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

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MICROPROCESSOR APPLICATION ENGINEERING PROGRAMME

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INDIA

Technical report: Development of microprocessor applications in industrial control*

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

Based on the work of Jan L. Peters,
expert in microprocessor applications in industrial control

Backstopping officer: V. Smirnov, Engineering Industries Branch

United Nations Industrial Development Organization
Vienna

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1/ Please note that annexes A and B are separate documents which are not attached to this report.

I SUMMARY

In order to meet the objectives of the mission as defined in II.A here, the Expert has:

1. Worked in the project centre in New Delhi and the Bagirathi 100MGD Water Treatment Plant and visited the regional centre in Pune.
2. Developed a proposal for the instrumentation and automation of the Bagirathi Water Treatment Plant.
3. Delivered lectures on the algorithms of industrial controls, control loop configurations, System Engineering Concepts, Control System Engineering and Automation Techniques.
4. Appraised himself about the status of industrial control in water treatment , power generation and sugar plants.

The expert has come to the following conclusions:

1. The activities of the Microprocessor programme of promoting improvement of industrial efficiency and quality by accepting modern microprocessor based equipment seems to have taken effect, the industry is aware of the need of these improvements.
2. There seems to be a shortage of experience in certain industries in the application of modern control techniques in the control of their processes.
3. The Centre therefore should, after now having acquired a good standard in single purprose microprocessor techniques, consider to shift their attitude to consulting how to apply the available state-of-the-art multi purprose apparatus in industrial control.
4. Pilot plant automation projects should be considered, where a complete revamping of the control might achieve aedequate results in plant performance, while at the same time engineering teams could obtain the necessary experience for further activities in the same industrial field.
5. Experts should perform pre-feasabilitystudies in different branches of industry to specify the needs for additional optimizing of existing control.
6. An expert should visit Universities and Colleges in India, investigate their programmes and report in detail, in which way the existing curricula should be changed to meet the industries need in operational technology and control systems engineering, and which post graduate courses on the same subjects should be given to enable experienced process and control engineers to update their knowledge.

II INTRODUCTION

A Objectives of the mission

Per the job description prepared by UNIDO, the purprose of the mission of the expert was to advise the centres in development of Microprocessor application in Industrial Control and more specifically to:

1. Appraise himself in the current status of microprocessor application in the Indian Industry.
2. Suggest measures for promoting microprocessor applications in Indian Industry.
3. Suggest development strategy for hardware and software.
4. To deliver lectures on the state of the art of technology.
5. To visit a few industries as appropriate and suggest a plan of action for further development.

B. Activities of the expert.

On arrival on 12 februar, at the duty station New Delhi, the expert was requested as a main task to develop a proposal for the instrumentation and automation of a Water Treatment Plant and, if possible, to complete this before his departure.

As to his opinion his task was within the scope as defined under 5. in the job description and would allow him to perform also the other tasks requested in a usefull way, the expert visited the appointed water treatment plant during the first week of his mission to analyse the process and determine the oprational requirements. In close cooperation with a delightfull assisting operational staff of the plant the necessary information was acquired and the process diagrams could be made. Consequently a first draft proposal of the necessary control systems for discussion with the operational staff of the plant was delivered on 13 march 1987. These discussions took place on 27 march 1987 and after that a preliminary planning for the instalment of the systems and the engineering thereof was produced and presented to the management of the Delhi Water Supply and Sewage Undertaking on 1 april 1987. After discussions on that day a second planning was made and discussed again on 13 april 1987. The final proposal was produced in the period from 10 april to 17 april. This final proposal is attached to this report as annexe A.

The expert participated in an Industry Meet on microprocessors and applications, reading five lectures on system engineering, control system engineering and automation techniques. The Meet took place on 2 and 3 april, the lectures were prepared and lecture notes produced between 13 and 25 march.

The lecture notes of this Industry Meet are attached to this report as annexe B.

From 7 to 9 april the expert visited the project centre of Pune to appraise himself of the activities of one of the smaller centres. There he also visited a sugar research institute and a sugar factory.

From 10 to 11 Bombay was visited to get an impression of the status of control of what is considered the most advanced water treatment plant in India.

In between those main activities the expert had meeting with appropiate engineering groups within DOE (Department Of Electronics) discussing the progress of industrial control in electrical power generation.

Further discussions with visiting representatives of control apparatus suppliers were held and one visit to a supplier gave the expert a first impression of the extent and capabilities of the Indian Instrument manufacturing Industry.

III INSTRUMENTATION AND AUTOMATION OF THE BAGIRATHI WATER TREATMENT PLANT

A. Actual status Plant

The Bagirathi Water Treatment Plant of the Delhi Water Supply and Sewage Disposal Corporation with its capacaty of 100 MGD (= 100 Million Gallon per Day) produces about 50% of the total of this corporations output of clear water. The plant was commissioned only a few years ago. Its input is river water from the Ganges from an intake point about 30 kms from the plant.

The cleaning process is by way of adding chemicals, that cause flocculation of the particles in the water, subsequent sedimentation in clariflocculators and final filtration in sandbedfilters.

At the time of the construction of the plant provisions were made for flow and level measurements through the plant at the following points:

Inputs clariflocculators (8)

Loss of head on filters (40)

Outputs filters (40)

Level clear water reservoirs (5)

Outputs clear water (5)

Mechanical control loops with process powering were made for:

Flow chemicals to mixers upstreams of cariflocculators (8).

Flow through filters (40).

However, calibration of the measuring points primary elements had seemingly not been done and most of the measuring instruments had not been commisioned. During the experts visits to the plant relevant questions from his part concerning the calibration of the primary elements only arouse general doubt about the overall existance of this vital information. Further, the installed measuring instruments were of an oldfashioned nature with probable low accuracy and non standard load dependable transmission systems, these were not considered as usefull for implementation in a modern control system.

The calibration of the primary elements as a necessary condition for such a modern control system has been emphasized in the experts report and suggestions for the realisation of these calibrations have been given.

B. Considerations for the Proposal

After the expert had done the system analyses of the water treatment process, the following general requirement was phased as common target for the plants control systems:

> To produce the necessary amounts of clear water of the best quality as required by the demand of the customers, while using the minimum of raw water, chemicals, energy and manpower in the most economic combination.

Implementation of these conditions came to redefining in terms of smaller process oriented items as follows:

1' To maximize plant capacity:
Establish plant flow partitions through clariflocculators in equal parts.
Establish water flows through filters in equality.

2' To minimize use of chemicals and to obtain clear water of the best quality:
Realise ratio control of added chemicals to raw water flow to clariflocculators with, if possible, pH-feedback from output clariflocculators.

3' To ensure all time plant availability:
Implement all time plant monitoring by installing a base and backup analog instrumentation with provisions for power failures.
Install a central plant control room.
Implement a general plant status alarm system.
Implement remote control of actuators and motors.

4' To assure supervision on plants performances:
Implement electronic supervisory systems for flows throughout plant with hourly and daily registration of integrated flows.

5' To assist in middle and long term plant overhauls and revisions:
Instalment of an electronic control unit for plant control and automation.

6' To reduce labour costs:
Implement sequence control systems for filter backwashing.

As virtually no experience in handling modern industrial control of a water treatment plant is available care should be taken, that the implementation of such control should be in a phased manner, so that operators and operational staff can adapt to the changes in handling the plant without endangering the availability of the total process.

The same applying to the maintenance, adequate measures should be taken to ensure availability of testing equipment, spare apparatus and training of maintenance pesonnel.

C Summary of the proposal

The proposal, added to this report as appendix A, consists of:

1. Requirements to the existing primary elements as to the calibration of these and the addition of primary elements for flow to the filter houses.
2. A base and backup system for central plant control room monitoring of all flows throughout the plant, levels in the clear water reservoirs, positions of actuators and motors as a first step to centralized control and possibility to compare the performances of process subsystems.

   This P & B system is illustrated using P & I diagrams for the whole plant and should allow a good 24 hours per day surveillance of the plant, which in the actual status is not available.

   As for this system nearly all primary elements, measuring principles and signal transmission already are to be installed, it allows the maintenance to start with a relatively simple system to obtain the necessary know how.

   Primary lay outs of control panels and specifications of equipment have been included in the proposal.
3. An alarm system to ensure independant safeguarding of all prominent system functions on basis of highly reliable sensors and an equally reliable alarm treatment system, mainly with level and pressure sensors, the specification of the sensors to be decided on by the operational staff in consultation with the control system engineers.
4. Remote control, allowing centralized on/off and open/close control of individual actuators and motors.
5. Steady state automatic control of individual proces parts as for instance the flow control through a filter and ratio control for the adding of the chemicals.
6. Group supervision by means of an electronic system, monitoring partial flows in the process, calculating and memorizing such partial flows, integrating and reporting these and reporting abnormal statusses and significant differences in comportance for plantmanagement and general management.
7. Group control and automation, handling and controlling functional groups of process elements as filters for filterwashing, cascading level control of a group of filters with the flow control per filter.
8. Plant control and automation, handling long term information to provide for maintenance scheduling as for pumps and filters, mostly combined with: centralized CRT-information on basis of information by exeption, enabling the plant management to obtain fast information on significant issues and abnormal statueses in real-time presentation.

D. Planning

First Phase: Try outs

I Sequence control Filter backwashing

electric actuators for 1 filter 7/87 - 9/87

pneumatic actuators for 1 filter 7/87 - 9/87

PLC automation on 2 filters

II Primary elements Process Instalment and calibration 5/87 -11/87

Flows venturiflume(2), input filterhouses(2),

* if other primary elements necessary delay: 3months

III Ratio Control addition chemicals 1 venturiflume 12/87 - 2/88

Second Phase: Necessary controls for Bagirathi Plant

IV Remaining Primary elements Process Instalment and calibration 3/88 - 9/88

Flows venturiflume, input filterhouses, output filters

outputs clear water, level reservoirs

* if other primary elements necessary delay: 3months

V Base and backup system in panel in central control room 3/88 -12/88

VI Ratio Control addition chemicals remaining venturiflumes 11/88 - 4/89

VII Steady state control flow 1 Filter 11/88 - 2/89

10 Filters + level + feed forward 3/89 - 8/89

40 Filters + level + feed forward 10/89 - 2/90

VIII Alarm system 11/88 - 5/89

IX Remote control motors clariflocculators/filterhouse 4/89 - 8/89

X Electronic Group supervisory Systems 1/89 - 4/89

incoming raw water, water to filters, output clear water

Third phase: Complete Plant Automation

X Distributed Process control system with CRT-based Operator

station or stations for: sequential control of 40 filters

monitoring performance clariflocculators

monitoring chocking filters

sequence-planning filterwashing

planning overhaul filters

monitoring performance clear water pumps

planning overhaul clear water pumps a.s.o. 10/89 - 6/90

Planning engineering

To enable operational staff of the Water Treatment Plant and engineers of MAEP,DOE to obtain the necessary experience in Industrial Control Systems Engineering the engineering of the whole project should be done on site in the following construction:

Appointing Project Management		5/87
Installing in a special office on the plant the engineering team, basically consisting of : three junior engineers of the Water Supply and Sewage Disposal Undertaking of Delhi three engineers of MAEP,DOE, training of staff on following topics: 1) sensors 2) steady state control 3) sequence control 4) control system engineering plus the additional manpower, funds and equipment to allow this team to function as a separate unit at 100% of their capacity		6/87
Appointing one expert as teamleader at 50% capacity		6/87
Activities of team for engineering phase I, in close cooperation with operational staff	6/87 -	7/88
Appointing maintenance crew for industrial control system (training mainly on site by engineering team)		10/87
Planning and defining operational requirements phase III by engineering team, operational staff and project management	4/89 -	8/89
Study-tour by operational staff, engineering team and project management to finalise decisions phase III		9/89
Activities of team for engineering phase II, in close cooperation with operational staff	8/89 -	6/90
Complete Plant Automation Commissioned		6/90

* If any new Water Treatment Plant will be planned with the process and equipment engineering to be executed in the period as proposed above, the engineering team for the plant control and automation should be consulted in the earliest stage about the implementation of primary elements in the process and possible simplifications of the process with regard to the capabilities of modern automation equipment.

IV REGIONAL CENTRE PUNE

A. Activities of the Centre

The Pune centre has as specialty the application of software and hardware in test and measuring instruments and medical electronics. At the moment amongst others the following projects are in development:

1' A relay tester

2' A cardiogram interpretation system.

3' A patient data acquisition system.

The projects are typical single purpose applications, ranging in complexity from relatively simple to quite complicated. For instance the cardigram interpretation consists of three subsystems, sensor adaption, signal identification and expert interpretation system. Of these three the software of the signal identification is compieted, the sensor adaption has been system analyzed and awaits delivery of hardware to be constructed and commissioned. The expert system for final interpretation is still to be done and should be considered as a tough job, as expert knowledge extraction generally is known as quite compiicated.

The centre also conducts courses on microprocessor application, generally on basis of "getting to know the microprocessor". A good range of learning models for hardware implementation and PC's for software development is available.

The centre specialises in single purprose instrumentation, to a large extent limited to laboratory level and conditions, general purprose microprocessor based industrial equipment to use in industrial control and its application is not taken into account and such apparatus is not available in the centre.

The staff of the centre consists of 7 electronic specialists and one junior instrumentation engineer. The complaint of the staff on this partition is, that the States financial conditions for employment of instrumentation engineers cannot match those of industry.

B. Pune College of Engineering

As there is a important working relationship between the Pune Regional Centre and the Pune College of Engineering, the expert has also looked into the College as a source of engineers for the Centre.

The Pune College of engineering has a basic first year for all disciplines. After that six semesters complete the education in the disciplines separatedly. The different disciplines include those for Instrumentation and Computer engineering.

The Instrumentation discipline has a good program of education in a wide range including nearly all subjects in control engineering. The graduates are much sought after in industry. The curriculi indicate, that in the same way as the centre does, the intention seems to be to prepare for single purprose applications in instrumentation and mainly for the construction of the equipment.
Again control systems engineering with multi purprose equipment has less emphasis.
Final independant work for a thesis is limited to about 25% of the last semester.

The computer Engineering Department has an interesting approach towards more industry related hard and software, thus resulting in good possibilities for cooperation with MAEP in software development.
Of course through this path a tendency to more theoretical and scientific inputs influence the total performance of the centre, but this should not be considered as a negative point, as at the same time the additional input of hardware knowledge is most welcome.

C. Sugar Industry / Deccan Sugar Institute

In the neighbourhood of Pune the Deccan Sugar Institute coordinates research, technical training and other services to their members/owners, there are about 90 sugar factories in Maharastra. Nearly 200 scientists, engineers and other workers are employed . Research and training is done in fields varying from sugar technology to sugar engineering and microprocessor technology.
The Institute has helped various member sugar factories in setting up some 20 by-product industries as distilleries, aceton plants a.s.o.
Due to the organisational structure of the Institute their approches and activities can be considered as result oriented.
The list of principal fields of research in the future includes:

1' Computerisation of various cane cultivation techniques.
2' Techniques for minimum steam and power consumption in sugar industry.
3' Complete computerisation and instrumentation of all engineering techniques.
4' Complete on-line brix measurement and control
5' Computerisation of clarification, evaporation and boiling techniques.

Although some of these subjects may still only be in the programm for the future, on the other hand studies on more specific subjects are ready on hand.

Papers from the chief technologist on automation in the sugar factories show well defined targets for this automation with good insights in the possibilities of steady state controllers and enhanced controllers with additional sequential and digital input possibilities. Pilot installations on Pan boiling automation with trials on conductivity control and alternatively viscosity control have already lead to proven advantages in sugar quality, shorter boiling times, reduction in steam consumption, reduced wash water quantities and some other points.

During a visit to one of the member sugar factories it could be seen, that development was not limited to research in the Institute alone. On site a pattern of new and newer sensors/indicators showed a good development of instrumentation and the use of this instrumentation. The newest indigenous electronic instruments were of a good industrial quality and had good performances as stated by the users.

On the other hand the available apparatus in the Institute for training purproses had not evolved with the development in the field. There the instruments were of a much older version and mainly restricted to flow, differential pressure a.s.o. and partly still of the mercury using type with load dependant transmission. Instruction in microprocessor applications was limited to basics of digital electronics assisted by practical training on IC-training kits.

Its seems clear, that in this for india vital field of Sugar Industry all conditions of sensor identification, process know how and target identification are already fullfilled and in different research institutes starts on dedicated control loops have been made.
The next step toward further development should be the implementation of closed loop industrial control on microprocessor basis with structured organisation of these controls.
The necessary know how for this approach should be acquired by establishing an engineering team, which could consist of 50/50 sugar technologists and control system engineers, and giving this team the task of engineering, installing and commissioning the integrated control for one sugar factory as a pilot plant. Subsequent setting up training courses for this kind of process control with adequate practical facilities, preferably on site, should spread the acquired know how.
UN-assistance by sending a control system expert to guide the engineering team could be very usefull.

V INDUSTRY MEET

The expert participated, together with Dr Krishna Kant, Chief Project Coordinator of MAEP and E. Wightman, UNIDO expert, as lecturer in a 2-day Industry Meet on Microprocessor applications for Industrial Control.

This series of lectures had been programmed to highlight the aspects of the introduction of microprocessors from the operational point of view. The general goal was to show, how to match the possibilities of microprocessor based equipment with the industrial need for higher performance in control engineering in terms of quality and productivity.

As a lead theme to show the system engineering aspects the application of modern control to a water treatment process was chosen.

Starting from the basic possibilities for microprocessor applications and the current trials to establish a general Manufacturing Automation Protocol as international standard, it was shown, that the marriage between the conventional EDP-systems (EDP = Electronic Data Processing) and Proces Control Systems is in the making, however that the approach of the EDP-systems engineer toward process control, often referred to as Top-Down approach, and that of the Proces Control Systems engineer, referred to as Bottom-Up approach, require to be reconciled.

The series of lectures presented an example of an extended bottom-up approach for process control and elaborated on such an approch, while the "Top Down" approach was used to formulate a strategy.

As the interconnections required for linking supervisory data will also be applicable to other automation systems, for example computer aided manufacturing, where the same arguments were applicable, this item was also given appropiate attention.

The systematic structure of the lectures was:

Introduction of a case history as a system engineering concept.

Sensor technology as the first basic need for instrumentation and automation.

Present techniques and future trends.

Other tools of the trade for automation such as microprocessor based controllers.

Process Control Instrumentation and communication systems

Application of these tools in system engineering of automated systems for process control.

Analogies in system engineering between Computer Aided Manufacturing and Process Control, particularly in the applications of microprocessors for linking specialised areas of a plant by means of a common database and communication network..

The Meet was well attended by some 50 engineers from differenet branches of industry and as this meet was the first on multi purpose apparatus for industrial control, the reactions on the lectures were lively and diversified.

THERMAL POWER PLANTS

After having completed a succesfull initative on the National HVDC Experimental Line Project the IPAG(= Information Planning and Analysis Group) of the DOE (= Department of Electronics) is now taking the lead in two projects of application of electronic industrial controls in thermal power generation:

1) Incorporation of a Data Acquisition System (DAS) and Artificial Intelligence System (AIS) for the Badarpur Thermal Power Station Unit V.
2) Renovation of the controls of the Keradi Thermal 200 MW Power Plant Unit V by installing a DDC (= Dedicated Digital Control) system for integrated plant control.

It should first be stated, that both projects deserve the nomination of being courageous and showing essential appreciation of the need of looking into the future to control the necessary development in this branch of industry.

The two projects are well chosen as separate items, the DAS and AIS project enables extensive studies on the behaviour of the process, the extraction of information from the process and the use of this information in an expert system, enabling further devicing towards increasing availability, safety and effiency.

The project for renovation by using DDC enables a straight forward engineering on basis of a good initial budget and well defined goals, such as:

- a 2% increase of availability through significant reduction of forced outages
- Better control of process variables resulting in reducing undue stresses and consequently enhancing plant life.
- faster plant diagnostics, enabling diagnostics of subsystem oncoming failures, scheduling maintenance and reducing MTTR and MTTRP times and costs.
- improving interfacing between process control and operators, this enabling more efficient and safe operator interventions and better quality of working conditions for the operators.
- providing training and experience grounds for further application of such systems in other units.

A three years all-in planning from intent to commissioning for the implementation of the new system on the Koradi Unit V with minimal outage of production has been proposed on realistic arguments.

Along with the overall system replacement, secondary plant problems will be tackled, such as implementation of reliable flue gas monitoring, improving coal feeder performances a.s.o. The overall configuration of the proposed control system shows reliable constructions of redundant and/or backed up dedicated controls and proven double data highways towards 2 out of 3 central monitoring CRT stations.

It is the experts opinion, that the organisation of this project is in good hands and that the proposed investments will lead to a fast catch up in Indian power generation towards modern technology.

Without any degradation of this last statement the following might be usefull to enhance the possible results of the project:

1) In the process control engineering studies should be implemented to configurate the control system as to increase the dynamic response of the steam generator. This would enable the unit to follow load demand changes faster and contribute to better frequency control of the grid and in a secondary way attribute to lesser forced outages.

2) Engineering of the control systems should not be limited to DHEL as a seperate supplier, the engineering team should at least include representation of the operational user, because operational requirements come best from operational experience.

VII CONCLUSIONS AS RESULT OF OBSERVATIONS

As a result of his dealings with the Centres, industrial plants and suppliers of apparatus, the expert has come to the following conclusions:

The Indian industry seems to be in a reasonable state as far as process implementation is concerned. Process know how usually is invariable available amongst construction and operational engineers. In industrial control however there is a clear lack of knowledge, especially in control systems engineering. Very often also the need for improvement of effiency and quality by use of good control engineering is mixed up with the possibilities of (and fear of) the labour saving possibilities.

The Centres for Microprocessor applications engineering under the active and intelligent leadership of Dr Krishna Kant, have been battling this phenomenal with the result, that the industry is starting to understand their arguments and accept their ideas. The Centres courses on microprocessor applications are well attended and questions to the lecturers during the industry meet showed, that in different branches of industry activities around this subject are proceeding.

The Centres themselves are invariably active on different single purprose projects. Basically this means, that for a certain application the microprocessor circuitry is developed, tested and given to an industrial producer to fabricate. Programming is usually done in he normal programming languages on PC's. The know how on this level seems to have developed really fast, hardly any differences with that in developed contries are detectable. However, the applications are mainly restricted to the single purprose projects in laboratory, hospital and other friendly environments.

The situation is different as far as the application of control engineering in industry is concerned. In the three branches of industry studied the following main characteristics should illustrate the status of industrial control:

Water treatment:

Poor industrial instrumentation from indigenous sources, no real time control, no central supervision. Only the most modern plant, that of Bombay Munipicial Works, has a certain number of imported flow and quality indicators spread over the plant.

Sugar

Some basic old instrumentation, mostly still of the mercury using type with non standard load depending transmission. New introduction of indigenous measuring devices of reasonably good quality. Industrial controls hrdly exists, although target identification is done.

Power generation

Mainly imported control systems, varying in quality. A few microprocessor based systems under execution for the newest expansions.

Excellent approach of revamping 200 MW unit with a Dedicated Direct Control system in a top down approach. Indigenous availability of system engineering know how not clear.

Essentially the common point in these observations is, that certain approaches towards good industrial control are on the way, but the actual system engineering is the difficulty towards completing the programs.

The same applies to the activities of the Centres. The single purprose applications for dedicated projects are handled on basis of a good knowledge of microprocessor engineering, while in most cases process knowledge is not really essential. The last will alsc be due to the fact, that the engineers of the Centres mostly have an electronic background.

For further development in industrial control based on the application of microprocessors the elements of control engineering and control systems engineering should be reinforced On the subject of manpower in the Centres this would mean postacademic training of the existing engineers in control engineering or enlisting new Instrumentation and Control engineers.

These engineers then can obtain their essential knowledge of control system engineering by participating in engineering teams of control engineers and process engineers of the relevant processes to be controlled. This construction has been proposed and accepted for the water treatment plant and should also be applicable for other branches of industry.

The application of industrial multipurprose apparatus will have to be with imported material, as indigenous items are not yet available.

However, as the engineering teams will obtain their experience in control system engineering, they will also be able to inform the Indian instrument and control apparatus manufacturers about the need of apparatus and thus give new impulses to the development of this branch of industry.

This is the more important, as in this field of industrial instrumentation a new revolution towards interfacing between various instruments by means of digital communication is just starting and in a well planned organisation the indian industry might just catch up in this development.

As the approach of formation of engineering teams might well be applicable to different branches of Indian industry, it could be wise to have experienced industrial control systems engineers do prefeasabilitystudies in these different branches to analyse the situation and advise about similar measurements to be taken there.

Finally the necessary inflow of engineers with the appropiate education should be considered by investigating the curriculae of the universities and engineering colleges and reporting the necessary additional knowledge to be given in these educations or in specialisations and postgraduate courses.

RECOMMENDATIONS

1. There seems to be a shortage of experience in certain indian industries in the application of modern control techniques in the control of their processes. The Centres for microprocessor application engineering therefore should, after now having acquired a good standard in single purprose microprocessor techniques, consider shifting their main attitude to considering how to apply the available state-of-the-art multi purprose apparatus used in industrial control.
2. Additional know how in applicable Instrumentation and Control Engineering is necessary for the Centres as well as in industry. The Centres should engage addidional control engineers and have post academic education given to their microprocessor application engineers.
3. The Centres should consider the spreading of this necessary additional knowledge in control engineering by organizing courses as post academic education for experienced industrial engineers and preferably do so in specialised branches of industry.
4. Pilot plant projects for industrial control on existing plants should be considered, where a complete revamping of the control might achieve aedequate results in plant performance, while at the same time engineering teams could obtain the necessary experience in control systems engineering for further activities in the same industrial field. These teams should be assisted or lead by experts in industrial control systems engineering.
5. As system and project orientation will become more important, study tours to visit modern controlled plants for project engineers and staff should be extended. If necessary at the cost of training fellowships.
6. Experts should perform pre-feasabilitystudies in different branches of industry to specify the needs for additional optimizing of existing control.
7. An expert should visit Universities and Colleges in India, investigate their programmes and report in detail, in which way the existing curricula should be changed to meet the industries need in operational technology and control systems engineering, and which post graduate courses on the same subjects should be given to enable experienced process and control engineers to update their knowledge.
8. As the above terms recommend projects with in general a duration of 2-3 years, extension of the UN-project assistance for another 3 years should be considered.
9. Experts on mission should be equipped with PC's with text and drawing editors as to improve their efficiency by factors up to 50%.

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