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ALUMINIUM ELECTROLYSIS EVALUATION AND CONTROL

TECHNICAL REPORT

on the expert mission carried out in India
February 25 to June 16, 1994.

DP/IND/88/015/11-06
J 13207

INDIA

Prepared by EDOUARD IANKO

BACK STOPPING OFFICER : T. GROF DIO/T/MET

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANISATION

ABSTRACT

The present report on Aluminium Electrolysis Evaluation and Control is the result of the second expert mission DP/IND/88/015/11-06 carried out in India from 25th February to 17th June 1994 (with briefing, debriefing and report preparation from 22nd February to 21st June 1994)

The objectives of mission were the following:

1. Assist in installation, commissioning and start up the Aluminium Electrolysis Department (Carbon Technology) in the Centre (JNARDDC).
   Review of methodology/procedure already available and provide additional information.
   Preparation of acceptance reports.

2. Preparation of status report on carbon electrodes (raw material, technology, quality specific consumption etc.) in the aluminium industry in India.
   Discuss it with the representatives of the carbon and aluminium industries in a two day workshop in the Centre.

3. Preparation of a list of R&D projects proposed to improve the quality and specific consumption of carbon electrodes in the smelters in India.
   Conclusions and recommendations of the status report

4. To elaborate and agree with the companies detailed R&D programmes for joint projects with the industries.
   Connect the start up programme for the Laboratory with the elaboration of a case study on a selected project.

According to these terms of reference three smelters (BALCO, NALCO, HINDALCO) were visited and a two day workshop on "Carbonaceous Materials and Anode Technology in Aluminium Industry" in Nagpur, JNARDDC was organised. Some detailed R&D programmes, protocols and technical proposals were prepared and agreed.

All these activities have been carried out and details are provided in the Report, following by findings, conclusions, proposals and recommendations.

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LIST OF ANNEXURES

INTRODUCTION

This report has been written by Dr. E. IANKO as a result of the second expert mission carried out in India, Nagpur under the UNDP/UNIDO project DP / IND / 88 - 015 at Jawaharlal Nehru Aluminium Research Development and Design Centre (JNARDDC), Nagpur.

According to the job description DP/IND/88/015/11-06 with the post title: "Expert in Aluminium Electrolysis Process Evaluation and Control" (as per Annexure-1) the expert was required to assist in the installation, commissioning and start up of the Aluminium Electrolysis department of JNARDDC. In addition to the job description some constructive suggestions have been given to the expert at the briefing in UNIDO VIENNA by Mr. T. Grof, BSO, in UNDP-DELHI by Mr. Ramamurthy and at JNARDDC in Nagpur by Dr. J. Zambo, CTA and Dr. T.R. Ramachandran, NPD. Both the job description and suggestions formed the basis for the work programme prepared at the very begining of the mission as given in Annexure-II.

It can be seen from the work programme that the activities and duties as per the job description were extended to carbon raw materials and anode production activities. This was done due to the fact that these problems are very close to the objectives of job description and are essential for starting activities of Aluminium Electrolysis Department and for Indian Aluminium Industry at the present time.

According to job description and work programme at JNARDDC main objectives were the following:

- To elaborate with aluminium companies detailed R&D programme for long term cooperation between JNARDDC and the industries to improve the quality and specific consumption of the carbon electrodes in the Indian smelters.

- To assist in setting up of laboratory equipment and control methods for Aluminium Electrolysis Department (Carbon Laboratory).

- Training the personnel of the Centre and Aluminium smelters in methods of investigation for improvement of production technology, control of raw materials and electrodes.

These objectives were not revised and carried out in totality. As a result of the second mission long term cooperation programme was prepared and laboratory equipments were commissioned.

Details of setting up of the Aluminium Electrolysis Research Department (Carbon Laboartory) as well as proposals for further extension of R&D activities in JNARDDC including research and testing equipment are given in section "A" of the report

Sections "B", "C", "D" of the report reflect the results of activities in technical assistance, achieved during visits to aluminium smelters and at the workshop.

Based on the experimental material and process data collected, recomendations are made to JNARDDC and the aluminium companies of India (as per para "D" of the job description UNIDO and UNDP).

ACTIVITIES

Itinerary and list of main activities following the job description (as per Annexure-I) and the work programme on second mission (as per Annexure-II) are given in Annexure-III. The main activities, findings, conclusions and recommendations are described as following:

A Setting up of the Aluminium Electrolysis Research Department (Carbon Laboratory)

The following are the planned activities in the Carbon laboratory:

- assistance in installation, commissioning and starting up of laboratory equipment.
- reviewing of test procedures and analysis
- reviewing of spares, accessories, instruments, chemicals and measurement techniques.
- improvement of existing laboratory equipment and providing with additional technique.
- designing, adaptation and installation of measuring devices, special modules and accessories not available in the Centre.
- providing carbonaceous material samples, data collection and evaluation systems.
- adaptation of analytical methods and analysis of raw carbon materials and electrodes.

All these activities in starting up of carbon laboratory were carried out at the period of second mission. A well equipped carbon laboratory was set up where, apart from testing and evaluation of raw carbon materials, research work on determining optimal technological parameters of anode paste, green an prebaked anodes production procedure will be carried out to meet the requirements of Indian smelters.

Equipments and testing facilities available in JNARDDC for testing of raw carbon materials, green and prebaked electrodes are detailed in Table 1. Brief description of analytical methods is also given in this table.

Revision of laboratory equipment list shows that some units of equipment (Goverment input) are not available.

Some critical points faced during setting up of the carbon laboratory are indicated below :

1. Rapoport Equipment for the determination of cathode swelling in aluminium electrolysis cells : Dilatometer alongwith sensor was found damaged when transported. It was sent to NALCO for rectification.

2. Digital viscometer model LVTDV -II of Brookfield Engineering Laboratories Inc., USA - for determination of pitch viscosity. Electrical heating system (THERMOSEL) did not function and we did our best for installing it through Indian representative in Bombay.

3. Laboratory mixing Machine (Model LUK 8,0 K2) for production of experimental anode paste in laboratory scale. It is not equipped with oil heating system and can not be started. That system is designed and under procurement.

4. Carboxy reactivity apparatus (Model RDC - 146/1) for determination of CO2 - reactivity of baked anc les by loss of weight method. This apparatus is not equipped with gas purification system and analysis procedure can be fulfilled with high purity gas. Such gas is very expensive and purification system for regular CO2 - gas must be ordered.

5. Hydraulic press for mechanical strength of baked anodes testing with pressing force 500 KN max. This press is not suitable for determination of mechanical strength because it is not equipped by measurement system of pressing force with destroy force fixer. The press is operating manually.

6. Ring and Ball apparatus for determination of coal tar pitch. This apparatus and testing method are rather obsolete and more up-to-date system "Mettler" could be used for that test. "Mettler" apparatus and method is more accurate and reproducable and is recommended by ASTM and ISO committees.

7. From the list of equipments, one equipment (Core Drilling Machine-Model PE2O, Bernat Salicre, France) can be eliminated without hampering the planned activity of carbon laboratory. This machine is more suitable for core samples drilling at production lines (prebaked anodes, cathode blocks etc), than for laboratory conditions. A smaller mobile drilling machine may be procurred for taking out core samples.

Reviewing the current situation with equipments and testing facilities we can conclude that the carbon laboratory is able to start all kinds of activities, but solutions for the problems and difficulties listed above is needed.

The lists of investigation and testing (measurement methods, services etc.) as well as scientific facilities are represented in my first mission report (page 3-6) and are not repeated in present report.

The next critical point in setting up of Carbon laboratory is staff personnel and providing services.

According to project document the following highly qualified personnel must be recruited for the carbon laboratory:

- Chemical Engineer with strong background in carbon materials (2 persons)
- Bachelor in Science or Diploma in Engineering (2 persons)

For the starting up of activities at least one experienced laboratory analyst in carbon analytical procedures is needed in addition. Without such analyst, laboratory is not able to carry out analytical studies for coal tar pitches and calcined petroleum cokes.

The most difficult task is to find out and train specialists for analytical methods such as insolubles in toluene and quinoline, volatile matter, real density etc. That is why we propose to recruit one engineer from smelters who has sufficient experience in this area. Only a short training programme for improving his knowledge and mastering in a university analytical laboratory is required.

For specialists (HQ) of carbon laboratory can be recommended education programme at one of the well equipped laboratory of international repute for example, R&D Carbon in Switzerland or Hydro Aluminium Carbon Centre in Norway.

The staff of Carbon Laboratory must be educated and trained in the following areas:

- Background of carbon materials and anode-cathode technology
- Analytical procedure
- Equipment for laboratory and industrial measurement
- Evaluation of measurement and analysed results

Detailed requirement on education and training programmes has been given in my first mission report.

B. Preparation of status report on Carbon electrodes (raw material, technology, quality specific consumption etc.) in aluminium industry in India

At the begining of my mission three primary aluminium producers, BALCO, HINDALCO, and NALCO were visited for collection of information, data and discussion with the management and experts of the companies on improvement of raw materials' quality, manufacturing processes and preparations of project proposals for smelters.

Record notes of discussions between JNARDDC experts and the management of aluminium companies (BALCO, HINDALCO & NALCO) are represented in Annexure-IV.

On the basis of these record notes, collected information and data "Status report" (Annexure V) was elaborated and discussed at the workshop on May 26-27, 1994 in Nagpur (Annexure VII). This report reflects the main problems and difficulties in area of carbonaceous materials and cell anode technology in Indian Aluminium Industry. Our conclusions and recommendations for the Indian primary Aluminium producers and Aluminium Electrolysis Research Department (Carbon laboratory) are the followings.

1. IN THE FIELD OF C.P.COKE PRODUCTION AND SUPPLY TO SMELTERS

Indian petroleum refineries produce C.P.Coke of high quality(low sulphur, vanadium, ash content, high bulk density, etc.). But, sometimes the quality of C.P.Coke supplied to the individual smelter varied widely from their specifications. This is due to the degree of calcination which is reflected in the real density of the coke. The deviations have been observed in the real density of coke from the local specifications, i.e., 2.03 - 2.06 g/cc for BALCO, and 2.05 - 2.09 g/cc for NALCO & HINDALCO. The inconsistency in the quality of coke adversely affects the quality of anode produced

Establishment of data bank on C.P.Coke in JNARDDC could be helpful in tackling this problem. The functions of the data bank will be as follows:

1. To collect information on installed and actual capacities of the coke calciners.
2. To collect information on the product quality.
3. To match the quality and capacity of the calciners with individual smelter's requirement.
4. To make the location map of each calciner and smelter and to recommend the source of C.P.Coke to every smelter in consultation with all the calciners and smelters for procurement of right quality of C.P.Coke.
5. To collect data on quality of C.P.Coke of each source and to analyse the variation for recommending the supplier to take necessary action for supplying C.P.Coke of required specification.

2. IN THE FIELD OF C.T.PITCH PRODUCTION AND SUPPLY TO SMELTERS

The problem of inconsistent quality of coal tar pitch supplied to the smelters is a serious one. The abundant availability of crude coal tars by the Indian Steel industry to the pitch distillators both in public sector steel plants (Rourkela, Bhilai, and Vishakapatnam) and private enterprenures, makes possible to produce a wide range of coal tar pitch with different specifications. But the agreement between smelters and distillators purely on the basis of cost criteria leads to abnormal variations in the quality of pitch supplied to the smelters (Cost of coal tar pitch produced by VSP is much cheaper than RSP & BSP although the quality does not conform to the specifications of HINDALCO & NALCO). Moreover, small pitch distillators have also entered the field. Due to this, all smelters are receiving pitches with softening point from 90 - 112 °C., quinolene insoluble from 4 - 14%, etc.

Establishment of data bank on C.T.Pitch in JNARDDC and elaboration of distribution scheme could be very useful from point of view of technology as well as economics. The functions of the data bank will be as follows:

1. To collect information on installed and actual capacities of the pitch producers.
2. To collect information on the product quality.
3. To match the quality and capacity of the pitch producers with individual smelter's requirement.
4. To make the location map of each pitch distillator and smelter and to recommend the source of C.T.Pitch to every smelter in consultation with all the pitch producers and smelters for procurement of right quality of C.T. Pitch.
5. To collect data on quality of C.T. Pitch of each source and to analyse the variation for recommending the supplier to take necessary action for supplying C.T. Pitch of required specification.

3. PROBLEMS AND OBJECTIVES OF THE SMELTERS IN THE FIELD OF CARBON PRODUCTION TECHNOLOGY

3.1. HINDALCO

In spite of old equipments, HINDALCO maintains high level technology and good quality pre-baked anodes. But they have some critical points which do not permit them to advance to the upper level, including reduction in carbon consumption from present level of about 430 kg/ton of aluminium by about 20 kg. The main point in the technology is press machine (pressing process in closed form without vibrating). The latest internatic l practice is to use vibroforming in stead of press forming.

Green anodes produced at HINDALCO have horizontal cracks, cavities, aggregations, etc. Baking procedures can not eliminate these defects and further improvement of baked anode quality cannot be achieved.

After the discussion between JNARDDC experts and HINDALCO management, both sides agreed that introduction of new vibro press machine will help in solving this problem as well as it will be possible to get anodes with increased dimensions and double in weight.

The carbon control laboratory is not properly equipped to control the green and baked anode quality. Existing equipments for raw materials' control are insufficient and not upto date. This situation adversely affects the development of carbon production facilities.

3.2. NALCO

The most critical areas in carbon production is mixer & press equipments. Production of green anode block is equipped with vibro press (2 nos.) supplied by Pechiney which have following shortcomings:

- The press supported on springs and rubber pads, is improperly balanced; press form is not monolith and not equipped with suction of fumes.

- The mismatch of capacities between mixer and the storage prior to the press leads to the generation of large quantity of green anode paste as waste.

Due to the problems of vibro compactors, low bulk density of green blocks and non-uniform structure characteristics are observed which lead to high percentage of waste in the form of green and baked anode. Since 1992 the quantity of waste has substantially increased.

The equipments installed are so close that opportunities for modification and restructuring are very limited.

The suggestion for improvement in the current situation are the followings:

- To select properly designed press machine with suction of gas and monolith form particularly for big size anodes for installation in separate area.

- To design and install a separate line for processing of green and baked waste. It is inevitable, because annual generation of wastes is high.

Other problems at NALCO smelter are

- Firing of fume deposits and explosions in exhaust gas duct system of baking furnace,
- Low life of flue wall refractory bricks of baking furnace,
- Cleaning system of recycled thimbles as well as corrosion of induction furnace linings.

These are also important but less severe than the problems of green anodes pressing procedure and waste formation. These problems can be solved with JNARDDC assistance and international consultants.

3.3. BALCO

Present paste consumption of BALCO smelter is very high (570 kg/ton of Al) and reduction of it by 30-40 kg/ton of Al is an important task for this smelter. After reviewing the anode paste quality and technological parameters of anode formation in cell houses, we conclude the following :

- Anode production facilities are maintained on good level and to normal conditions. Anode paste quality (porosity, mechanical strength, electrical resistance, etc.) is also satisfactory.

- Anode formation parameters are most critical points (current distribution, temperature of liquid part, cone height, etc.). The current distribution per stud varies to a large extent due to variation in stud lengths. Anode top temperature is 160 °C., against normal temperature of 130 -140 °C etc.

On the basis of this analyses, we elaborate the draft programme of cooperation as given :

1. Calibration of existing anode studs for improvement in current distribution in anodes.
2. Installation of artificial cooling systems in liquid part of anodes,
3. Improvement in anode cases design,
4. Repairing of damaged current studs by friction welding methods,
5. Improvement in raw carbon materials quality .

A long term programme of laboratory assistance between JNARDDC and BALCO is to be made to fulfill the above. These programmes will be helpful in reducing carbon consumption by about 30 - 40 kg/ton of Al.

In conclusion, it can be said that no major or serious reconstruction for BALCO is required. There is no international experience available in the soderberg designs and procedures which can be implemented in BALCO smelter. Improvement in technological situation in anode paste production and anode formation procedure are most important programmes for BALCO. Additional reduction of carbon consumption is possible when general technological situation will improve to high level.

C. R&D programme for the joint projects with the industries

Taking into account the various problems suggested by Indian Aluminium Industry, and the availability of staff and equipment in JNARDDC, three R&D programmes for cooperation with BALCO, HINDALCO and NALCO were elaborated and agreed with smelter's management (Annexure VI).

On the basis of these programmes the following list of main R&D projects proposed to improve the quality and specific consumption on the carbon electrodes in smelters of India is formed.

1. Improvement of quality and supply system of raw carbon materials (pitch and coke), organisation of data bank in JNARDDC with participation of coke and pitch producers.

2. Technical assistance in modenisation of pressing process for production of green anodes at NALCO and HINDALCO smelters.

3. Improvement of existing ring open baking furnace operation at NALCO for elimination of fire and explosions in exhaust gas duct system and increasing the life of flue wall bricks.

4. Technical assistance to BALCO smelter for achieving reduction of anode paste consumption from the present level of 570 kg/ton of Al by about 30-40 kg.

5. Dry anode technology for Soderberg cell pots (BALCO) for reduction of tars and polycyclic aromatic hydrocarbons (PAH) pollution into the potroom atmosphere.

6. Technical assistance to BALCO, HINDALCO and NALCO for inducting specific testing of raw carbon materials, green and prebaked anodes, to improve the control laboratory facilities according to recent requirement to control methods.

More detailed programmes for these projects are represented in draft programmes for cooperation in Annexure-VI.

D. WORKSHOP ON PRODUCTION OF CARBONACEOUS MATERIALS AND ANODE TECHNOLOGY IN ALUMINIUM INDUSTRY

A two day workshop was organised at JNARDDC, Nagpur, to provide the latest relevant technical information/literature and to present lectures on the latest developments in this area. In addition sufficient time was provided for round table discussion on carbon materials topics and formulation of R&D proposals. Keeping these factors in mind the following objectives were envisaged:

- To analyse the present situation in production of carbonaceous materials and anode technology in aluminium industry.

- To analyse the possible ways in improvement and development of electrolysis process on prebaked and Soderberg anodes.

- To promote activities and cooperation on development of anode and cathode materials production, improvement of their quality.

- To discuss the raw carbon materials quality and the way of their improvement in domestic producers.

- To educate the smelters experts in the field of up-to- date technology for green and baked anode production, dry anode technology (Soderberg cells), cathode blocks control testing etc.

- To contribute to establishing long term Research and Development programmes and promote activities on priority projects including detailed planning, programming and implementation.

The following literature survey papers were presented and discussed at the workshop (the participants were provided with complete text of the material presented).

- Raw carbon materials, coal tar pitch and calcined petroleum coke (5 pages, 4 references)
- Production of anode paste and green anodes (11,2)
- Baking procedure (6,3)
- Baked anode quality (4,1)
- Soderberg anode technology improvement (4,2)

The programme of the workshop, list of participants from the companies and recomendation of the workshop are given in Annexure VII. Copies of the papers of references quoted were given to the participants.

TABLE I

EQUIPMENTS & TESTING FACILITIES AVAILABLE IN JNARDDC FOR TESTING OF C.P. COKE

Characteristics/tests	Description	Equipments & testing facilities available
Physical Test	Granulometric composition	Rotap Sieve Shaker, Sieves.
	Bulk density	RDC-147 RESIFLEX COKE supplied by M/s. R&D Carbon, Switzerland.
	Specific electrical resistivity	RDC-147 RESIFLEX COKE supplied by M/s. R&D Carbon, Switzerland
	Hardgrove Grindability Index	Hard grove Tester
	Real density	Helium Pycnometer Model 1305 supplied by M/s Micromeritics, USA
Chemical	Moisture content	Analytical facilities
	Volatile matter content	Analytical facilities
	Ash content	Analytical facilities
	Elemental analysis of Fe, Si, Ni, Ti V, S	1. Analytical facilities 2. XRF (PW 1480) supplied by M/s. Philips Export BV, Netherlands.

TABLE I (CONTD.)

EQUIPMENTS & TESTING FACILITIES AVAILABLE IN JNARDDC FOR TESTING OF C.T. PITCH

Characteristics/tests	Description	Equipments & testing facilities available
Physical	Softening Point	Ring & Ball apparatus
	Viscosity	Viscometer Model LVTDV II supplied by M/s. Brookfield Engineering Laboratories Inc., U.S.A.
	Flowability Number	Mould, Measuring plate Oven etc. supplied by M/s. Aluterv - FKI Ltd. Hungary.
Chemical	Distillate content	Distillating retort, Heater etc.
	Moisture content	Analytical facilities
	Coking value	Conradson apparatus
	Toluene insoluble content	Analytical facilities
	Quinolene insoluble content	Analytical facilities
	Ash content	Analytical facilities
	Sulphur content	Analytical facilities
	Effect of heating	Heat treating equipment supplied by M/s. Aluterv - FKI Ltd., Hungary.
	Elemental analysis of Fe, Si, Ni. Ti, V, S.	XRF (PW 1480) supplied by M/s. Philips Export BV, Netherlands.

TABLE I (CONTD.)

EQUIPMENTS & TESTING FACILITIES AVAILABLE IN JNARDDC FOR TESTING OF GREEN ANODE MASS

Characteristics/tests	Description	Equipments & testing facilities available
Preparation	Production of green anode mass	Jaw crusher, Disc pulveriser, Vibrating screen, & Laboratory kneading & mixing machine.
Physical	Bulk density	Physical testing facilities
	Plasticity	Physical testing facilities
	Elongation No.	Physical testing facilities
Chemical	Benzene soluble content	Analytical facilities
	Anthracene soluble content	Analytical facilities
	Volatile matter	Analytical facilities
	Ash content	Analytical facilities
	Sulphur content	Analytical facilities

EQUIPMENTS & TESTING FACILITIES AVAILABLE IN JNARDDC FOR TESTING OF BAKED ANODE MASS

Chatacteristics/tests	Descrpition	Equipments & testing facilities available
	Baking of green anode mass	Furnaces for primary baking and secondary baking with micro processor based controller, and accessories. Total system supplied by M/s. Aluterv - FKI Ltd., Hungary.
Physical	Apparent density	Physical testing facilities
	Real density	Helium Pycnometer Model 1305 supplied by M/s Micromeritics, USA
	Specific electrical resistivity	Hydraulic press, DC power source, variable resistance,etc. Hydraulic Press supplied by M/s. Aluterv - FKI Ltd., Hungary.
	Compressive strength	Bending unit, Hydraulic press, etc.
Chemical	Carboxy reactivity	CO_2 Reactivity apparatus (Model RDC - 146/1) and Tumbling apparatus (Model RDC - 181) supplied by M/s. R&D Carbon, Switzerland.
	Air permeability	Air permeability apparatus
	Ash content	Analytical facilities
	Elemental analysis of Si, Fe, Ni, Ti, V, S.	XRF (PW 1480) supplied by Philips Export BV, Netherlands

TABLE - 2

STATUS OF EQUIPMENTS UNDER GOVERNMENT INPUT

Sl. No.	DESCRIPTION	QT	NOTES
1.	Temperature measuring instrument	5	under procurement
2.	Volt-ampere meter (analog/digital)	8	under procurement
3.	Thermostat	2	under procurement
4.	Simple power supplier	1	under procurement
5.	Contact thermometer	1	under procurement
6.	Volt meter (Digital)	1	under procurement
7.	Power supply unit	1	under procurement
8.	Electric furnace (muffle)	3	Ordered
9.	Sampler	1	under procurement
10.	Paste mixer	1	To be deleted. One oil heating system for kneader mixer available under UNDP input to procured
11.	Coke oven (Conradson apparatus)	1	under procurement
12.	Air permability meter	1	Ordered
13.	Grain-size distributor	1	Ordered
14.	Compression strength meter	1	Modern equipment to be procured as available press fro Aluterv-FKI is not suitable as a C.S. meter
15.	Air flowmeter	1	Ordered

RECOMENDATIONS

To the Centre

1. To complete the recruitment of Carbon laboratory staff according to project document, including

   - Chemical Engineer with strong background in carbon (2 persons)
   - Bachelor in Science or Diploma in Engineering (2 persons)

   and one analytical laboratory analyst with strong background in carbon materials analysis.

2. To equip the laboratory with special instruments and devices (thermocouples, gas measurement devices, sampler etc.) for industrial investigations and measurements at the running equipments such as Soderberg anodes, vibro compactors, baking furnaces, mixers etc.

3. To organise carbon information service by collecting informations on quality of raw carbon materials (domestic and foreign producers), and bank of samples, to elaborate the optimal supply scheme (pitch and coke) according to smelter specifications.

4. To formulate and start-up the cooperation programmes and projects from the third quarter, 1994 between JNARDDC and aluminium smelters according to Annexure-VI.

5. To establish in the Centre a special scientific Bulletin JNARDDC (for example 4 issues per year) for publishing views and articles in the area of metallurgy of aluminium and fabrications.

6. To organise for specialists (HQ) of Carbon Laboratory an Education programme at one of the carbon centre of international repute.

<u>To the Industries</u>

1. For NALCO Smelter

- To organise a special expertise with participation of independent (international) experts for clarifying the reasons of low quality of green anodes and high anode waste output. To make independent conclusion for modernisation of vibro compacting equipment.

- To revise specification of refractory bricks of flue wall to increase the alumina content (50 % min.) and to include the limits of impurities content (Fe_2O_3 + TiO_2, CaO + MgO, Na_2O + K_2O).

- To equip the exhaust gas duct with special temperature/pressure devices and steam injection system to avoid fire and explosions.

2. For HINDALCO Smelter

- To establish carbon control laboratory for testing of green and baked anode quality and to equip this laboratory with modern control equipments.

- To modernise the green anode production facilities with micro processor based weighing and batching system and installation of modern vibro compactor.

3. To BALCO Smelter

- To start up in 1994 studs' calibration programme for improvement of anode current distribution in cells.

- To carry out the programme of converting Soderberg anode from wet to dry anode technology.

During our visits to Smelters and some meetings in JNARDDC these problems were identified, objectives defined and agreed to and recommendations for immediate and future actions made, as can be seen from the records notes of discussion of BALCO, NALCO & HINDALCO.

ANNEXURE-I

REQUEST FROM THE GOVERNMENT OF INDIA

JOB DESCRIPTION

DP/IND/88/015/1106

POST TITLE	Expert in aluminium electrolysis process evaluation and control
DATE REQUIRED	April 1992
DURATION	12 months in split missions as follows : 4 months in 1992, 4 months in 1993 and 4 months in 1994.
DUTY STATION	Nagpur, India, with travel within the country.
DUTIES	The expert will be required to assist in the setting up of the Aluminium Electrolysis Research Department of the Centre, and in particularly of process evaluation and control laboratory. The expert will undertake and/or assist in research and investigations on aluminium electrolysis process evaluation, monitoring and control.

His main duties will be to :

a) Provide training for the counterpart staff/scientists of the Centre in the measurement and monitoring of electrical parameters of the electrolysis cells, (voltage, fluctuations, noise, anodic/cathodic current distribution) as well as thermal state, magnetic field, anode gas, composition and gas collection efficiency.

b) Assist and train in measurement and evaluation of process data for aluminium electrolysis cells through a special mobile van.

c) Assist and train in preparation of detailed energy and material balance of aluminium electrolysis cells.

d) Prepare technical proposals for measurement of cell operation based on experimental measurement and process data collected. The expert is expected to submit progress report after completion of every split mission assignment and a final report.

WORK PROGRAMME FOR DR. E. IANKO, EXPERT IN CARBON ELECTRODES FOR ALUMINIUM ELECTROLYSIS

March -June/July 1994

Activities:

1. Assist in installation, commissioning and start up the Carbon Laboratory in the Centre
   Review of methodology / procedured already available and provide additional information if necessary
   Preparation of acceptance reports

2. Preparation of status report on carbon electrodes (raw material, technology, quality specific consumption etc.) in the aluminium industry in India
   Discuss it with the representatives of the industries on a one / two day workshop to be organised by and in the Centre

3. Preparation of list of R&D projects proposed to improve the quality and specific consumption of the carbon electrodes in the smelters in India
   Conclusions and recommendations of the status report

4. To elaborate and agree with the companies detailed R&D programmes for the joint projects with the industries
   Connect the start up programme for the Laboratory with the elaboration of a case study on a selected project

Programme :

One week visit to each of the primary aluminim producers, BALCO, NALCO, HINDALCO and optionally INDAL for collection of information, data and discussion of the issues listed above with the management and experts of the companies. This should be done at the beginning of the expert's mission .

Organisation of the workshop in the Centre at least one month before te departure of the expert

Detailed programme for the scheduled activities is given in the Annexure enclosed

Feb 22, 1994

PROGRAMME OF DR. E. IANKO, UNIDO EXPERT IN ALUMINIUM PRODUCTION

POST (NO : 11-06)

DATE	PLACE	ACTIVITIES	ACTIONS
FEB27, '94	Arrival Nagpur	Study of documents Programme/itinerary objectives & content of report	Implementation of programme for preparation
28 FEB - 6 MAR	JNARDDC, Nagpur	Reviewing of test procedures and methods of different carbon materials with reference to aluminium smelters	
		Programme for Workshop on Carbon materials.	
		Programme for installation of equipments	
7 MAR - 11 MAR	BALCO SMELTER, Korba	Visit to BALCO Formulation of project and discussion	To contact CMD / E.D. (Works), Korba
12 MAR - 28 MAR	JNARDDC Nagpur	Prepartion for workshop Reviewing of spares accessories Preparation for Acceptance Reports Preparation of project proposal for BALCO	
29 MAR - 4 APR	HINDALCO SMELTER, Renukoot	Visit to HINDALCO Formulation of project and discussion.	To contact S/sri A.K. Agrawal/V.K. Agrawal/ O.S. Choudhuri
5 APR - 8 APR	NALCO SMELTER, Angul	Discussion at NALCO H.Q. Formulation of project and discussion	To contact CMD / E.D. / G.M. (SM)
9 APR- 21 APR	JNARDDC, Nagpur	Preparation of project proposal for HINDALCO & NALCO	
23 APR -25 APR	Bombay	Visit to Brookfield Ltd., Consultation for erection of viscometer.	To contact with representative of company
26 APR - 1 MAY	JNARDDC Nagpur	Starting of Laboratory equipment	
2 MAY - 4 MAY	NALCO Bhubaneswar	Discussions with NALCO for projects taken	To contact with Sri M.M. Seth, CM (R&D)
5 MAY - 16 MAY	JNARDDC Nagpur	Detail study on dry anode paste technology	
		Discussion with Aluminium Producers for projects taken.	
		Discussion with Carbon material manufacturers on improvement of raw material quality.	
17-18 MAY	Calcutta	Visit to HILDIBARI Ltd., For organisation of calcined anthracite production in India - discussions	

ANNEXURE - II (CONTD.)

19 MAY - 13 JUNE	Nagpur	Workshop (two days)	To contact all primary aluminium producers, carbon raw materials producers.
		Preparation of status report on carbon electrodes, its raw materials, manufacturing processes, quality control/laboratory testing procedures etc.	
		Acceptance report of equipments.	
		Preparation of conclusions and recommendations	
		Preparation of final report	

ITINERARY AND LIST OF MAIN ACTIVITIES OF THE EXPERT MISSION BY DR. E. IANKO AT JNARDDC IN NAGPUR AND SOME SMELTERS IN INDIA

WEEK	DATE	PLACE	ACTIVITIES
1 st	22/02/94	ST.PTB - VIENNA	TRAVEL
	23/02/94	VIENNA	BRIEFING AT UNIDO
	24/02/94	VIENNA - DELHI	TRAVEL
	25-26/02/94	DELHI	BRIEFING
	27/02/94	DELHI - NAGPUR	TRAVEL AND ARRIVING TO DUTY STATIO
2 nd	28/02/94 6/03/94	NAGPUR	PREPARATION OF WORKSHO PROGRAMME. REVIEWING O EQUIPMENT INSTALLATION PROGRAMME.
3 rd	7/3/94	NAGPUR - KORBA	TRAVEL
	8-11/03/94	KORBA	PREPARATION OF WORKING PROGRAMME FOR JNARDDC - BALCO SMELTER COOPERATION
	11/03/94	KORBA - NAGPUR	TRAVEL
4th	14-20/03/94	NAGPUR	PREPARATION FOR WORKSH REVIEWING OF SPARES ACCESSORIES PREPARATION OF PROJECT PROPOSALS FOR BALCO SMELTER
5 th	21-27/03/94	NAGPUR	STARTING OF LABORATORY EQUIPMENT (RESIFLEX, RAPOPORT TESTER)
6 th	28/03/94	NAGPUR	PREPARATION OF MATERIAL FOR VISIT TO HINDALCO AND NALCO SMELTERS
	29/03/94	NAGPUR - RENUKOOT	TRAVEL
	30/03/94 - 03/04/94	RENUKOOT	VISIT TO HINDALCO SMELTE ELABORATION OF COPERATI PROGRAMME
7 th	4/04/94	RENUKOOT - ANGUL	TRAVEL
	5-8/04/94	ANGUL	VISIT TO NALCO SMELTER. ELABORATION OF COOPERATION PROGRAMME
	9-10/04/94	NAGPUR	COOPERATION PROGRAMME
8 th	11-17/04/94	NAGPUR	PREPARATION OF JOINT PROGRAMMES FOR JNARDDC AND SMELTERS COOPERATI AND REPORT ABOUT VISIT T SMELTERS
9th	18-21/04/94	NAGPUR	STARTING THE LABORATOR EQUIPMENT (VISCOMETER)
	22-24/04/94	NAGPUR - BOMBAY	TRAVEL

	23-24/04/94	BOMBAY	VISIT TO BROOKFIELD ENGINEERING LAB. (INDIAN REPRESENT OFFICE) FOR CONSULTATION IN STARTIN OF VISCOMETER
10 th	25/04/94	BOMBAY	VISIT TO BROOKFIELD LTD..
	25/04/94	BOMBAY - NAGPUR	TRAVEL
	26-30/04/94 3-4/05/94	NAGPUR	STARTING LABORATORY EQUIPMENT
11 th	2/05/94	NAGPUR - BHUBANESWAR	TRAVEL
	3-4/05/94	BHUBANESWAR	VISIT TO NALCO OFFICE FOR COOPERATION PROGRAMME DISCUSSION
	4/05/94	BHUBANESWAR - NAGPUR	TRAVEL
	5-8/05/94	NAGPUR	STARTING OF LABORATORY EQUIPMENT (CARBOXY REACTIVITY)
12 th	9-15/05/94	NAGPUR	PREPARATION FOR WORKSH
13 th	16/05/94	NAGPUR - CALCUTTA	TRAVEL
	17-18/05/94	CALCUTTA	VISIT TO HULDIBARI LTD.. OFFICE FOR ORGANISATION CALCINED ANTHRACITE PRODUCTION IN INDIA AND JNARDDC - HULDIBARI COOPERATION PROGRAMME
	19-22/05/94	NAGPUR	PREPARATION TO WORKSHO
14 th	23-29/05/94	NAGPUR	COMPLETION OF WORKSHOP PREPARATION. WORKSHOP ON PRODUCTION OF CARBONACEOUS MATERIALS AND ANODE TECHNOLOGY IN ALUMINIU INDUSTRY.
15 th	30-31/05/94 1-5/06/94	NAGPUR	COLLECTION OF MATERIAL FOR FINAL REPORT
16 th	6-12/06/94	NAGPUR	PREPARATION OF THE FINAL REPORT
17 th	13/06/94	NAGPUR	FINALISATION OF THE REPO
	13-14/06/94	NAGPUR - DELHI	TRAVEL, ARRIVING TO DELH
	15-16/06/94	DELHI	HEALTH CONTROL ACCORIN TO RUSSIAN EMBASSY REQUIREMENT. ARRANGEMENT BACK TRAV VISA TO AUSTRIA. VISIT TO BALCO OFFICE. DEBRIEFING UNDP.
	17-19/06/94	DELHI - VIENNA	TRAVEL AND ARRIVING AT VIENNA
18 th	20/06/94	VIENNA	DEBRIEFING IN UNIDO
	21/06/94	VIENNA - STPIT	TRAVEL

ANNEXURE IV

Record Note of Discussion Between JNARDDC & BALCO for Closed Cooperation in the field of Cabon Technology.

March 8 - 10, 1994

Present-

JNARDDC

1. Dr. E. Ianko, UNIDO Expert
2. Mr. A.K. Basu, Scientist

BALCO

1. Mr. K.P. Pal, DGM (Sm)
2. Dr. P.K. Moitra, DGM (QC)
3. Mr. G.D. Upadhyay, AGM (Sm)
4. Mr. C.P.S.Sodhi, AGM (Sm).

1. The analysis reports of C.P.Coke supplied by M/s IOC, BRPL, ICL, and Goa Carbon Ltd. during 1993-94 have been Scrutinized by JNARDDC experts and their observations are as follows:-

a) The real density varied between 2.03 - 2.07 g/cc. The typical recommended value for V.S.S Cell is 2.03 - 2.05 g/cc. Effort should be made with the suppliers to keep this value within 2.03 - 2.05 g/cc.

b) The bulk density varied between 0.79 - 0.87 g/cc. It is suggested to specify the B.D. as 0.80 g/cc minimum and in close range.

c) The Nickel content of C.P. Coke supplied by M/s Goa Carbon Ltd is rather high at 190 ppm. Effort should be taken with the part to bring down the value to 100 ppm maximum.

2. It has been informed by BALCO that about 55-60% of the total requirement of C.T. Pitch is met from Rourkela Steel Plant, 20 -30 % from Bhilai Steel Plant and the balance quantity from Vizag Steel Plant. The scrutinization of the analysis reports of

C.T. Pitch By JNARDDC experts received in 1993-94, reveals that there is wide variation of Softening Point of pitch, 93 - 110 ^{o}c (R&B). This abnormal variation adversely affects the paste quali ty. Effort should be taken with all the suppliers to receive pitch within closed tolerance value. JNARDDC experts suggest to procure C.T. Pitch with Sofening Point 95 +_ 2 ^{o}c (R & B)

3. JNARDDC experts request BALCO to give pitch sample of different origin to carry out the rheology behaviours of these pitches.

4. JNARDDC experts has requested to give baked anode samples to carry Co_2 reactivity test at their Centre. Written request has already been sent to BALCO.

5. JNARDDC experts observed that the quality of Anode Paste is quite consistent and no modification is required at present.

6. JNARDDC experts express that it woud be better to procure major requirement of each rawmaterials from one source and re strict the minor suppliers to one only.

7. BALCO has been informed that the Rappaport Equipment at JNARDDC is going to be commossioned in April'94. BALCO has been requested to send necessary samples for the same.

8. JNARDDC experts suggested to put cooling plates on the top of anode during their visit in 1992. The situation after putting

these plates in Cell 127 has been discussed and BALCO informed that there is no change in the anode top temperature. JNARDDC experts explained to take trial after modifying the sizes until the top temperature comes down to 140 ^{o}c . However, it has been suggested to BALCO to increase thickness of the plate by 20 mm and height by 50 mm. It has also been hold to increase the number of plates to 8.

9. BALCO informed that they are facing problems of low baking cone at the corners. JNARDDC expert suggested to put insulation boxes at the top corner of anode Casing. However it is informed to them that some trials in 10 Cells to be taken before arising at actual size of insulation boxes. JNARDDC experts request BALCO to provide drawing of anode casing for this purpose.

10. BALCO explained that non availability of proper size of studs at the shopfloor is a major problem. The stud sizes vary from 192 - 170 cm. JNARDDC experts informed that Russian Smelter use machine to cut deformed part of Anode stud and join one new piece by friction welding. JNARDDC experts will furnish the requisted information of the supplier / manufacturer of the machine to BALCO.

11. JNARDDC experts suggested modified granulomtric paste to take trial in one Cell during their visit in 1992. It is informed that about 80-85 MT of Anode Paste was produced and trial was taken in Cell 827. BALCO informed that observation & of the trial will be furnished to JNARDDC shortly.

12. BALCO has requested JNARDDC for mathematical modelling for calculation of pitch requirement based on the coke characteristics and fractions.

13. In the fourth phase of modernisation, Korba Aluminium Smelter may adopt Dry Anode Paste Technology. JNARDDC offers their expertise to take a study on dry anode paste suitable for BALCO based on Indian conditions.

(DR. E. IANKO)

(K. P. PAUL)

(A. K. BASU) 10.3.94

RECORD NOTES OF DISCUSSION BETWEEN JNARDDC AND M/S HINDALCO, RENUKOOT PERIOD: MARCH 31, 1994 TO APRIL 4, 1994

Participants:

JNARDDC	HINDALCO
1. Dr. E. Ianko UNIDO expert	1. Mr. O.S. Chaudhary Jt. President (Red. Plant)
2. Mr. A.K. Basu Scientist	2. Mr. V.K. Agrawal Vice President (R & D)
	3. Mr. V.S. Surana Vice President (Red.Tech.)
	4. Mr. Arun Kumar Dy Chief Metallurgist (Red. Tech.)

The process of manufacturing ready prebaked anode, quality control of anode carbon materials and general situation of raw materials, ie, C.P. Coke & C.T. Pitch, was reviewed by JNARDDC experts alongwith HINDALCO experts. Based on the review JNARDDC experts express the following opinions.

1.0 Raw materials of anode carbon.

1.1 Calcined Petroleum Coke.

It is found that HINDALCO received C.P. Coke from 6 (six) Calciners during 1993 - 94. The quality of C.P. Coke are not consistent/stable. The most important specification data which are not stable are as follows:

Real density varies from 2.04 - 2.11 gms/cc against HINDALCO specification of 2.05 - 2.07 gms/cc. According to best international experience for anodes of similar dimension, the real density should be limited to 2.06 - 2.09 gms/cc.

Ash content mainly varies from 0.45 - 0.60% against HINDALCO specification of 0.45% max. Some parties have supplied coke with very high ash content

(i) India Carbon Limited, Budge Budge 0.98%(Jun'93) and 0.80 - 1.27%(Sept'93)

(ii) Bihar Carbon, Barauni 0.82 - 0.85%(May '93), 0.44 - 1.64% (Oct.'93), 0.88%(Nov. '93) 0.94 - 1.50%(Dec.'93) 0.98-1.27% (Jan. '94)

The content of Si, Fe and Ni found sometimes significantly higher than the limiting values of HINDALCO specification. It is well known that Fe & Ni act as catalysts for CO2 reactivity and Si (in small quantity) as inhibitor for the same. The higher content of impurities deteriorates the quality of primary aluminium.

1.2 Coal Tar Pitch:

It is found that HINDALCO recieved C.T. Pitch from 2 (two) major indigenous producers and imported from North Korea during 1993-94. They are also receiving C.T. Pitch from small manufacturers (10 parties).

- The softening point of C.T. Pitch supplied by Vizag Steel Plant varies significantly from 97 - 108 deg.C accompanied by very low coking value (48 - 51%), low benzene insoluble (27 - 34%), quinolene insoluble (3 - 6%) comparison to following HINDALCO

<u>Specifications:</u>

S.P. - 109 - 113 deg C.

C.V. - 56% min.

Benzene Insoluble - 30 - 37%

Quinolene Insoluble - 10 - 14%

- Quality of other suppliers pitches are in general conforming to HINDALCO specification.
- Distillate content and viscosity of pitch are not analysed at HINDALCO. The distillate content is an important factor for baking process as high distillate content of pich increases the porosity of baked anode. The viscosity of pitch affects mixing and pressing process and the quality of green anodes.

2.0 Production Technology

2.1 Production of green anode paste

In spite of rather old production equipments of about 40 years old; high level maintenance and according its technological characteristics (crushers, screens, ball mill with air separating system, weight dosing system and mixer capacities) enables the carbon plant to produce anode paste of satisfactory quality.

4.0 HINDALCO indicated to seek cooperation of JNARDDC for specific experimental work for future development projects without afecting day to day operation of the plant.

JNARDDC	HINDALCO
(Dr. E. IANKO)	(O.S. CHAUDHARY)
(A.K. DASU)	(V.K. AGRAWAL)
	(V.S. SURANA)

ANNEXURE IV (Contd)

RECORD NOTES OF DISCUSSION BETWEEN J.N.A.R.D.D.C AND NATIONAL ALUMINIUM COMPANY ON DT.-7.04.[illegible] AT SMELTER PLANT, ANGUL

PERSONS PRESENT;

M/S.JNARDDC	M/S.NALCO
1. MR. E.JANKO, UNIDO EXPERT	1. MR. B.K.DUTTA,[illegible]
2. MR. A.K.BABU, SCIENTIST	2. MR. S.P. MOHAPATRA, [illegible]
	3. MR. S.N.SINGH,[illegible]
	4. MR. A.L.BAGJI,SR.[illegible]

NALCO Smelter produced about 129020 MT green anode blocks and [illegible]0 baked anode during 1993-94. The anode dimentions are as follows:

Green anode ; 1460mm L x 1010mm W x 554mm H = [illegible] Kg.

Baked anode : Avg. wt..: 1142 Kg.

Each baked anode has 6(six) holes. The apparent density of green anode is 1.56 gm/cc and 1.50 g/cc for baked anode.

NALCO smelter uses these anodes in 4(four) pot houses. The hot metal production for 1993-94 is about 196000 MT. The cells are 180 KA prebaked ones with 16 anodes per cell. At a current efficiency higher than [illegible]% the avg. net carbon consumption is about 440 kg/ton of aluminium. The DC power consumption is about 14100 KWH/Ton of aluminium.

2. JNARDDC representatives studied the production technology of green and prebaked anodes as well as assembly technology and situation in cell pot houses together with NALCO specialists, evaluated the current production situation as following:

2.1 Production of green anode paste is according to production instruction within permissible variation of parameters.

2.2 Production of green anode blocks is carried out by vibropress (2 nos.) supplied by Pechiney which have following shortcomings:

- The press supported on springs are balanced unsatisfactorily; so the movement is divided in vertical and horizontal direction. The horizontal force is more than vertical force and [illegible] the uniform compactness throughout the anode.
- The press is not monolith and equipped by two lifting doors resulting reduction of impact of vibro compression and increase the crack in Anodes of such big dimension.
- The press is not equipped with suction of fume (vacuum [illegible]) affecting bulk density of green anode blocks.
- The working space around the press is not sufficient which hinders the repair and maintenance of the press.

[illegible] uniform structure characteristics, cracks and damages, as well as high percentage of waste of green paste are observed.

It is also found that the capacity of hopper to store green anode paste is insufficient at the pressing temperature for longer time which leads to waste of green anode paste.

2.3 Baking of anode blocks:

The baking process is carried out in ring furnaces (open type) consisting of 74 sections having 6 pits in each section. In general 4 fires are working. The main problems in baking section at present are:

a. Periodical explosion at exhaust gas system resulting in damages at gas pipe line, scrubbing chambers as well as stoppage of baking furnaces for long period and reduction of capacity.

b. Life of flue wall bricks are very less. The life of initial brick lining was 68 heats with 3 fires; this reduced to 45 during second generation bricks and at present about 28 with 4 fires. This may be due to non satisfactory quality of bricks and improper heating along the section which results in periodical formation of over heated zone.

2.4 Production of assembled anode

Anode nipples are joined with baked anode by pouring molten cast iron. The cast iron is melted in induction furnace (3 nos.). At present 1 part of fresh cast iron is used with 3 parts of recycled cast iron in the furnace.

The furnace is having monolithic lining of 99% silica and 1% boric acid(binder). The operating temperature is 1370 deg. - 1450 deg.C. The problems faced by this unit are:

a. Cleaning system of recycled thimbles are not working resulting in adherance of C and fluoride salt with the thimbles being recycled.

b. As result of above, formation of [illegible] in the induction furnace which corrodes the [illegible] at much faster rate reducing lining life.

3. On the basis of problems mentioned in para 2.1 [illegible] cooperation with JNARDDC in the following areas:

- Improvement of equipment and technology of mixing and [illegible] for reduction of anode paste and green anode block [illegible].

- Improvement of baking process to eliminate [illegible] [illegible]

-- Elaboration for increasing life of bakaing furnace flue wall refrarroty bricks.

-- Elaboration for increasing the life of induction furnace lining.

4. JNARDDC Experts offer to NALCO some additional control method for testing raw carbon materials,green and baked anodes.

5 Both JNARDDC and NALCO representatives elaborated proposals for cooperation in carbon production technology as mentioned in para 2 to 4 which will be presented to JNARDDC management for detail study and NALCO will be informed accordingly.

J.N.A.R.D.D.C	NALCO
(Dr. E.Ianko)	(B.K.Otta) DGM (Opn.)
(A.K.Basu) 7/4/94	

Encl.: ANNEXURE-I

STATUS REPORT ON CARBON ELECTRODES (RAW MATERIALS, TECHNOLOGY QUALITY SPECIFIC CONSUMPTION ETC.) IN THE ALUMINIUM INDUSTRY IN INDIA

In India, at present the four producers of aluminium and anode carbon are INDAL, HINDALCO, BALCO, and NALCO. These smelters are equipped differently and they have specific problems regarding supply of raw materials, production technology, and laboratory control systems. In this report, I review the current situation at the smelters in India including

- Quality of Calcined Petroleum Coke and Coal Tar Pitch
- Production of green anode paste and green anodes
- Baking equipment and baking procedure
- Quality of anode paste and prebaked anodes
- Specific problems in Soderberg anode technology
- Carbon laboratory control system

This report is prepared on the base of our visits to smelters (protocols in Annexure IV) and work programme for my second mission.

1. COAL TAR PITCH

The typical pitch specifications used in HINDALCO, BALCO, NALCO, INDAL smelters are represented in Table 1.1. To review the softening points they are according to equipment and temperature conditions opportunities of every smelter. But for BALCO Smelter softening point of pitch could be increased up to 95-100°C (Ring and Ball).

Lower limit of quinolene insoluble content is not normally specified for all smelters. For all smelters according International standards lowest quinolene insoluble content limit can be specified as 6-7%. The upper limit for prebaked anodes production must be not higher than 11-12% and for Soderberg paste 9%. Some variations out of these limits are possible, but their effect on the quality of anode paste will be rather negative.

Benzene (toluene) insolubles are specified for three smelters only. That is not normal, because benzene insoluble (toluene insoluble) is the main binder component of the pitch. Typical specifications for benzene insoluble (toluene insoluble) is following:

Medium softening point pitch 26-31% (29-35)

High softening point pitch 28-34% (31-38).

Coking values (or fixed carbon) are according to international experience, as well as ash content and impurities.

Various parameters for CT pitch provided by the producers (the steel plants) indicate considerable variations.

Pitch from Bhilai Steel Plant has very low benzene and quinolene insoluble contents. Pitch from Rourkela Steel Plant had quinolene insoluble content upto 15%. Pitch from Vizag Steel Plant had rather low benzene insoluble content and coking value. All actual specifications are not stable from party to party.

The plenty of crude coal tars in Indian Steel and Chemical Industries provide production of coal pitch with various specifications. But the agreement between smelters and distillators on the basis of cost criteria leads to abnormal variations in quality of pitch supplied to the smelters. Due to this all smelters are supplied pitches with softening point from 90 to 112 ^{o}C, quinolene insoluble from · to 14% etc. which are not upto smelter's specifications. Such situation adversely affects the anode paste (prebaked anode) quality and optimal anode paste composition and green anode quality cannot be maintained.

We propose to establish systematic pitch data bank for all producers and to elaborate optimal pitch supply scheme according to smelters specifications. This scheme should include quality specifications, minimum transport costs and all other requirements and characteristics.

We also recommend to all anode producers to follow pitch specifications for medium and high softening point varieties, as well as for control methods. For softening point test we recommend Mettler, for coking value - Conradson, also to include toluene insolubles instead of benzene insolubles. Some additional laboratory equipment is need for that.

Sodium content is very important characteristic from the view point of baked anode carboxy reactivity and must be included in such specifications (Normal specified limit is 500 ppm.).

Viscosity, distillation and impurities (S, Fe, Si, & Ni) control is reasonable only for periodical investigations, mainly by independent organisation such as JNARDDC.

2. CALCINED PETROLEUM COKE

Specifications of coke produced by Indian Calcining Companies are represented in Table 2.1.

Six main C. P. Coke domestic calciners produce the coke material of rather close quality with low content of sulphur and impurities. Only C. P. Coke from Bihar Carbon has very high ash, and metals impurities content.

Reviewing of the situation in C. P. Coke supply reveals that there is wide variation in real densities. In 1993-94 at HINDALCO smelter real density varied from 2.04-2.11 g/cc against smelter specification 2.05-2.07 g/cc. At BALCO Smelter real density went up to 2.07 g/cc, but for VSS condition 2.03-2.05 g/cc is optimal. NALCO uses C. P. Coke with real density from 2.0-2.072 instead of 2.04 g/cc (min.).

The establishing of data bank on C. P. Coke actual and typical specifications in JNARDDC could be very favourable for improvement of C.P. Coke distribution system.

Analytical control system in Indian aluminium and calcining industry is not uniform. Practically normal coordination between suppliers and smelters is absent. So a very important task of carbon laboratory at JNARDDC is to organise such system and recommend most suitable testing methods, specially for regular (typical) parameters: Real Density, Bulk Density, Resistivity, volatile matter and sulphur content.

3. PRODUCTION OF GREEN ANODE PASTE

Indian aluminium Smelters have absolutely different production equipment and technological schemes for preparation of green anode paste.

BALCO, HINDALCO Smelters have periodical production scheme and equipped by batch mixers. HINDALCO Smelter has manual weighing dosing system of dry aggregates with collection of dry materials in moving car. In spite of rather old dosing system the last one maintain a good condition of equipment and satisfactory accuracy of granulometric composition.

BALCO Smelter is equipped with automatic weighing and batching system which permits to guarantee high dosing accuracy, instant regulation and changing of granulometric composition.

NALCO Smelter has the most modern dosing and mixing equipment working in continuos scheme.

In the following we try to compare some technological parameters in green anode paste and green anodes production. Granulometric composition (dry aggregate) are represented in Table 3.1 (plant A - NALCO, plant B - BALCO, plant C - HINDALCO)

Difference in the granulometric compositions reflects the requirement to anode of small and big dimension.

1460 x 1010 x 550 mm	|	big anodes (NALCO)
Avg. Wt. - 1140 Kg	|	
500 x 480 x 425 mm	|	small anodes (HINDALCO)
Avg. Wt. - 155 Kg	|	

Biggest size particles -12+4.75 mm and -6+4.75 mm are comparable with anode dimension, because the size of biggest particles must be proportional to anode dimension directly. But limitation of coarse fraction -12+4.75 mm for big anodes in such boundaries are not satisfacted, because variation between -12 mm and 4.75 mm is not under control. Fraction 12-10mm, 10-8 (6) mm must be controlled.

So if size variation removed to 4.75 mm cracks and cavities in baked anode will be formed, if size variation removed to 12 mm, the apparent density of green and baked anode will reduce. Normally particles size distribution in that fraction must be relatively uniform. The control of separate fractions and summary granulometric composition for such distribution is very actual.

For estimation of fine dust quality percentage we represent some additional information in Tables 3.2 and 3.3 (ALCOA), for three sorts of cokes with

- High bulk density
- Medium bulk density
- Low bulk density

For preparation of summary dry granulometric composition with maximum bulk density the fine fractions (-48+100, -100+200 and -200 mesh) must be dosed as pointed in Table 3.3. So if low bulk density coke is used the sum of that fraction to compare with coke of high bulk density has to be increase up to 52.4 % compare with 44.3 %. This information is very important for normal regulation of current granulometric composition.

Soderberg anode paste granulometric composition is comparable with international experience and anode paste on the base of actual composition has satisfactory quality:

		NORMS	ACTUAL
1.	Apparent density, g/cc	1.4 min	1.49
2.	True density, g/cc	1.99 min	2.01
3.	Porosity, %	30.0 mix	25.75
4.	Mechanical strength, Kg/cm^2	300 min	312
5.	Resistivity,Ohm mm^2 / m	75 max	64.62
6.	Ash, %	-	0.35

4. PRODUCTION OF GREEN ANODES

4.1 Small Anodes (HINDALCO)

The smelter produces green blocks in closed form by pressing (total pressing force 850 Ton), with a rather old conventional process which is not being followed in new international practices.

Visual inspection of surface structure of green anodes, by JNARDDC experts revealed the following :

- Middle and long horizontal cracks at the center of anode.
- Aggregation and bad pressed structure on the top of anodes (specially at the area of nipple holes)
- Other damages like cavities, structure defects, concealed cavities.

the three operating cycles : weighing - compacting - discharging are performed simultaneously at three different stations.

The Swiss R&D Carbon Ltd., Zurich has developed and patented a new vibrocompactor which is now in successful operation at Alu-Chemie in Rotterdam. It has a paste feed rate of 40 tons/hour and a production rate of 48 anodes/hour average. The last one is suitable for both smelters too.

For NALCO the installation of new vibro compactor will be required in the near future. Tadjic, Australian and Indian smelters (equipped by FBC machines) have similar waste problems and these problems are not resolvable without the changing the vibro compactors to more perfect ones.

But at NALCO the vibro equipments designed so close that reconstruction opportunities are very limited. The most practical steps for improvement of current situation are the following :

- To select properly designed vibrocompacting machine with vacuum facilities and uniform monolith (that is very important for big size anodes) for installation on separate area (out of existing house). That is an extremely difficult task.

- To design and install a separate line for processing of green anode waste (crushing, screening machines, storage capacities). That is actual for processing of green and baked anode waste. A new batch mixer machine must be installed for melting and preparation of green wastes for vibro compacting. Heated green wastes will be given in Buss mixer with a separate conveyer line.

5. BAKING PROCEDURE

HINDALCO and NALCO smelters have baking ring furnaces of open type. Generally the baking process (Baking temperature schedule, process control facilities, firing cycle, rate of heating, etc.) follow the normal baking procedure. But some serious technological problems we met at NALCO where gas fire and explosions occur periodically. The smelter are requesting more and more stringent control and regulation for the exhausting of tars and hydrocarbons.

The main reason of explosions and fire in the exhaust gas duct is reduction of temperature of flue gas which results in deposition of pitch fumes where the temperature

These defects reveal that process of pressing is not sufficient enough. This is due to specific characteristics of pressing process in closed form without vibrating, and also perhaps not sufficient temperature of pressing and granulometric composition. The last two points need special investigation/study.

4.2 Big Anodes (NALCO)

Production of green anode blocks is carried out by vibro compactors (Fiver Cail Babcock type machines, France) which have following shortcomings :

- The press supported on springs and rubber pads is balanced unsatisfactorily; so the vibrating movement is divided in vertical and horizontal direction. The horizontal force is more than vertical force which affects the uniform compactness throughout the anode.

- The press mold is not monolith and equipped by two lifting doors resulting reduction of impact of vibro compression and increases the crack in anodes of such big dimension.

- The press mold and cover weight are not equipped with suction of fumes (vacuumation) affecting bulk density of green anode blocks.

- The working space around the press is not sufficient which hinders the repair and maintenance of the press.

Due to these shortcomings, low bulk density of green anode block, non-uniform structure characteristics, cracks and damages, as well as higher percentage of waste of green anodes are observed.

It is also found that the capacity of hot anode paste hopper to store at the pressing temperature for longer times is insufficient which leads to waste of green anode paste.

Vibro compacting procedure and Vibro machines are very important problem for both smelters. From this viewpoint our information about vibro compacting procedure and machines will be interesting for both smelters.

A new turntable machine Humboldt wedag AG (KHD) is recommended for both smelters. This machine differs from the vibrating compactor with sliding table insofar as is lower than the fume condensation temperature particularly at the bend and bottom zone of the duct.

The gas temperature reduces when large quantity of cold air leaks from the area of preheating chambers and mixes with the gases.

The air leakage may take a number of paths such as :

- the opening at the head wall cover
- the opening at the peephole cover
- the cracks in the brickwork at the top of the flues
- the packing coke

The leakage calculations were made for the first section next to the exhaust manifold, where the pressure difference between the flue and atmosphere is greatest. The height of the nonporous part of the flue wall was varied from 0.03 to 0.36 m. In addition, a foil was placed in the packing coke.

The distribution of the air leakage in the heating zone of the ring furnace is following (Kg/s and %):

		Kg/s	%
-	Head wall cover	0.0272	14
-	Peephole cover	0.0488	25
-	Brickwork cracks	0.1154	58
-	Packing coke and foil	0.0055	03
-	All openings	0.1969	100

According to these results the sealing of the brickwork at the top of the flues would be the most effective way of reducing of the air leakage in to the flue walls. Due to the constraction of the flue and the high operating temperature, cracks may form in the brickwork after a few operating cycles.

For elimination of explosions and fire in exhaust gas duct, our recommendations are the following:

1. Maximum hermetisation of cold loaded chamber and preheating zone chambers by granular coke protection covering and plastic sheets (NALCO practice). Air intake through the leakages must be minimum.

2. Stable furnace operation and observation of prescribed temperature curve. Zero pressure position at the area of equalising chamber (between last firing sections and beginning of cooling position).

3. Installation of special pressure/temperature control devices in exhaust gas duct after the furnace which give immediate signals about increase of pressure/temperature. This device should be connected with the control system for immediate switching off all exhaust manifolds, firing frames and cooling manifolds.

4. Installation of emergency steam lines for immediate steam injection into the exhaust gas duct for extinguishing the fire automatically (after receiving signal from special control devices under point 3).

Low working life of flue wall bricks of baking furnace is the next serious problem of NALCO smelter. Initially for this Smelter the life time of flue wall bricks was about 68 fires; this reduced to 45 during second generation bricks and at the moment to 28 fires. This is a very poor result in comparison with international experience.

F. Keller (Aluminium Chemie, Rotterdam, B.V.) indicated that they have achieved an average 100 fire cycles of first generation and 80 fire cycles for second and third generation bricks for similar open ring type baking furnace.

Negative result in NAALCO is due to unsatisfactory quality of bricks and improper heating schedule along the section (including high temperature gradient in preheating zone and formation of overheated zones).

The comparative Russian Standard for refractory bricks includes

Al2O3	50 % min.
Fe2O3 + TiO2	3 % max.
CaO + MgO	1 % max.
Na2O + K2O	0.9 % max.

Haogovens Al Huttenwerk GmbH (Germany) specified refractory brick for Al_2O_3 content upto 55%.

Haogovens Al Huttenwerk GmbH (Germany) specified refractory brick for Al_2O_3 content upto 55%.

NALCO specification for fluewall refractory bricks specifies Al_2O_3 content as 43% minimum. Other impurities are not specified. But mullite with Fe_2O_3 + TiO_2 content more than 3% has rather low spalling and creep resistance.

We recommend to revise the mullite specification according to international standards.

6. BAKED ANODE QUALITY

Big baked anode quality (NALCO):

Baked apparent density, T/M^3	-	1.5
Crushing strength, kg/Cm^2	-	> 300
Resistivity, micro-ohm m	-	< 60
Ash, %	-	0.70
Fe, %	-	0.133
Si, %	-	0.027

Small baked anode quality (HINDALCO)

Baked apparent density, T/m^3	-	1.59 min
Resistivity, by Carbotest, (micro ohm meter)	-	100

It is clear that test methods for the determination of prebaked anode properties are very poor for both smelters.

The aluminium industry has developed standardised tests to evaluate baked anode samples (Table 6.1). These methods are helpful in diagnosing anode problems and improving net carbon consumption.

In 1993, W.K. Fisher (R&D Carbon Ltd., Switzerland) developed the following formula relating net carbon consumption to anode quality parameters and current efficiency. Actual net carbon consumption varies between 399 to 465 Kg/T Al. This formula is suitable for analysis of current situation at smelters and improvement of production data.

For example HINDALCO smelter has good opportunities to reduce net carbon consumption down to 399 Kg/T Al, NALCO smelter down to 420 Kg/T Al. For realising these improvements the programme of green anode procedure and equipment must be realised as well as stabilization of all baked anodes parameters.

The next rather important problem: the carbon control laboratories of smelters are not properly equipped to control prebaked anode quality. Particularly, recent control methods and equipment must be implicated as early as possible

7. SODERBERG ANODE TECHNOLOGY IMPROVEMENT

Soderberg Cells Smelter (BALCO) is equipped with cells pots of medium capacity (104 kA) with high and stable technological characteristics and good anode parameters. With normal technological regulations, the current efficiency must be not less than 89 %, electrical power consumption 15,000 kWH, anode paste consumption 510-520 kg/ton of aluminium. But at the moment the technological situation at the smelter is unsatisfactory.

Anode formation parameters are the most critical points (current distribution, temperature of liquid part, cone height, etc). Current distribution per stud varies to a large extent due to variations in stud length. Anode top temperature is 160°C, against normal temperature of 130-140°C.

On the basis of received information, we elaborated draft programme of co-operation. According to this programme, calibration of existing current studs for improvement of current distribution in anodes is most important and long term point.

Other activities are installation of artificial cooling system in liquid part of anodes, improvement in anode case design, repairing of damaged current studs by friction welding method, etc. as well as improvement of raw carbon materials quality are also very actual. We are also planning to fulfil a long time programme of laboratory assistance JNARDDC to improve raw materials and paste quality control system.

Totally this programme is sufficient for reduction carbon consumption by 30 - 40 kg/ton of aluminium.

atmosphere during the anode baking process. Regulations imposed on PAH exposure have initiated a change in VSS anode operation from wet to dry anode tops.

The objective of simultaneous low PAH emissions and baking of anode with optimum baked carbon quality implies a more critical control of operation parameters, raw materials and paste production. The principal difference between a wet and a dry anode paste is reduction of pitch content by 2-3% absolute and converting the liquid part of the anode top into the dry consistence (solid or soft). When dry anode process is optimal the PAH emission (tars and benzo-a-pyrene) reduces 0-10 times and achieves the standard norms. For example, operational data NORSK HYDRO VSS Plant are following :

	Conventional VSS operation	Dry anode operation
PAH exposure, micrograms/m^3	120	22
Current efficiency, %	86.9	88.3
Anode voltage, mV	600	450

For BALCO Smelter the conversion to dry anode technology must include the following steps.

- Conversion from medium to high softening point coal tar pitch with following specification :

Softening Point, °C	105 - 110 (Ring & Ball)
Quinolene Insoluble, %	10 - 12
Benzene Insoluble, %	30 - 35
Density, g/cc	1.30 min
Coke value	55 min

  C.P. Coke is the same, without modifications.

- Granulometric composition of dry anode paste is rather close to regular paste, but fine fractions (-100 mesh) must be reduced down to 36-38%, including extra fine (-200 mesh) down to 28+/-2% because quinolene insoluble content in high softening point pitch is relatively higher.

- Special kind of anode paste as "**Stud hole paste**" production must be organised. This sort of paste is going for filling of stud holes. Quantity of such paste is 7-9% to total paste production and separate production and storing are needed. Pitch content in stud hole paste is 32-33%, granulometric composition is following.

- 6 +4 mm	3.0 % max.
- 4 + 2 mm	18 +/- 2 %
- 2 + 1 mm	18 +/- 2 %
- 2 + 1 mm	by difference
- 100 mesh	12 +/- 2 %
- 200 mesh	34 +/- 2 %

The + 4 mm fraction is eliminated because big coke particles obstructs to studs putting.

- A special correcting sort of anode paste is recommended for production (more dry with pitch content by 2% lower than conventional dry). Quantity is 2-3 % of total production. This sort of paste is going for correction of relatively "wet" anodes.

- A special transport system for separate transportation of these sorts of anode paste is needed.

- Stud cranes must be reconstructed for dry anode procedure operations. Every crane must be equipped by dosering system, consisted of small hopper, dosator and target - device for aiming of feeding conveyer to stud hole. That is a most expensive part of the converting programme.

- All studs with uneven weld surface must be machined and calibrated very carefully.

- More critical control of operation parameters, raw materials and paste production are needed.

CONCLUSIONS :

On the base of this Status Report the cooperation programmes between JNARDDC and the Smelters were elaborated and discussed with smelters management (Annexure-VI). Our conclusions and recommendations are included in these programmes as a working plan of JNARDDC for next 2-3 years.

TABLE 1.1

SMELTER'S PITCH SPECIFICATION

Smelter	SP, °C Ball and Ring	Coking Value % Min.	QI, %	BI, %	BETA RESIN % Min.	DENSITY g/cc	ASH % Max.	MOISTURE %	Na PPM	Fe PPM	FIXED CARBON %
Plant A *	105 **	-	5.0 min	-	20	1.30 min	0.5	-	-	-	52 min
Plant B ***	90 - 95	53	10 max	30 min	20		0.3	-	-	-	-
Plant C	103-113	56	10-14	30-37	24	1.30 min	0.2	0.5 max	400 max	200 max	-
Plant D	86-105	50	5-10	25-30 ****	20	1.28-1.30	0.2	0.2	-	0.02	-

* VISCOSITY IS SPECIFIED AS 20,000 CPS MAX (140°C) and 3,000 CPS MAX (160°C)
** METTLER
*** DISTILLATION IS SPECIFIED AS 1.0 % MAX (300°C and 7.0 % MAX (360°C)
**** INSOLUBLE IN TOLUENE
QI - Quinolene Insoluble BI - Benzene Insoluble

TABLE 2.1

SMELTER'S CALCINED PETROLEUM COKE SPECIFICATIONS

Smelter	Real density g/cc	Ash, Max. %	VM Max. %	B.D. Min. g/cc	El. Res. Max. ohm mm²/M	Moisture % Max.	Chemical Analysis, % Max. Si	Fe	Ti	V	S	Ni	Granulometry %
Plant A	2.04 * MIN	0.5	0.5	-	550	0.5	0.04	0.06	-	0.025	3.0	0.02	+ 4 Mesh - 25% Min. - 48 Mesh 15% Max.
Plant B	2.03-2.06	0.45	0.5	0.79	600	0.2	0.05	0.10	0.01	0.01	1.2	0.01	+12mm: 8-17% -0.296mm: 2-4%
Plant C	2.05-2.07	0.45	0.5	0.8	550	0.1	0.035	0.035	-	0.02	1.2	001	-
Plant D	2.03-2.06	0.5	0.4	0.8	-	0.1	0.05	0.04		0.03	1.2	0.03	

* Toluene density

TABLE 3.2

AVERAGE VIBRATED BULK DENSITIES OF FRACTIONS OF THREE GROUPS OF CALCINED COKES

Vibrated Bulk Density, mg/m³

Coke Type	- 4 + 8	- 8 + 14	- 14 + 28	- 28 + 48	- 48 + 100	- 100 + 200	- 200
High Bulk Density	0.87	0.91	0.95	0.97	0.99	0.99	1.05
Medium Bulk Density	0.83	0.88	0.90	0.93	0.92	0.97	1.07
Low Bulk Density	0.78	0.79	0.81	0.85	0.90	0.94	1.07

TABLE 3.3

AVERAGE WEIGHT PERCENTAGES OF FRACTIOINS FOR MAXIMUM BULK DENSITY SIZINGS OF THREE GROUPS OF CALCINED COKES

Coke Type	- 4 + 8	- 8 + 14	- 14 + 28	- 28 + 48	- 48 + 100	- 100 + 200	- 200
High Bulk Density	10.3	21.8	15.9	10.0	10.0	12.0	22.3
Medium Bulk Density	9.4	18.7	15.1	10.1	8.3	13.8	24.6
Low Bulk Density	6.0	7.2	15.3	9.1	11.2	14.6	26.6

Table 6.1.

R&D Carbon Ltd.	PREBAKED ANODE			JULY 1992
PROPERTIES		**METHOD**	**UNIT**	**TYPICAL RANGE**
APPARENT DENSITY BAKED		ISO N 838	kg/dm^3	1.50 - 1.60
SP. EL. RESISTANCE		ISO N 752	$\mu\Omega m$	50 - 60
FLEXURAL STRENGTH		ISO N 848	MPa	8 - 14
COMPRESSIVE STRENGTH		DIN 51910	MPa	40 - 55
ELASTICITY MODULUS	Static	-	GPa	3.5 - 5.5
	Dynamic	-	GPa	6 - 10
COEF.THERMAL EXPANSION	20 - 300 °C	-	$10^{-6}K$	3.7 - 4.5
FRACTURE ENERGY		-	J/m^2	250 - 350
THERMAL CONDUCTIVITY		ISO N 813	W/mK	3.0 - 4.5
DENSITY IN XYLENE		ISO DIS 9088	kg/dm^3	2.05 - 2.10
AIR PERMEABILITY		-	nPm	0.5 - 2.0
CO_2 REACTIVITY	RESIDUE	ISO N 804	%	84 - 95
	DUST	-	%	1 - 10
	LOSS	-	%	4 - 10
AIR REACTIVITY	RESIDUE	ISO N 805	%	65 - 90
	DUST	-	%	2 - 10
	LOSS	-	%	8 - 30
ELEMENTS XRF	S	-	%	0.5 - 3.2
	V	-	ppm	30 - 320
	Ni	-	ppm	40 - 200
	Si	-	ppm	50 - 300
	Fe	-	ppm	100 - 500
	Al	-	ppm	150 - 600
	Na	-	ppm	150 - 600
	Ca	-	ppm	50 - 200
	K	-	ppm	5 - 30
	Mg	-	ppm	10 - 50
	F	-	ppm	150 - 600
	Cl	-	ppm	10 - 50
	Zn	-	ppm	10 - 50
	Pb	-	ppm	10 - 50

DRAFT PROGRAMME FOR COOPERATION BETWEEN JNARDDC & BALCO IN CARBON PRODUCTION AREA

1. Technical assistance to achieve reduction of anode paste consumption from present level of 570 kg/ton of Al by about 30 kg.

1.1 Installation of artificial aluminium plates cooling system in liquid part of anode.

1.1.1 Modifying the existing experimental cooling system until the top temperature comes down to 140°C.

1.1.2 Testing the modified cooling system at 1-2 cells for 6 months.

1.1.3 Equipping cell pots by cooling systems in full volumes.

1.2 Calibration of existing current studs for improvement of current distribution in anodes.

1.2.1 Preparation of methods for calibration of studs in two size groups (175 +/- 5 and 185 +/- 5 cm, for example).

1.2.3. Preparation and implementation of installation programme for cell pots houses.

1.3 Improvement of anode cases design for increasing baking cone at the corners.

1.3.1 Testing the heat insulation of the top corners of anode casing (5-10 anode casing)

1.3.2 Full volume installation of heat insulation in cell houses.

1.4 Repairing of damaged/short length current studs by friction welding method.

1.4.1 To investigate current situation in friction welding technology and to recommend to BALCO the welding machine of the most suitable construction.

2. Improvement of raw carbon materials quality.

2.1 To establish data bank on carbon materials. JNARDDC requests BALCO to furnish relevant informations (at least 2 times per year)

2.2 To review the situation every year with BALCO in the field of C.P. Cokes and Coal Tar Pitches quality.

2.3 To recommend future coarse of action in selection of quality coke and pitch suppliers.

3. To conduct specific testing of raw carbon materials and anode paste.

3.1 To analyse the viscosity and distillate content of pitches of different suppliers.

3.2 To analyse the grain stability of C.P. Coke of different suppliers

3.3 To investigate CO_2 reactivity, air permeability of baked anode paste.

4. To conduct specific testing of cathode block samples for swelling index by Rapoport equipments.

5. To prepare recommendations for improvement of carbon laboratory equipment.

6. To elaborate and agree with BALCO for proposals to introduce Dry Anode Paste technology, including high Softening point Coal Tar Pitch Specification, Dry Anode Paste composition (granulometric composition and pitch content), Soderberg anode formation procedure, anode stud cranes reconstruction

ANNEXURE-I

DRAFT PROGRAMME FOR COOPERATION BETWEEN JNMARDDC & NALCO

1. REDUCTION OF ANODE WASTE:

1.1 Reduction in generation of green anode paste and green anode blocks.

1.1.1 Improvement of existing pressing process by proper balancing of vibrating process(checking and replacement of springs if required ; installation of vibrating control devices).

1.1.2 Improvement in granulometric composition , temperature and mixing condition.

1.1.3 Selection of optimum temperature and time for pressing.

1.1.4 Improvement in loading situation of green anode paste into vibro form.

1.1.5 To investigate existing press equipments and to select properly designed press with vacuumation system and monolith form, considering space available and continuous production of anode.

1.2 Reduction in existing stock of scraps of green anode paste, green anode block and baked anodes.

1.2.1 On basis of international experience, to elaborate and offer to NALCO a separate line for crushing & screening the existing stock of wastes.

2. ELIMINATION OF FIRING FUME DEPOSITS AND EXPLOSION IN EXHAUST SYSTEM.

2.1 To install flue gas sampling system for systematical analysis of the gas.

2.2 To install control system to detect fire in gas duct and to prevent explosions.

2.2.1 To install protection system for release of gas pressure and switching off burners and air blowing systems.

2.2.2 On the basis of international experience, to [illegible] and propose to NALCO methods for elimination of explosions.

2.3 After installation of control devices mentioned in 2.2 to carry out investigation for selection of optimum baking process parameters to achieve fumeless flue gas.

3. IMPROVEMENT OF REFRACTORY BRICK OF BAKING FURNACE

3.1 To study existing brick specification and compare with international practices for similar anode size and furnaces and to recommend proper brick's specification.

3.2 To represent for NALCO to replace existing ceramic protection tubes of thermocouples with heat & chemical resistant steel protection tube. NALCO will furnish the size of existing tube.

3.3 To select & recommend optimum thermocouples type for temperatures upto 1250 deg.C.

4. INCREASING OF LINING LIFE OF INDUCTIOIN FURNACE

4.1 Improvement of preparation of recycled cast iron thimbles for elimination of carbon and fluoride impurities.

4.2 To investigate existing situation (materials, procedures) being carried out in induction furnaces lining and present proposals to NALCO for increasing life time of lining. NALCO has furnished all kinds of specifications to JNARDDC.

5. TO INVESTIGATE/STUDY SCOPE FOR REDUCTION IN NET CARBON CONSUMPTION - (20-25 kg/T Al.) FROM EXISTING LEVEL.

5.1 Raw carbon materials.

To analyse existing situation of raw carbon materials, i.e. CP Coke & CT pitch and to recommend best selection of supplies.

5.2 To conduct specific testing of baked anodes (CO_2 reactivity, air permeability) at JNARDDC for reduction of oxidation of anodes in cell pots.

6. JNARDDC is setting up a data bank on carbon raw materials and production technology. NALCO is requested to furnish informations as sought from time to time. The situation will be reviewed every year with NALCO for improvement of raw material and process technology.

ANNEXURE - I

DRAFT PROGRAMME FOR TECHNICAL ASSISTANCE & COOPERATION BETWEEN JNARDDC & HINDALCO

1. Technical assistance in modernisation of pressing process for green anodes.

1.1 To investigate current situation in press production of green anode including

- To produce & investigate some batches of anodes at higher pressing temperature (125 - 130 deg.C)
- To produce & investigate some batches of anodes with correction of granulometric composition & pitch content
- To investigate different properties of anode at different points of block by taking out core samples (50 mm ⌀ x 60 mm H).
- To evaluate and conclude about opportunities of improvement in carbon structure of anode at existing pressing capacity.

1.2 To compare the results of study at 1.1 with international figures for checking the performance of existing press. If required, to investigate and study to replace existing press with modern ones.

1.2.1 To elaborate and agree with HINDALCO for requirement to introduce vibro press (specification, capacity considering space available at anode shop and productivity.)

1.2.2 To investigate with manufacturers of vibropress, to compare their performance levels and to recommend HINDALCO for selection of most suitable Vibro Press Type.

2.0 Carbon Laboratory Preparation:

The facilities available at Carbon Laboratory is felt insufficient. To assist HINDALCO to introduce new equipments in the Carbon Laboratory and train people to carry out diferent testing of carbon materials.

2.1.1 To assist HINDALCO to carry out specific test of anode carbon materials in the Centre.

2.1.2 To analy the viscosity and distillate content of pitches of different suppliers.

2.1.3 To analyse grain stability of C.P. Coke of different suppliers.

2.1.4 To investigate microscopic structure characteristics for green anode paste (particle distribution, aggregation, micro & macro porosity)

2.1.5 To investigate CO2 Reactivity of baked anodes

2.1.6 To investigate air permeability of baked anodes.

2.1.7 To investigate bulk density, real density and porosity of baked anodes.

2.1.8 To investigate specific electrical resistivity of baked anodes.

2.1.9 To investigate mechanical strength of baked anodes.

2.1.10 To investigate electrical resistivity of cathode materials.

2.1.11 To investigate cathode swelling index by Rapoport equipment.

2.1.12 To investigate mechanical strength of cathode blocks.

3.0 To establish data bank on carbon materials. JNARDDC requests HINDALCO to furnish relevant informations as requested from time to time.

3.1 To review the situation every year with HINDALCO in the field of Carbon production technology and raw materials.

3.2 To recommend future course of action in the production technology and raw materials.

4.0 Technical Assistance to achieve reduction in net carbon consumption from present level of 430 Kg /ton of Al by about 20 Kg.

4.1 To study and characterize the anode raw materials received from different sources.

4.2 To study the CO2 reactivity, air permeability of existing baked anodes samples.

4.3 To coordinate with National Laboratories/Institutes to carryout Thermal Conductivity, Air reactivity test of anode samples.

4.4 To compare all results of 4.2 & 4.3 with the expected range and to investigate areas for improvement of properties.

4.5 To make bench scale test of experimental paste of modified granulometry and pitch content for improving ~~of~~ anode properties.

WORKSHOP ON

PRODUCTION OF CARBONACEOUS MATERIALS AND ANODE TECHNOLOGY IN ALUMINIUM INDUSTRY

JAWAHARLAL NEHRU ALUMINIUM RESEARCH DEVELOPMENT AND DESIGN CENTRE, NAGPUR.

MAY 26 & 27, 1994.

Programme

Thursday May 26, '94

9.00 - 9.15 hrs	Inauguration
9.15 - 10.45 hrs	The Current Situation in Indian Aluminium Smelter on Supply of Carbon Raw Materials, Production of Anode Carbon and Cell Anode Technology - Proposals and Recommendations : Dr. E. Ianko, UNDP/UNIDO Expert, JNARDDC Nagpur
10.45 - 11.15 hrs	Tea Break
11.15 - 12.45 hrs	Continuation of Dr. Ianko's Lecture
12.45 - 14.00 hrs	Lunch
14.00 - 15.00 hrs	Presentations from the Industrial Participants
15.00 - 16.00 hrs	Equipments, Methods and Procedures - Presentation of Proposal for Cooperation : A.K. Basu, JNARDDC Nagpur
16.00 - 16.30 hrs	Tea Break
16.30 - 17.30 hrs	Visit to Carbon Laboratory of JNARDDC

Friday, May 27, '94

9.00 - 10.30 hrs	Carbon Production Technology, Industrial and Laboratory Equipments for the Nineties : Dr. U. Mannweiler, R&D Carbon Ltd. Switzerland
10.30 - 11.00 hrs	Tea Break
11.00 - 13.00 hrs	Discussion on Possible Long Term Cooperation between industries and JNARDDC, Conclusions and Recommendations

JAWAHARLAL NEHRU ALUMINIUM RESEARCH DEVELOPMENT AND DESIGN CENTRE, NAGPUR

WORKSHOP ON PRODUCTION OF CARBONACEOUS MATERIALS AND ANODE TECHNOLOGY IN ALUMINIUM INDUSTRY

DATE 26-27TH MAY, 1994

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WORKSHOP ON PRODUCTION OF CARBONACEOUS MATERIALS AND ANODE TECHNOLOGY IN ALUMINIUM INDUSTRY

DATE 26-27TH MAY, 1994

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RECOMMENDATION OF THE WORKSHOP ON PRODUCTION OF CARBONACEOUS MATERIALS AND ANODE TECHNOLOGY IN ALUMINIUM INDUSTRY

1. The subjects considered in the workshop cover wide spectrum - from raw carbon materials quality and specifications to anode technology in aluminium industry. It is recommended that regular interaction between C.P.Coke / C.T.Pitch producers and users industry should be organised.
2. Training programme for personnel from smelters and producers of carbonaceous materials like C.P. Coke & C.T. Pitch should be organised regularly, at least once in a year to provide adequate updated information on laboratory techniques for quality control and production parameters for anode manufacturing. JNARDDC may act as nodal agency for this programme involving national and international experts in the field. Other consumers in this field, e.g., ferro-alloys and other industries may also be invited in this programme.
3. JNARDDC may function as an independent test house for testing and characterisation of carbonaceous materials particularly for those which are of interest to aluminium smelters.
4. Indian raw petroleum coke is costlier than imported ones; but the quality of imported raw petroleum coke is inferior to that of indigenous one. It is proposed that the coke calciners should introduce proper blending technology after characterising all the raw petroleum coke qualities in order to meet the specifications of Indian aluminium smelters .
5. Possibilities to reuse smelter waste products, i.e., spent potlining material, to be explored.
6. The area of raw carbon materials (specifications, control methods, laboratory equipments) requires special attention, hence, it is proposed to establish a systematic data bank on C.P. Coke & C.T. Pitch at JNARDDC. This will include quality, specifications, and recommendations for improving raw materials quality.
7. The cooperation programme in the area of carbon production between JNARDDC and smelters must be formulated and started sometime in the third quarter of 1994.