pots can be used as training aid to both maintenance and production people

11. If a change is envisaged such as metal level adjustment or crust breaker installation monitor it on the test pots before introducing to the whole plant

Experience can be gained quickly in a section of test pots since close attention is being focused on a small part of the plant. A most important phase of the programme is the transfer of knowledge and know how gained to the rest of the people operating pots. Other operators can be assigned on a temporary basis to the test pots and test pot supervisors can advise pot room management.

A complaint often made is that with only five pots to run the test pot people have an unfair advantage over the rest of the plant. It should be explained to people that the aim of the test pots is to demonstrate the physical capability of the equipment and a degree of overmanning is intended to ensure everything is done precisely according to standard operating procedure and on time.

When the objectives have been reached i.e. cells have been refurbished or modernized, operating procedures have been improved etc. etc. the test pots can be returned to pot room management until a further major operating or equipment change is envisaged when they may be reverted.

A test pot programme designed to demonstrate that the pots will run better must succeed as it represents the future of the enterprise. Unless the test pot programme is going to properly managed and supported it should not be undertaken.

JNARDDC could play a significant role in test pot operation.

A suggested plan of action leading to the introduction of phase II of the BALCO Modernization Programme

The major feature of the Phase II modernization is the installation of Crust breakers on the BALCO pots. These will be controlled by the CELTROL system already installed. Only after this will the full potential of the CELTROL system be available.

This programme can only be introduced after the Phase I programme has been proved to be effective throughout the plant. To do this quickly and to prepare for the introduction of Phase II the following plan of action is suggested.

1. Set up a test pot management group of one senior technologist and four foremen all experienced in the operation of VSS cells with and without automatic feeding systems (People from the INOTA plant of HUNGALU would be ideal in this respect).
2. Select six adjacent pots and designate them as test pots
3. Fully upgrade the six pots
   - Full complement of new studs
   - Full complement of good clamps
   - Clean anode bus
   - Full complement of gas hood
   - No high resistance cathode flexibles
4. The pots will be given operating priority e.g. they will be fed on time, anode effects will be dealt with promptly, standard operating practices will be followed precisely.
5. The pots will be brought to best operating condition by adjusting metal and bath levels, proper ore covering, careful bath chemistry control, accurate tapping, sludge elimination, end breaking etc. etc.
6. Standard Operating Practices may be adjusted to improve the operation of the pots if thought necessary

7. Six months of operating excellence will be achieved and the methods and techniques of achieving it will be spread throughout the plant by training of pot room management and operators

8. Take decisions to install Phase II equipments on the test pots

9. Test pot management group will develop an operating strategy for the automatic feeding of the test pots

10. CELTROL will be programmed to impose the strategy automatically on the test pots

11. Six crust breakers will be installed

12. The test pots will be operated on automatic feed for six months to sort out any problems and demonstrate the gains to be made from automatic operation

13. Throughout this time management and operators of the pot rooms will receive training and familiarization with the equipment

14. New standard operating document will be prepared

15. Based on information gathered from test pots decision as when to install crust breakers etc. throughout the plant can be taken

NB The test pots will need a means of end breaking during six months trial.

Record notes of discussions

Mr. Hamilton, Dr. Horvath, UNDP experts and Mr. Agrawal from JNARDDC visited Balco Korba plant on 27th and 28th November '1995 to formulate joint R & D programmes which can be taken up by JNARDDC.

The team first met Mr. K.Chattopadhyay GM(Works) and discussed the report of an earlier visit of a JNARDDC team. Mr. A.K. Roy, GM (Smelter) and Mr. K.P. Paul, GM (Alumina) were also present during the meeting. Later on the team visited the smelter plant and held detailed discussions with Smelter executives. On the basis of the plant study and the discussions the following areas were identified, where JNARDDC can offer assistance:

1. Stabilisation of pot operation technology
2. Setting up six test pots with automatic crust breaking system
3. Laboratory testing of raw materials, intermediate and product of the anode paste plant
4. Study on the phenomenon of deposit formation in the cathode bottom and suggestions to avoid deposit formation
5. Study of fluorine balance and suggestions to reduce fluoride consumption

1. Stabilisation of pot operation technology

There are number of areas that require attention to improve the performance of the Balco pots. These include:

a. Evaluation of the extra joint in the anode riser bus bar
b. Evaluation of the extra joint in cathode flexible connection with bus bar
c. Status and condition of clamps
d. Condition and cleaning of anode bus bar

The team feels that this involves a lot of work and JNARDDC could assist in carrying out a study to fully assess the situation from technical and economical point of view to assist management in making decisions as to how and when these problems can be dealt with. Cost benefit analysis could be undertaken by JNRDDC. The stud repairing and replacement work is already under way and very good progress has been achieved. This may be continued on a regular basis.

2. Setting up six test pots with automatic curst breaking system

Prior to the installation of automatic crust breaking system through out the plant, it would be prudent to obtain few months of operating experience and optimisation of technological parameters on a small group of pots, while the stabilisation process is going on. This would permit the installation of automatic crust breaking system in whole plant once the decision to proceed is taken. This will also indicate the benefits associated with the system and will help the plant personnel to get acquired with the system. The consent and support of the technology suppliers, in the form of softw re and hardware for crust breaking system will be needed.

JNARDDC can help in providing operating assistance and in optimisatio f parameters by providing on the spot measurement and recording facilities by M: Van.

3. Laboratory testing of raw materials, intermediate and product of the anode paste plant

Improper anode current distribution. excess carbon dusting in the electrolyte, paste leakage etc. indicate that there may be problems with anode paste formulation. For instance it is known that some part of the pitch presently used is highly viscous. JNARDDC have facilities to thoroughly test these materials and to make recommendations to improve the performance of the anode. This may also include discussions with raw materal suppliers. It is proposed that these facilities are utilised by Balco.

4. Study on the phenomenon of deposit formation in the cathode bottom and suggestions to avoid deposit formation

Laboratory studies on the Balco's alumina solubility could be undertaken at JNARDDC. On the basis of these studies the phenomenon of deposit formation can be studied more thoroughly, and suggestions to avoid deposit formation would be fomulated.

5. Study of fluorine balance and suggestions to reduce fluoride consumption

The detailed fluorine balance of Smelter pots could be undertaken at JNARDDC. On the basis of these studies suggestions would be formulated to reduce fluoride consumption.

INDIAN ALUMINIUM COMPANY, LIMITED

HIRAKUD

RECORD NOTES OF DISCUSSIONS

Mr. Hamilton, Dr. Horvath and Mr. Agrawal from JNARDDC visited INDAL, Hirakud plant on 30th of November. The team visited the plant and held discussions with Mr. J. Panda. The team also met Mr. A.K. Kar.

At the outset the team would like to express thanks for the hospitality extended by INDAL during the visit.

Based on the discussions the following areas were identified where JNARDDC can work with Hirakud smelter to improve productivity. These include:

1. Measurements with the help of Mobile Van of electrical, thermal and magnetic parameters. These services are particularly valuable when any major change in cell equipment such as automation of feeding is envisaged. The measurements can also be called on an ad-hoc basis when required by Hirakud smelter.

2. Utilisation of carbon laboratory facilities available in JNARDDC. This may include determination of thermal stability of paste, CO2 reactivity and other measurements to improve anode performance.

3. Utilisation of carbon laboratory to optimise cathode life with particular reference to sodium penetration of pot lining.

4. Mathematical modeling of cathode to determine heat losses and to define the shape of the ledge. Mathematical modelling of anode to determine the theoretical voltage drop.

5. Possibilities of using analytical facilities available with JNARDDC. These can be for unusual analysis and cross checking if required.

6. Energy audit studies in Hirakud works. JNARDDC would work out the detailed project proposals in this regard and submit to INDAL for consideration.

7. Organisation of technical seminar at Hirakud works. Talks are already going on in this connection and JNARDDC would submit a detailed proposal to INDAL for consideration.

JNARDDC will make INDAL aware of all services and equipments that are available at Nagpur.

RECORD NOTES OF DISCUSSIONS

Mr. Hamilton, Dr Horvath, U.B. Agrawal and A.K. Basu from JNARDDC visited Nalco Angul plant on 1/12/95. The team met Mr. S.D. Chouharia, Mr. S.P. Mahapatra and visited the plant. Mr. S.D. Chouharia desired for support in finding solutions to existing plant problems, rather than just provision of technical data. On the basis of discussions and plant visit, the following areas of future activities were identified. These include:

1. Comprehensive survey of all aspects of carbon manufacturing process from raw materials to rodded anodes. A detailed proposal would be submitted by next fortnight by JNARDDC for consideration and if required modifications by Nalco.

2. Using the measuring services of JNARDDC, a full survey of baking furnace pit temperatures is proposed.

3. Prediction of potlife based on statistical and techno-economic considerations. A detailed proposal would be submitted within next fortnight by JNARDDC to Nalco.

4. Following the completion of suggested carbon project at Sl No 1, the services of mobile van would be used to determine the effect of this on any improvements on pot parameters.

SP Mahapatra 1-12-95.
S.P. MAHAPATRA.
NALCO.

J P Hamilton