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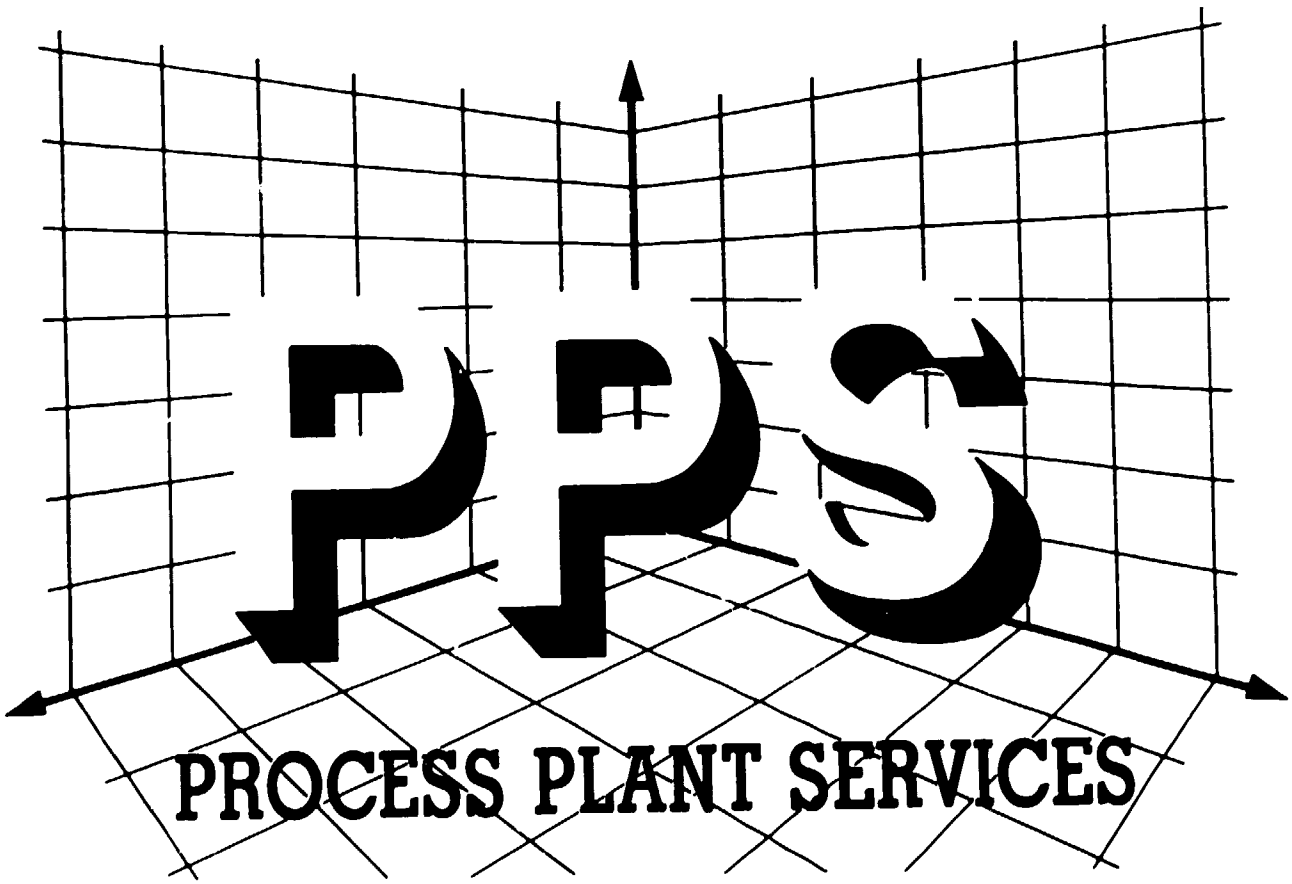
FINAL REPORT

UNIDO PROJECT DP/IND/84/001

PERFORMANCE OPTIMISATION OF PETROCHEMICALS COMPLEX AT INDIAN PETROCHEMICALS CORPORATION LIMITED, BARODA

PHASE II – ADDITIONAL SERVICES



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1.0 SUMMARY

Imperial Chemical Industries PLC (ICI) undertook the UNIDO project PD/IND/84/001 Performance optimisation of Petrochemical Complex at Indian Petrochemicals Corporation Ltd (IPCL) Baroda, India Phase II between April and December 1985. With additional services associated with Energy Management being executed in 1987.

The objective was to investigate and recommend operational improvements at the complex. The overall improvement was to be achieved by considering improvements to equipment, to operational and maintenance procedures and through improvements to equipment, to operational and maintenance procedures and through improvements in skills and knowledge of the IPCL staff.

The scope of the project was divided into six activities.

Environmental Control
Material Management
Welding Activities
Rotating Equipment
Corrosion Monitoring
Energy Management

In each of the six areas one highly qualified consultant was nominated to visit the complex at Baroda for one, or in most cases two, separate visits.

The first visit was used to investigate and assess the scope of each activity, to transfer knowledge,skills and experience and to prepare an interim report. The reports contain a vast amount of relevant technical and managerial information and set out the findings of the investigations together with the consultants conclusions and recommendations.

Throughout the investigation the consultants were required to analyse and probe for the root causes to problems and to then give their objective recommendations for an attainable solution. Where this was not possible the problem was further investigated in the UK by ICI experts and the solution taken back to IPCL during the consultants second visit.

The second visit was used to review the interim report with IPCL and to further investigate similar and new problems. It was also an opportunity to reinforce the major recommendations of the report and to achieve their implementation.

The project also required that ICI should help prepare IPCL staff for the new Maharashtra Gas Cracking Complex by providing a training programme associated with each of the six activities. Each training programme lasted for four weeks and was conducted in the United Kingdom. It was possible during the first visits of the consultants to assess the needs of the trainees and to design the training programmes to accommodate their particular requirements.

Overall the project was highly successful and was seen to meet the objectives of all six activities. The training programmes were considered very effective and both ICI and IPCL were satisfied with the execution of the project and the high standard of the consultant's work.

Further, the unified approach adopted between the consultants and the trainees is a model that is shown there to be extremely effective in achieving performance improvements.

2.0 INTRODUCTION

2.1 BACKGROUND

ICI was invited by UNIDO in August 1985 to submit a written proposal for the second phase of the project DP/IND/84/001 Performance Optimisation complex at Indian Petrochemicals Corporation Ltd: (IPCL) Baroda and was asked in 1987 for a proposal to execute additional work.

The scope of the Phase II was divided into five areas; Materials Management; Environmental Control; Welding Activities; Rotating Equipment and Corrosion Monitoring. Energy Management being covered in the additional work.

The request emphasised that a quick response and the ability to commence work quickly was important.

ICI submitted the proposal in October 1985 and was pleased to be awarded the contract on 4 March 1986 and that for the additional work a year later.

The team leader was briefed in April 1986 and the first consultant arrived at Baroda at the beginning of May 1986. Each of the five consultants visited the factory over the next five months and promptly prepared their reports back in the UK. A set of interim reports were submitted IPCL during the intervening period between visits. The findings of the consultants contained in the reports were then discussed during the follow up visit.

The training of IPCL personnel in the UK was undertaken shortly after each consultant's visit and the consultants and team leader returned later in the year to further assist and debrief. The final debrief was concluded in December 1986. A timetable of the visits and training programmes is contained in Appendix 1.

2.2 OBJECTIVES

2.2.1 Project Objective

The object of the project was to investigate and then help implement operational improvements at the Petrochemical and Plastic complex, Baroda, belonging to IPCL.

The overall improvement was to have been achieved by improvements to equipment, operation and maintenance procedures and through improvement in skills and knowledge of the IPCL staff at the site.

The project was also planned to prepare IPCL staff for the new plants at the Maharashtra Gas Cracker Complex. (This would involve intensive training in the UK by ICI and other professional organisations).

2.2.2 Consultants Objectives

A) Environmental Control

To assess the current performance of the factory environment against legal standards and to consider how environmental requirements and production trends might change in the future. To make recommendations for technical and organisational changes that would enable the factory (including the new plants) to meet these legal constraints.

B) Material Management

To propose changes to the Materials Management function to improve its operation and provide the necessary management information to enable effective control of this function.

C) Welding Activities

To advise and assist IPCL on how to improve their existing welding techniques with particular reference to special metals and alloys.

D) Rotating Equipment

To survey and examine the major items of equipment and compare operating and maintenance procedures. To advise and assist IPCL on monitoring mechanical performance and to help develop modern maintenance techniques. Advise on the interpretation and diagnosis of performance problems.

E) Corrosion Monitoring

To examine existing equipment and procedures on installations used to prevent and monitor corrosion. To advise and assist on improvements by the introduction of modern techniques that will accurately monitor and minimise corrosion.

F) Energy Management

To identify the principal areas where specific studies and advise are needed to determine any specific training for the IPCL trainees.

3.0 PROJECT EXECUTION

In each of the activities one highly qualified expert was nominated to act as consultant. Drawing on their experience they prepared audit plans appropriate to the requirements of this project. They then visited the Baroda site and investigated in depth the scope of their activities and made initial recommendations. On returning to the UK, each prepared a thorough report (with assistance from colleagues) with full recommendations. The proposed training programmes were discussed during the first visit and amended where necessary. After completion of the UK based training and an appropriate period given for the consideration of the reports, a final visit by the

consultant to Baroda concluded the work activities and completed the transfer of skills.

Overall the organisation and arrangements for the project went very well. After a few initial accommodation adjustments and a short period of culture acclimatisation, the consultants quickly made progress towards their objective. The timetable contained in Appendix 1 represents the relative time spent on each activity and the period between visits and training. Before the first visit it was requested by the customer that the proposed time planned for each activity would be more profitably spent by the consultants at Baroda. Therefore the original timetable was revised to maximise the consultants' time in India as illustrated in Appendix 1.

3.1 THE MAJOR EVENTS OF THE VISITS AND THE TRAINING PROGRAMME

A) Environmental Control

The Visits

Dr Norcross visited the site for five weeks during June and July 1986. He carried out an extensive environmental audit to:

1 Assess the current performance of the site against the standards set for it by legal constraints and by public and political pressures.

2 Consider the ways in which the legal constraints and other pressures would change in the future.

3 Make recommendations about technical and organisational changes which are required to enable the Baroda site and the new Maharashtra Gas Cracking Complex to meet its environmental obligations in the future.

Dr Norcross went on to consider how environmental affairs are managed at IPCL and the extent to which it is meeting its environmental obligations. He reported on the planned changes in production and in environmental protection. He considered both these topics against the stiffening of legal constraints and recommended measures to enable the site to meet its needs of the future and to lower costs and improve efficiency.

Dr Norcross returned to Baroda for four weeks in November and December 1986. During this visit he went into more depth on the positive contribution IPCL were making to the environment by the significant use of horticulture, the afforestation of large area of derelict land and the operation of an experimental farm. Much of this later work considered the complex interaction of the site effluents with the human and natural environment.

The Training Programme

Four IPCL personnel visited England for four weeks in September 1986.

They were:

Dr R B Mohite, Quality Control Manager
Mr S Darshan, Deputy Maintenance Manager
Mr U S Mehta, Microbiologist
Mr J P Pandya, Environment and Ecology Manager

On the basis of Dr Norcross's appraisal in July 1986, a training programme was agreed, taking into account the differing needs of the trainees.

Visits were paid to ICI production sites at Billingham, Wilton, North Tees, Huddersfield, Runcorn and Hillhouse. These were used to study effluent treatment arrangements, environmental control and monitoring.

Visits were also made to one complex and one simple effluent treatment plant operated by regional water authorities and to a nuclear power station.

Two days were spent at the ICI laboratory of marine and fresh water sciences. The four also had a course on how to train and coach other people and on presentation skills.

The IPCL team stayed together for most of the time but special requests were catered for, that allowed for a four day visit by Mr Pandya to local farms, the Forestry Commission and a parks department nursery. Likewise there were trips by his colleagues to visit other ICI production sites.

Overall the trainees were satisfied with the programme and remarked that they had learnt a great deal. They had made contacts inside and outside ICI that should be very valuable in their jobs at IPCL. ICI was also satisfied with the organisation of the course.

B) Materials Management

The Visits

Mr J Atherton visited the site for four weeks during August and September 1986. He investigaged the current practices of the Purchasing department and commented upon the roles of the purchase officer, finance officer and their interaction with plant personnel.

Mr Atherton followed the materials management system from the production plant request to the purchasing department and analysed how the order was processed. He then considered the storage of the items until they were delivered to the plant and how the financing of the order was achieved. As a part of his investigation, the

consultant visited the various stores around the site and inspected both the equipment and the procedures. He was able to discuss with the materials management department a comparison of functional procedures and the benefits that a computerised system would provide. He did however gain an insight to the scope of the problem associated with replacing the current manual system with a computerised one.

Mr Atherton revisited the Baroda site for two weeks in December 1986 and was asked to analyse further topics such as the quantity of insurance spares needed as a cover for breakdowns, methods for protecting stock from corrosion and damage, how to deal with surplus materials from a completed project and to help produce a procedure for the inspection of spares.

The Training Programme

Two IPCL personnel visited England for four weeks training in September 1986. They were:

Mr H M Bhatt, Deputy Materials Manager
Mr L P Patel, Deputy Materials Manager

The trainees were first introduced to the purchasing and supply department where they received hands-on experience on the procedures for purchasing, methods of deciding when to buy, how much how often, selecting a supplier and how best to pay. The trainees inspected the stores section at Wilton where they studied the stores system before familiarising themselves with the computer systems used in the stock control office. In the Stock Control office they learnt the procedures for storing and delivering items, requisitioning them, monitoring stock levels and providing information to management. A useful period was set aside at the end of the programme for a course in negotiation skills.

C) Welding Activities

The Visits

Mr R H Thompson and two welding technicians visited the site for four weeks in May 1986.

They visited the plant problem areas and discussed possible solutions with production, maintenance and inspection personnel. The technicians demonstrated specific welding techniques while Mr Thompson inspected IPCL's equipment and commented on its availability, maintenance and possible replacements. He also assessed the standard of supervisors and craftsmen and freely gave his comments for improvement. Detailed repair and welding techniques for a wide range of metals were discussed and a wealth of information on welding procedures was passed on. Many documents and specifications were handed over and indepth discussions on particular problems were arranged for the UK training visit.

There was no requirement for a return visit by Mr R Thompson after the training visit but close contact has been maintained.

The Training Programme

One IPCL personnel visited England for four weeks in July 1986.

The trainee was:

Mr K V Mokasi, Senior Welding Officer

After a general introduction to the Wilton site the trainee returned to the Olefines plant where they discussed in depth, particular problems on furnace alloys and heat exchanger leaks He witnessed the ICI approach to

rebuilding a heat exchanger using advanced repair equipment. Where repair is not possible the trainee was introduced to ICI techniques and procedures for plugging leaking heat exchanger tubes. In the workshop he was shown that ICI is a world leader in In-situ machining and that it operates propriety and ICI designed equipment. Merlin, probably the world's most advanced computerised maintenance management system for managing maintenance work including costs, timing and resources, was demonstrated. The replacement of heavy wall, large diameter pipework is particularly difficult and ICI described its methods and illustrated them by a site visit. The trainee attended a week long course on how to avoid defects in welded joints run by the School of Welding Technology at Cambridge.

During the consultants visit, IPCL showed considerable interest in orbital welding of heat exchangers and the welding of special nickel alloy materials. To illustrate and demonstrate these techniques the trainee was taken to ICI's west coast facility where for many years ICI has been pioneering the methods. The trainee was able to see in practice the various techniques. To conclude the programme the subject of quality assurance was discussed and the most relevant topics previously discussed were given more time.

D) Rotating Equipment

The Visits

Dr H B Carrick visited the site for three weeks in September and a further two weeks in December 1986. During the first visit he surveyed the major items of equipment and compared the operation and maintenance procedures with ICI practice. Most of his time was spent with members of the Rotating and Machines cell visiting plants on the site and listening to accounts of problems both historical and current. Dr Carrick was able to use his knowledge and experience to give the ICI approach and recommendations on a wide range of

possible solutions. He was able to give a presentation to the cell on non return valves and centrifical compressors and also inspected the condition monitoring equipment that is available to IPCL, giving ICI's view on their potential use and some recommended equipment additions. During his second visit Dr Carrick spent a major proportion of his time on the Olefine plant exhaustively discussing current problems such as steam turbine fouling and how to improve performance monitoring, and the operating efficiency of the larger machines. To find the cause of the steam turbine fouling required intensive investigation and analysis of steam and water laboratory data. There was also a general discussion with senior operating managers with the objective of reviewing the report and discussing further work. During discussions with the trainees in the first visit it was obvious that the IPCL would benefit considerably if they could visit the manufacturers of the major pieces of their equipment and so on the consultants return the training programme was revised.

The Training Programme

Two IPCL personnel visited England for four weeks in October and November 1986.

The trainees were:

Mr P K Acharaya, Senior Maintenance Engineer
Mr R D Solanki, Senior Maintenance Engineer

Both trainees had a very busy travel schedule to maintain and were fortunate to be able to visit specialist manufacturers and experts throughout Europe. Visits were made to the National Centre of tribology to learn about lubricants and lubrication. Visits were also made to Siemans in Germany, Dressers in France, Howdens in Scotland and Scientific Atlanta in the south of England. At Teesside they visited the Billingham and Wilton sites where they

discussed many common machine problems and covered many important operational topics such as machine start up and shutdown procedures and trip systems.

E) Corrosion Monitoring

The Visits

Mr R F Smith visited the site for four weeks in May 1986. He spent all of his time with the Corrosion and Inspection Group. Some time was spent inspecting the non destructive testing equipment (NDT) and metallurgical laboratory equipment and giving recommendations of further purchases and suggestions of how the equipment might be better utilised.

The identification of how ICI could improve the procedures carried out by IPCL fell into two areas.

1 Specific plant problems which required close examination and the typical approach that ICI would take to diagnose the problem.

2 General topics of corrosion monitoring and related NDT techniques universally used throughout the site.

By visiting most of the plant areas and discussing a large number of problems, Mr Smith was able to define a number of these general topics and was then able to provide comment and suggestions.

Wherever possible Mr Smith tried to give immediate suggestions and recommendations to particular problems. If this was not possible then the details and sometimes a sample were brought back to the UK for further analysis and the results conveyed back to IPCL during the consultants second visit.

Mr Smith had an opportunity to make a presentation to the whole Corrosion and Inspection Group and felt that it was very well received.

Before he left in May he discussed the training needs of the two IPCL personnel and a training programme was agreed. On returning the consultant organised the programme and attended some of the events.

The second visit to Baroda was for two weeks in September 1986. Mr Smith reinforced some of the points made during the first visit and provided feedback on the particular problems that had been researched in the UK between visits. He was also able to pick up some more problems which had occurred during his absence.

During both visits much time was spent with Dr Basil, an IPCL corrosion expert. They discussed in great depth, electrochemical corrosion evaluation techniques and how to transfer laboratory results to operating plants. Both experts found these discussions extremely useful.

The Training Programme

Two IPCL personnel visited England in July 1986 for four weeks.

They were:

Mr P Brahmbatt, Corrosion and Inspection Engineer
Mr T R Patel, Corrosion and Inspection Engineer

The trainees were guided around the Petrochemicals and Plastics Division plants at Wilton and Billingham where they had the opportunity to discuss with ICI corrosion experts the 'state of the art' in corrosion technology and common problems.

They were introduced to the Physics and Raiosotopes services group and were shown a number of radiotracer techniques as well at IRIS - Internal Rotary Inspection System for inspecting heat exchanger tubes of which they had shown much interest during Mr Smith's first visit.

Specific hands-on training was given in relevant NDT techniques such as Flash radiography and hot ultrasonics.

The trainees visited the Materials Group laboratory gaining hands-on experience of laboratory techniques used in corrosivity testing and corrosion sample analysis.

Time was spent with Mr Smith, the consultant, discussing and reviewing IPCL's particular problems and solutions were sought while in the UK.

F) Energy Management

The Visit

Dr C Baker visited Baroda for 4 weeks during May 1987. During this time he addressed the question of the most efficient use of energy in a manufacturing complex in order to maximise added value of the products and minimise energy expenditure.

In order to do this the processes, utilities and organisation were studied and recommendations made in the field of strategies for improvement.

The Training Programme

IPCL managers visit ICI Billingham for a 4 week training programme in June/July 1987. During this period they were given a wide exposure to both the practical and theoretical aspects of Energy Management by specialists from both Billingham and Wilton sites.

4 DISCUSSION OF CONSULTANTS FINDINGS AND RECOMMENDATIONS

The Reports

Each ICI consultant produced a very detailed and professional set of reports on his return to the UK.

Within the reports the consultant recorded his observations, his understanding of the situation the organisational structure and management roles.

He commented on his findings and freely gave the ICI approach to reviewing and solving many of the problems. Considerable mention was made of tried and tested ICI procedures and techniques. Throughout the report his (and his colleagues) recommendations were fully explained and very effort was made to try to help and assist IPCL to improve their operations and procedures.

4.1 FINDINGS OF THE CONSULTANT

A) Environmental Audit

Liquid Effluents

Apart from waste oil, the only liquid effluent is waste water. It is treated at the plant and/or the Central Waste Water Treatment plant (CWWTP) before discharge to the Baroda effluent channel.

Abnormal and unpredicted short loads of effluents from the production plants can upset the operation of the CWWTP and lead to effluent from IPCL exceeding one or more of the tolerance limits of the Water Consent. This causes embarrassment to management because of the technical problems raised at CWWTP and also the need to explain the reason of the excursions to the authorities.

The final effluent pumped into the Baroda effluent channel is frequently above the consent limits because of unnecessary dumping of untreated effluents down the storm water channels.

In the report the consultant expands on the causes of liquid effluents and gives a full list of recommendations to help solve the problem practicably. It is not expected that the new and expanded facilities will cause any problems to the existing effluent treatment plant.

Emissions to Atmosphere

IPCL emit gases from 11 stacks and 4 flares. The main pollutant is SO_2 and the quantity is calculated from the fuel content. IPCL has no reason to believe that they operate other than within the Air Consent and there is no

evidence that emissions are a hazard to the environment or a nuisance to local people. The Air Consent does however require the measurement of stack gas emissions and up to now IPCL has done no measurements. They are now however, investigating how gas sampling could be best carried out and in order to comply with the Air Consent, IPCL has ordered four ambient air monitoring stations, a fully equipped mobile van and meteorological station. They were expected to be in operation during March 1987. Careful design of all future stacks and the use of new measuring equipment will minimise stack gas ground concentrations.

IPCL has a good air pollution record compared to local industry and is intent in complying fully with the Air Consent.

Solid Waste

Normal industrial waste is removed by contractors. Toxic and hazardous waste is disposed of in a controlled tip but this is viewed by IPCL to be unsatisfactory and they plan to close the tip and incinerate most of the waste. Consideration is also being given to deep and secure landfill for some of the waste.

The future needs for solid waste disposal have been included in the incinerator design and new landfill methods.

Future Control

IPCL is currently operating within statutory tolerance limits. These are seen to be stringent compared to international standards. It is therefore unlikely that there will be many changes to these limits in the foreseeable future. However the state government is obtaining more authority to inspect and control emissions and IPCL must be seen to meet these limits at all times.

Conclusion and Recommendations

The Audit has shown that IPCL devote a great deal of effort and resources to environmental protection and achieve a large measure of success. In addition, the corporation is making a contribution to the improvement of the environment by planting trees and gardens and by their irrigation trials using treated factory effluent.

A new environmental law recently passed will probably require IPCL to operate within specification at all times. This is especially important if the treated water is to be used safely for irrigation and watering livestock. In order to achieve this requirement it was recommended that IPCL implement changes and improvements in three areas:

- organisation, training and motivation
- purchasing of equipment
- research, investigation and trials

The consultant's main contribution was in advising and organising, training and motivation since IPCL already use sophisticated equipment and are continually making technical improvements.

For example it was recommended that formal arrangements should be established between CWWTP and production management in order to define the quality and quantity of effluents which are acceptable for treatment and an action which can be taken when there is an abnormal shock load of effluent. Training and motivating both shop floor workers and management to become more conscious of effluent treatment might reduce much of the avoidable pollution such as that caused by spillage down the storm channels.

Many of the equipment items discussed during the first visit have already been arranged. Three of the planned modifications to the water effluent treatment process were completed and the performance of CWWTP has improved significantly. It now remains a top priority that the rest of the plans be implemented as soon as possible.

Much investigative work could be done by management to define cost saving projects that will also reduce effluent discharges. Such as finding sales outlets for hazardous wastes and replacing large open ground sludge drying beds with equipment.

IPCL management have agreed to give their utmost attention on how to implement changes in organisation and further improve training and motivation.

B) Materials Management

The Materials Management department were seen to provide a very creditable service and the staff were committed to improving their performance.

Management Procedures

One of the greatest obstacles to the improvement of materials management is the very rigorous control procedures surrounding the raising of orders. This causes a very long delay that requires the user to anticipate the likely future needs rather than the actual and so encourages inefficiency and over ordering of items. The result is a higher than necessary inventory coupled with hidden costs to production plants in obtaining materials. It was suggested that IPCL must replace these rigorous controls by the delegation of authority.

Purchasing

This problem of overwhelming bureaucracy was also seen to reduce the efficiency of the purchasing system with too many signatures required to place an order. Again it was recommended that this procedure be replaced by the delegation of purchasing power.

Stock Control

Stock control could be significantly improved if it were automated by a computer. This would eliminate the time consuming, manual effort of reviewing stocks and chasing up exhausted stock. Confidence in the system would reduce overhigh stock levels and facilitate improvements in re-ordering and maintenance of adequate levels.

The current practice of materials management bearing the cost of stock was identified as counter productive and was recommended to be discontinued. In future the reordering plant should be charged on the requested items when received in stores.

A major exercise is required to be carried out in the stores to identify all unusable items and either dispose of them or charge them to the plant that requested them. Some concern was expressed regarding the safety aspect of manhandling drums and cylinders. Specifically designed equipment was brought to the attention of management.

Computer System

The scope for improvement provided by computerisation is enormous. Currently IPCL has a large and complex manual system which is very slow and laborious. It was seen as paramount that IPCL should introduce a fully integrated and

dedicated computer to operate the purchasing and material control systems. Data stored would be available for fast retrieval and the information would be up-to-date and accurate.

Conclusion and recommendations

Overall the Materials Management System at Baroda works well if not slowly. A number of philosophical and policy changes such as delegation of authority and reduction in bureaucracy would help reduce frustration and improve planning procedures.

IPCL should seriously consider the installation of a fully computerised purchasing and material control system.

C) Welding Activities

Employment

It was noticed by the consultant that there was a different emphasis on the numbers of manpower employed at Baroda compared to ICI in the UK. ICI is predominantly a western based company operating in a world market while IPCL primarily supplies its home market. This requires that ICI reduces manpower to an absolute minimum while IPCL is encouraged to offer employment to the local community.

It was also observed that IPCL has many more layers of management than ICI. This may be because ICI has developed roles of greater personal responsibility as a consquence of more delegation of authority than is the present case in IPCL.

Selection of Supervisors

The selection of supervisors through seniority and promotion

was considered by the consultant to be less effective than the ICI system of promotion by merit. In IPCL there is the possibility that the best man might not be chosen for the job. The consultant recommended that the candidate be chosen through a selection event that identifies potential and merit and then be given a wide breadth of experience in other skills before promotion to supervisor. A training programme should be followed up immediately.

Craftsmen

There is need for extensive training of all craftsmen to upgrade and extend their skills.

Quality Assurance

Quality assurance could be improved by better understanding of job procedures and communication of job requirements.

Equipment Maintenance

All equipment is suffering from lack of maintenance. It is important that a maintenance procedure be drawn up to provide for routine maintenance and rapid response to breakdowns.

Welding Techniques

The discussions covered a wide variety of welding techniques on many types of material. For individual observations and recommendations see Page 11-23 of the consultants report. The major topics discussed were the welding of furnace alloys, welding repairs to leaking heat exchangers and the latest techniques for welding special Titanium, Tantalum and Nickel alloys. Both companies have had similar problems with high temperature alloys but the two companies have different approaches to repairs. These differences were discussed in detail and the exchange of information should

benefit each company. IPCL is contemplating the purchase of orbital welding equipment to carry out tube to tube sheet welding on heat exchanger tube bundles. ICI has considerable experience operating such equipment. The consultant recommended the use of such equipment but was concerned that its full potential could only be exploited if the project leader was competent and knowledgeable in welding and that he is trained by the manufacturer to a high standard. The team leader should then have the equipment operators fully trained and geared for what is a highly skilled operation. Overall the consultant suggested that IPCL should not be over-ambitious in expecting quick results and that further discussions with ICI would be advantageous.

The technicians demonstrated a number of welding techniques on special alloys and the consultant then went on to spend considerable time covering various weld repair techniques, tube plugging and the bending of U tubes.

The visit was concluded by the consultant leaving a list of follow up subjects and contacts that would be covered in the UK training visit.

Conclusion and Recommendations

The consultant spent the majority of his time reviewing particular fabrication problems and helping IPCL to consider a different approach to firstly finding the cause of the problem and secondly reconsidering the method of repair. IPCL has a lot to learn about the very latest welding equipment and techniques and hopefully the visits and training programme have increased their knowledge with particular respect to the welding of special alloys. Overall it is recommended that the IPCL personnel receive more training and experience in these techniques.

D) Rotating Equipment

Rotating Machines Cell

It was evident that the role of IPCL Rotating Machines Cell (RMC) is mainly advisory. It was suggested by the consultant that RMC should operate more closely with the production and maintenance personnel and that there should be joint ownership of critical machine problems. This would allow RMC to be exposed to a wide range of machines and problems by which they could develop expertise through exposure.

It was surprising to find that RMC were not consulted earlier for their input into new projects. There seems to be scope for developing the role of RMC in support of both process development and projects.

Performance Analysis

Performance analysis of machines could be better used in IPCL as it has been proved at ICI Wilton. It can indicate improvements in efficiency when corrective action is taken and can also be used as an indication of the machine's condition, so allowing the planning of the next overhaul.

Condition Monitoring

IPCL already has the capability to carry out the basic analysis of steady state vibration but they are also interested in evaluating a computer based vibration data logging system. ICI has recently installed such a system and has been operating it for six months. However, to date there is no evidence to suggest that trend monitoring is giving major preventative cost savings. It does however provide the ability to analyse problems which could not be done previously. ICI think it difficult to justify the use

of such equipment if it is expected that predictive maintenance savings will pay for it.

Fouling of Gas Turbine

Probably the largest single machine problem IPCL has is fouling of the Cracked Gas Compressor Turbine on their Olefines plant. This is surprising since ICI has not experienced such fouling in the many years it has been operating this type of machine. After much investigation it was suggested that the cause might be that the steam contains too much silica and this is being deposited on the turbine blades. The consultant recommended that this problem should be tackled at its source by implementing a steam and condensate monitoring programme.

Surge Protection Device

IPCL has had considerable difficulty with the refrigeration compressor on the VCM plant tripping. The manufacturers of the compressor do not usually fit such a device and do not consider it necessary. It was concluded by the consultant that this device was not necessary but he recommended that trip should be converted to an alarm and that if it should alarm an operator be sent to listen to the machine.

Vent Gas from Sour Oil Pots

Significant cost savings could be made by modifying the pipe vents from the ethylene and propylene compressors sour oil pots back to the cracked gas compressor suction. If this simple recommendation was implemented it would pay for itself many times over.

Conclusion and Recommendations

It is not possible to report on all of the specific problems covered in the report but further details can be obtained by looking at Pages 24-20 in the consultant's report. Overall ICI transferred its knowledge and experience and gave many recommendations for resolving the specific problems. There is also an overall recommendation that any work done to a machine should be recorded as a part of a maintenance record and that if possible photographs of work in progress should also be included.

E) Corrosion Monitoring

Inspection Facilities

Overall the IPCL inspection facilities are adequate for routine testing of most installations. Some additional equipment was suggested that would be helpful for solving some particular problems such as IRIS, a technique for measuring the thickness of heat exchanger tubes.

Corrosion Monitoring

IPCL seem to make only minimal use of corrosion monitoring on the plants. It would be greatly improved by the introduction of continuous automatic equipment. By incorporating the instrumentation into the control room it becomes a part of process monitoring and so emphasises that corrosion is also a process concern. During his tour of the site the consultant provided a vast amount of information on the various corrosion monitoring techniques used at ICI. A good example being Radioactivation, which is one of the latest methods in which ICI is leading the way. Each technique was described in detail and the consultant gave ICI's view of its worth and a list of practical applications it had been used on.

Recommendations on which areas IPCL should concentrate on corrosion monitoring were listed and an overall monitoring philosophy suggested.

During the visit it was noted that IPCL does not use electrochemical protection although there might be a strong case for its implementation on suitable structures. By introducing this technique IPCL can extend the life of equipment and save material costs by using cheaper less alloyed steels.

IPCL has a systematic programme of corrosion monitoring of cooling water that seems to be effective. However it was noted that in common with ICI there are difficulties in maintaining minimum velocities in some pipelines. This leads to the accumulation of suspended solids and so causes corrosion.

Corrosion Problems

During the plant visits, it was noted that there was a common problem of corrosion of carbon steel under insulation. ICI has set up a working party to examine the extent of the problem and to propose the causes and possible remedies. A series of simple checks can be used to identify installations most liable to corrosion and ICI listed them in the consultants report.

Also observed by the consultant during his site tour was evidence of failure of some of the structural concrete members. Unless remedied at a very early stage this can lead to very serious problems. ICI repair the corrosion by applying new concrete or using a saturation sealer and building up with a synthetic resin mortar. Both are found to be effective.

Both companies have had common problems with leaks in buried pipelines. ICI has chosen a survey system to locate the leaks and have been quite successful in coping with the problem. As well as passing on documentation ICI recommended that IPCL should contact a number of UK equipment suppliers. The addresses were enclosed in the consultant interim report.

The consultant brought it to IPCL's attention that there have been serious cracking problems of weldments in deaerators. It is now a recognised problem in the western world that receives considerable attention. ICI suggested that IPCL should inspect all its deaerators as soon as conveniently possible.

In addition to these general topics of corrosion monitoring and protection, the consultant compiled a second report of specific plant problems that had been diagnosed during the first visit and researched upon in the UK. Such problems ranged from tube failures in steam generators to pitting of steel tubes and inspection of hydrogen bullets. The list is too large for comment on each problem but as far as possible the consultant made recommendations and suggestions on the direction of investigation and possible solutions.

Latest Technology

IPCL expressed interest in inspecting some types of equipment using Acoustic Emission. ICI has had many years experience and after some initial doubts now consider that the technology has lately improved to such an extent that it can be used successfully in selected cases and is gaining growing acceptance throughout the western world. It has major cost and time benefits over traditional methods and ICI would be very pleased to discuss its application further.

Although IPCL already use some heat exchanger inspection techniques the consultant was able to introduce and describe many more. Being a regular user, ICI was able to assess their value and suggest to IPCL which techniques might be of most use to them.

During further discussions the consultant was able to introduce the latest inspection techniques. These were shadow ultrasonics, hot ultrasonics and flash radiography. They were explained in further detail during the training visit when an ICI expert illustrated their uses and limitations.

Pipework Inspection

In common with IPCL, ICI has a vast amount of pipework which will need inspection during the plant lifetime. Clearly it is impracticable and undesirable to have to inspect all pipework. To keep the time spent on this to a sensible level it is necessary to set up a piping registration system. Actual and suspected corrosion should be regularly inspected and tested. A log of such inspections must be kept up to date.

It is recommended that IPCL adopt such a system in order to reduce the inspection of piping systems to a manageable level.

Conclusion and Recommendations

Mr Smith, the consultant, produced two sizeable reports that included a large volume of ICI papers, manufacturers brochures, trade reports and magazine articles. These papers covered a very wide range of specialist topics and ranged from corrosion monitoring and protection through structural inspection to detailed possible solutions to specific problems. Mr Smith concluded that IPCL was

conscious of the damaging effect of corrosion and was doing much to combat the degradation caused by it. He did mention however, that the personnel of the Corrosion and Inspection Wing were not as far ahead as ICI in investigating and trying out the latest corrosion monitoring and prevention equipment and that his visits and two reports had done much to inform and teach IPCL about the latest state-of-the-art techniques.

F) Energy Management

Conclusions

1 The current awareness and determination of the site management to support a technical energy management resource and the performance of the embraonic resource group is impressive.

2 Where it was possible to assess the performance of the plants on the visit, it appears that this compares favourably with European standards. However, it is possible that the use of electricity is rather higher than will be expected in European processes.

Recommendations

1 A centralised site energy management group should undertake the formulation management of a three "Energy Plan".

2 A regular analysis of process data to establish energy usage should be instituted. A personal computer is recommended as being useful to facilitate this function.

3 Targets should be set, related to production, for both energy and utility consumption. The energy utilisation of the plants should be coordinated on a site side basis, in a two way communications system requiring it to be established.

4 Energy awareness on the plants should be increased by the training and appointment of energy co-ordinators and energy wardens.

5 Increase in the use of plant simulation models for the optimisation of operational perameters.

5.0 CONCLUSIONS

It is important to recognise that although IPCL is a state owned corporation it is operated as if it were privately owned. It therefore has to balance the responsibility of being the most significant employer in the area and operating as efficiently as possible to what is essentially a home market. Overall IPCL were seen to be a responsible, sensitive and competent company but like most organisations there is always room for improvement.

The consultants noticed that there was a great deal of bureaucracy and duplication of paperwork. Although it was recognised that such a cultural characteristic could not be changed overnight each suggested that any reduction would significantly improve the overall efficiency of the corporation. Even a relaxation in the power of authority to sign and pass purchase orders by allowing for more delegation of authority would reduce the time wasted in processing documents. One outcome of this cultural characteristic is the time taken to implement the consultants recommendations. It should therefore be accepted that a reasonable period of time be allocated for their implementation and that close contact with ICI be maintained to provide further assistance and to assess their benefits. There has been however, progress at the complex already for example the completion of three planned modifications

to the water effluent treatment system. These indicate that improvements are being made by IPCL and that the momentum for implementing the consultants recommendations must be sustained and receive high priority.

A proportion of the causes of project and modification time delays can be associated with the difficulty of hiring foreign services and equipment. Indian Industry has the objective of maximising self sufficiency but also to learn as much as possible from outside assistance. Hopefully ICI's involvement with this project will reinforce the view that IPCL can improve its efficiency and operations with the help of western consultants and that close relations between IPCL and ICI can be beneficial to both companies.

The technical and management standards of employees was considered good but could be improved further by greater exposure to more technically advanced companies. This was particularly highlighted when assessing the competence of the welding craftsmen. It was also reflected in the standard of maintenance of plant equipment which was below what ICI would have expect. The solution lies in providing more training and a better understanding of the mechanics and proper use of the equipment.

The Consultants were able during their first visit to assess the training needs of the IPCL personnel and therefore amend the programme to accommodate changes and additions. All of the training programmes were well received and many important contacts and friendships were made. These will be particularly useful for the IPCL personnel back in India.

The consultants were able to visit many of the plants on site and to discuss a large number of problems with operating and service personnel. One finding common to all activities was that the engineering service groups were mainly acting in an advisory capacity. It was seen as very important that these groups should take a more active part in owning the plant problems and that they involve themselves not only in diagnosing and solving but also in design and modification work. This could be achieved by closer links with operating and maintenance personnel as well as more regular, formal meetings.

IPCL was very interested in computerising some of its major functions such as materials management. ICI recognised that there was great scope here for improvement and would be willing to further discuss methods of implementation.

IPCL would also like to discuss future work on an Environmental Impact Analysis to assist them in negotiations with the authorities, to help build on a favourable public image and in planning future developments.

ICI identified that it could help further on a number of general topics.

1 Water technology: There is the opportunity to optimise the cooling water circulation system and water economy in general throughout the site by the use of purified waste water for cooling, washing down production plants and for make-up to the fire water system.

2 Laboratory analysis of olefine plant steam: To detect condensate conductivity on all condensate returning to the boilers and conductivity of final superheated steam. Also to control the silica level in the steam drum. See Page 14 of report on rotating equipment by Dr Carrick.

for a full explanation of this serious problem and the consultants recommendations.

3 Corrosion monitoring: IPCL would benefit further from a long term investigation of corrosion problems and more immediately, further consultancy assistance on more specific problems.

4 Works cost accountancy: There are savings to be made by making services such as water more accountable. By measuring such services and charging them to the operating plant there is an incentive for more efficient use.

5 Appraisal of staff: There does not seem to be sufficient incentive for development and promotion. A few changes to the appraisal system could improve the moral and prospects of the best people. This requires an understanding of the Indian culture of job promotion.

In conclusion. ICI was very happy with the organisational arrangements of this project. ICI consider that the consultants produced reports of a very high standard and that they conducted themselves on a highly professional manner. The training programme was left purposely flexible and was seen to meet the objectives set by IPCL. IPCL seemed well pleased with the recommendations and expressed that they were very satisfied with the quality of work. It was the intention of IPCL senior managers to consider the recommendations in great detail and to start implementing the main ones as soon as possible.

Overall the project was well organised and a very high standard of work was achieved. It was seen to meet the project objective of investigating and recommending improvements to operational and maintenance procedures at the Baroda Petrochemicals complex.

6.0 REFERENCES

6.1 UNIDO CONTRACT: Request for proposal No P85/45 - DP/IND/84/001 - Performance optimisation of Petrochemical complex at Indian Petrochemicals Corporation Ltd, Baroda. Phase II.

6.2 ICI PROPOSAL dated October 1985

6.3 CONSULTANTS REPORT

6.3.1 ENVIRONMENTAL CONTROL: Final Report of an environmental audit of the Baroda Factory complex of IPCL by Dr G Norcross December 1986.

6.3.2 MATERIAL MANAGEMENT: Report on Materials Management, 17 November 1986 and Addendum, 10 December 1986 by Mr J Atherton.

6.3.3 WELDING ACTIVITIES: Observations and recommendations pertinent to fabrication activities on the IPCL Petrochemical Complex by Mr R H Thompson.

6.3.4 ROTATING EQUIPMENT: Report on Rotating Equipment by Dr H B Carrick, 17 November 1986.

6.3.5 CORROSION MONITORING: A report on a survey of the IPCL complex. Corrosion and inspection by Mr R F Smith. Addendum to report: IPCL Plant Problems by Mr R F Smith, 27 August 1986.

6.3.6 Energy Management: Report of visit of Dr C H Baker, May 1987.