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APPROPRIATE AUTOMATION PROMOTION PROGRAMME

DP/IND/82/034

INDIA

Technical Report: Automation and Process Control for Paper and Pulp Industry*

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 D. Popovic,
expert in automation and process control for paper and pulp industry

Backstopping officer: C. Gürkök, Engineering Industries Branch

United Nations Industrial Development Organization
Vienna

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* This document has not been edited.

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1. Summary

In order to meet the objectives of the mission, as defined in Job Description DP/IND/82/034/11-15, the expert has

- visited the Project Centre of AAPP at Madras
- reviewed the on going project activities in the area of automation of paper and pulp industry
- visited the project laboratory at CIRI Madras and studied the equipment and the running experiments there
- informed himself about the steps planned for the future development of the Centre
- provided the project staff with the relevant, most recent literature in the field of process automation
- participated in the National Seminar on Applications of Electronic Systems in Industrial Process Control, held in Madras, February 16-17, 1989, and delivered there the Key-Note Address on Recent Trends in Electronic Systems Usage in Industrial Process Control
- delivered a one-week course on Process Identification, Modelling, and Advanced Control of Industrial Plants
- consulted the participants of the course, engineers from the industry, in solving their current automation problems
- participated in a local TV programme on the importancy of plant automation and of the National Seminar held in Madras

2. Objectives of the Mission

Following the Job Description, the expert is expected to

- assist the Project Centre at Madras in promotion of automation in paper and pulp industry
- deliver a series of lectures on in National Seminar on Application of Electronic Systems in Industrial Control
- to give a course on Identification, Model Building, and Advanced Control in paper and pulp industry
- to review the development work being carried out by the Madras Centre in the field of instrumentation of paper and pulp industry, and suggest means of improvements over existing design
- to visit a few paper and pulp industries and suggest requirements in instrumentation of them and the appropriate approach for that

3. Activities of the Expert During His Mission

In accordance with the activities, already mentioned in 1. here, the expert has specifically

- reviewed the on going project works of the Centre
- discussed with the project staff the major difficulties in solving the technical problems and advised the staff in methods and tools to be preferably used in further project work
- contributed to the National Seminar through his Lecture, conduction of technical sessions and discussion during the closing session
- advised a series of participants of the Seminar during the breaks in solving their problems in the industry or in other Project Centres
- given a full-week course on modelling, identification and advanced control of industrial plants
- participated in local advertisement work on television and in the press

4. Findings of the Expert

4.1 Findings Concerning the Project Centre at Madras

The AAPP Project Centre at Madras deals with the variety of projects in the field of instrumentation and measurements for pulp and paper industry. This work is based on the relatively long tradition of CERI-Laboratory in this field and on the long-time practical experience of its Project Coordinator in the same field. This finally means that a reach technical know-how and a variety of instrumentation was from the very beginning available in the Laboratory, so that from the very beginning of the project work a rather good success was predictable. This, at the same time, should serve as an example that in the future the Project Centres should be placed there where a long automation tradition is available.
In fact, the CERI Madras Centre started the development of quality control instrumentation for pulp and paper industry in 1981, mainly with the grant-in-aid from the TDC Group of DOE, which phase I was successfully finished in 1986 and the continuation of the phase II already recommended. As per Memorandum of Understanding, signed in 1986, the duration of the development activities should be extended up to 1991. It is expected that in this way the pulp and paper industry of India can essentially be modernized. The major areas of activities have been

- digester instrumentation
- programmable controllers for wet end instrumentation
- field trial for 'C' frame instrumentation
- brightness monitor
- IR moisture monitor
- on-line viscosity monitor
- on-line tensile strength monitor
- microprocessor-based rheometer for rubber industry

The Centre envisages to proceed with the development of microprocessor-based quality and process control instrumentation systems and allied industrial electronics(Pulp and Paper, Plastics and Rubber, Plywood, Food industries, etc).Here, the final aim would be to develope an indigenous distributed computer control system for automation of industrial plants, that is nowadays the state-of-the-art worldwide.The main components of such systems are the programmable controllers, data transfer links and the CRT monitors.

The proposed thrust area is in fact the priority area indicated by the Government of India for Indian industries and discussed in greate detail during the National Seminar in Madras.

It is of outstanding interest to mention here that the CERI Centre at Madras is, as far as the expert knows, the only research and development centre in India consequently working on development of microprocessor-based instrumentation systems right from sensors and transducers and down to the relevant control elements needed for modernization of Indian paper and pulp industry.Based on this experience, the centre would like to concentrate on design and development of appropriate sensors and transducers needed also for the Wood and Food industry. The technology developed here can also be used in other AAPP and MAEP Project Centres in their automation work.This will, of course, be very important from the point of view of self-sufficiency in sensor and transducer technology, that saves a vaste amount of foreign currency to the country. This is a fact that has recently been pointed out as an essential one by a group of UNIDO experts in December 1988 in New Delhi.

With this in view, it is proposed to extend the area of research and development to the optoelectronic sensors which are increasingly needed by the industry, especially in the manufacturing using in an extensive way the industrial robots as work facilities.

Summarizing, the AAPP Project Centre at Madras has capability to continue and extend its work on

- transducers, sensors and appropriate front-end devices
- sensor-based monitoring and control systems using microprocessors and personal computers as intelligent parte of the system
- flexible, universal data acquisition systems for industry and laboratories
- programmable multiloop controllers
- communication links for data transfer
- knowledge-based systems for process diagnostics
- education of people from the industry and the Universities and research institutions.

4.2 Findings Concerning the National Seminar

The National Seminar on Application of Electronic Systems in Industrial Process Control was held in Hotel Park Sheraton on February 16 - 17, 1989. It was organized by Madras Centre of CERT and the Centre for Development of Electronic Systems, AAPC /DOE, under co-sponsorship of a series of Indian Companies. The technical part of the Seminar was organized into five Sessions:

- Applications of Electronic Systems in Food and Diary Industries
- Applications of Electronic Systems in Pulp and Paper Industry
- Application of Electronic Systems In Rubber and Plywood Industry
- Application of Electronic Systems in Sugar Industry
- Application of Microprocessor-Based Systems in Process Industries

In addition to this, the usual introductory and closing session has been hold up.

On the Symposium some 30 papers have been read. There have been in the average 80 participants per Session, majority of which has been from the Universities and Research Institutions. There was in the most cases an interesting discussion after presentation of the papers.

Of special interest was the closing Session, in which a series of well-known participants, also from the industry, have given an extensive analysis of present situation in the field and made a variety of valuable suggestions for the steps to be done in the time to come.

However, also here, like in the similar situations in the past, the real selection of the papers to be presented on the Seminar was not optimal. Further to this, there has been no instructions to the authors how to prepare and present the papers, and no advices to the session chairmans how to prepare, schedule and guide the sessions.

4.3 Findings Concerning the Course

The one-week course on Process Identification, Modelling, and Advanced Control of Industrial Plants took place at CEERI Centre, CSIR Campus at Taramani, Madras from February 20 to February 25, 1989. There have been approximately 20 two-hour lections in the above topics, that have been visited by 34 participants from most different cities of India belonging to the universities and the industry. During the course application examples have been given from different industrial processes, that has helped the participants to better appreciate the applicability and the importance of the methods, tools and techniques exposed.

In order to further improve their knowledge in this field, the participants have been given the materials for individual study that has also included numerous further references.

However, in order to avoid the misunderstanding, the participants should be informed in advance that the most important prerequisite for following the course is solid knowledge of control and system theory, and that such a course does not include the description of electronic circuits or of fibre optic communication links.

During the course, the discussion was interesting in the classroom as well as the discussions during the coffee and lunch breaks.

Generally, the wish was presented to the expert that such and even more advanced courses should take place more frequently and at different places of the country. They can even contribute to the improvement of curricula at the universities and the colleges since also some university teachers have been among the participants of the course.

Of course, the efficiency of such courses can essentially be improved if they are accompained by some experimental demonstrations in the laboratory(by the use of microcomputers), like the expert does it at his Institute for the people from the Industry.

5. Summary of Findings

The AAPP Project Centre at CERI Madras, visited by the expert, as well as well as the National Seminar and the course there, lead to the following observations:

- the main field of work at the Centre is the development of sensors, transducers and appropriate electronics for measurements and control of industrial processes
- this work should be extended to the research of modern, optoelectronic and other sensors, primarily used in the manufacturing, where the robots and material handling facilities are in use
- there is a long-time practical experience and a deep know-how within the centre in development and application of measurement and control instrumentation in the pulp and paper industry
- the Centre is planning to extend it to plastic and rubber, food, and plywood industry
- the Centre has a rather good equipped laboratory in which all kind of sensors for measurement of major process parameters can be developed
- the project staff is very well skilled in physical, electronical, as well as in the software development
- some hardware and software programms for data acquisition, parameter monitoring and process control could find general application also in other industries and in other project centres
- the centre intends to work in the development of communication links for data transfer within the plant as well as in development of hardware and software of process monitoring stations
- the last can contribute to development of an indigenous distributed computer control system for process automation
- in view of the importancy of the work in the area of field instrumentation that the Centre is doing, there must be a better incorporation of the Centre into future automation Projects
- the relatively good connection of the Centre to the industry has directly contributed that its work has always been practice-oriented

- the National Seminar on Application of Electronic Systems in Industrial Process Control has been very well organized and well attended
- there is still the need to better chose the papers to be presented
- some effort should also made in order to get a better paper presentations and sessions scheduling
- also something should be done that more participants come from the industry and, possibly expose their products during the seminar
- the one-week course on Process Identification, Model Building, and Advanced Control of Industrial Plants, which was attended by 34 participants from all over India, was a full success of the Centre
- the efforts of the Centre to multiply and distribute the course accompanying material have been very valuable
- there has, finally, been given much help to the expert in delivering the course

6. Summary of Recommendations

Based on his findings, exposed here, the expert recommends the following:

- support the development of sensors, transducers and appropriate electronics for measurements and control of industrial processes within the project center
- extend this work to development of modern optoelectronic and other sensors for application in manufacturing and robotics
- extend the application activities to the food, plawood, plastic, and rubber industry
- extend the software development field to data acquisition, process monitoring and diagnostics, as well as to advanced process control
- work on development of an indigenous distributed computer control system by development the relevant communication links and graphic software, even in cooperation with other project centres of AAPP and MAEP
- incorporate the Madras Centre more frequently in other automation projects running within some other project centres
- organize regularly the National Seminars on Application of Electronis Systems in Industrial Process Control and, if possible, an international seminar
- select the papers to be read during the seminar better than it is usually the case
- provide the authors of the papers with the instructions how to present the papers and the chairmans how to guide the sessions
- try to animate the engineers from the industry to increase their participancy in the seminar
- organize some further one-week courses in model building, process identification and advanced process control for engineers from the industry and the teaching staff of the universities and colleges
- accompany the topic presented by some experiments in laboratory or by the use of personal computer at classroom

APPENDIX A - Sessions Contents of the National Seminar

SESSION - I

APPLICATIONS OF ELECTRONIC SYSTEMS IN FOOD AND DAIRY INDUSTRIES

16-2-89 **11.45 – 13.15 Hrs.**

Chair Person
Shri.S.K. Majumder
Additional Director
Central Food Technological Research Institute
Mysore

Session Co-ordinator
Shri.R. Sridhar

1. **SOME ELECTRONIC APPLICATIONS IN FOOD PROCESSING**
   Shri.G.S. Varadan
   Shri.Ravikant Taxali
   Department of Electronics (AAPP)
   New Delhi

2. **POTENTIALS FOR APPLICATION OF PROCESS CONTROL INSTRUMENTATION TO FOOD PROCESSING**
   Shri R. Venkatakuppiah
   Shri.A. Ramesh
   CFTRI, Mysore

3. **PC BASED ELECTRONIC WEIGHING SYSTEM**
   Prof.V.V. Athani
   Shri.R. Vaswani
   Indian Institute of Technology
   Bombay

4. **A PHASE LOCK LOOP BASED 'VIBROTONE' FOR VACUUM TESTING IN SEALED CANS**
   Shri.R. Sridhar
   Dr.P.E. Sankaranarayanan
   CEERI Madras Centre

5. **ELECTRONIC CONTROL SYSTEM IN PROCESS INDUSTRIES WITH SPECIAL REFERENCE TO DAIRY AND SUGAR INDUSTRIES**
   Shri.N.J. Narayanan
   Instrumentation Limited
   Madras

6. **MICROCOMPUTER BASED DATA ACQUISITION NODE AND IBM-PC BASED CENTRAL MONITORING STATION FOR TEA FACTORIES**
   Shri. A. Sutradhar
   B.E. College
   Shibpur
   &
   Shri. S. Roy Choudhury
   Shri. A. Sinha
   Shri. S. Mandal
   Wg.Cdr. H. Pal (Retd)
   Prof. A.K. Mandal
   AAPP Eastern Regional Centre
   Calcutta

SESSION - II

APPLICATIONS OF ELECTRONIC SYSTEMS IN PULP & PAPER INDUSTRY

16-2-89 **14.15 – 15.45 Hrs**

Chair Person
Shri.S.G. Rangan
Vice-President
Indian Pulp and Paper Technical Association
&
Adviser
M/s. Seshasayee Paper & Boards Limited
Madras

Session Co-ordinator
Shri.P. Sudhakara Rao

1. **PROGRAMMABLE CONTROLLERS FOR AUTOMATION OF BATCH DIGESTER**
   Shri.S. Venkatesh Prasad
   Larsen & Toubro Limited
   Madras

2. **AN ELECTRONIC SYSTEM FOR REAL TIME MONITORING OF ALKALI CONCENTRATION**
   Shri.G. Prasad
   Shri.B. Sundaresan
   Smt.S. Uma
   Dr.P.E. Sankaranarayanan
   CEERI Madras Centre

3. **PERFORMANCE OF LOCOMON - A REAL TIME LOW CONSISTENCY MONITOR**
   Shri.R. Sridhar
   Dr.P.E. Sankaranarayanan
   CEERI Madras Centre

4. **SMART PAC - A PC BASED DATA MONITOR FOR THE PULP & PAPER INDUSTRY**
   Shri.P. Sudhakara Rao
   Smt.K. Meenakshi
   Smt.R. Revathy
   Dr.P.E. Sankaranarayanan
   CEERI Madras Centre

5. **AN INFRA-RED MOISTURE GAUGE AND ITS PERFORMANCE**
   Shri.K. Subrahmanyam
   Shri.V. Venkataraman
   Smt.N. Malathi
   Dr.P.E. Sankaranarayanan
   CEERI Madras Centre

SESSION - III

APPLICATIONS OF ELECTRONIC SYSTEMS IN RUBBER AND PLYWOOD INDUSTRIES

16-2-89 **16.00 – 17.00 Hrs**

Chair Person
Dr.P.E. Sankaranarayanan
Deputy Director-in-charge
CEERI Madras Centre

Session Co-ordinator
Shri.M.R. Rajagopalan

1. **DESIGN AND DEVELOPMENT OF ELECTRONIC SYSTEMS IN TYRE INDUSTRY**
   Shri.D. Kalimani
   M R F Limited
   Madras

2. **REVIEW AND STATUS OF PROCESS AND QUALITY CONTROL EQUIPMENTS AND INSTRUMENTS FOR PLYWOOD INDUSTRY**
   Shri.V.S. Aswathanarayana
   Shri.K. Shyamsunder
   Indian Plywood Industries Research Institute
   Bangalore

3. **DRY VENEER MOISTURE SCANNER**
   Shri.K. Shyamsunder
   Indian Plywood Industries Research Institute
   Bangalore

4. **IBM-PC BASED GRIST MONITORING SYSTEM FOR JUTE MILLS**
   Shri. A. Sinha
   Shri. S. Mandal
   Shri. S. Roy Chowdhury
   Wg. Cdr. H. Pal (Retd)
   Prof. A.K. Mandal
   AAPP Eastern Regional Centre
   Calcutta

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SESSION - IV

APPLICATIONS OF ELECTRONIC SYSTEMS IN SUGAR INDUSTRY

17-2-89 **09.15 – 10.45 Hrs.**

Chair Person
Shri.B.S. Gurumurthy
Managing Director
Ponni Sugars and Chemicals Limited
Pallipalayam, Erode

Session Co-ordinator
Shri.K. Subrahmanyam

1. **INTEGRATED ELECTRONIC CONTROL SYSTEMS FOR JUICE CLARIFICATION PROCESS IN SULPHITATION IN SUGAR FACTORIES**
   Dr.G.N.Acharya
   Shri.L.N. Choudhary
   Shri.K.S.N. Rao
   Shri.K. Srinivas
   CEERI. Pilani

2. **A REAL TIME VISCOSITY MONITOR**
   Shri.M. Natesan
   Dr.P.E. Sankaranarayanan
   CEERI Madras Centre

3. **MICROPROCESSOR BASED MULTI-CHANNEL TEMPERATURE CONTROLLER FOR SUGAR AND ALLIED INDUSTRIES**
   Dr. Hausila Singh
   Shri.S.M. Sharma
   Shri.C.R.K. Prasad
   Shri.K. Sivadasan
   Shri.D.P. Sharma
   Shri.B.L. Saini
   Shri. Bharat Singh
   CEERI. Pilani

4. **CONTROL OF SUGAR CRYSTALLISATION PROCESS BASED ON ITS MATHEMATICAL MODEL**
   Dr. Pawan Kapur
   Shri.V.L. Patil
   Shri.T.R. Vasudeva
   Shri.G.K. Gautam
   CEERI. Pilani

5. **MICROPROCESSOR TO BETTER SUGAR PLANT EFFICIENCY**
   Dr.B.P. Singh
   Shri.R.N. Shukla
   M.M.M. Engineering College
   Gorakhpur

SESSION - V

APPLICATIONS OF MICROPROCESSOR BASED ELECTRONIC SYSTEMS IN PROCESS INDUSTRIES

17-2-89 **11.15 – 13.00 Hrs.**

Chair Person
Prof. V.V. Athani
Indian Institute of Technology
Bombay

Session Co-ordinator
Shri. G. Prasad

1. **AN INDIGENOUS MICROPROCESSOR BASED FOUR CHANNEL UNIT PROCESS CONTROLLER**

   Shri. M.R. Rajagopalan
   Department of Electronics (AAPP)
   New Delhi

   Shri. S. Ganesan
   Shri. M.V. Geethesh Menon
   Smt. Nirmala N. Shenoy
   Dr. P.E. Sankaranarayanan
   CEERI Madras Centre

2. **EXPERT SYSTEMS IN PROCESS CONTROL**

   Dr. (Smt.) Hema Khurana
   Department of Electronics (AAPP)
   New Delhi

3. **DATA HIGHWAY FOR DISTRIBUTED CONTROL**

   Shri. A.B. Pansare
   Instrumentation Limited
   Kota

4. **IMPROVING THE HUMAN ELEMENT IN PROCESS CONTROL BY USING ELECTRONIC SYSTEMS**

   Kum. K. Alli
   Prof. K.N. Visveswaran
   Tamilnadu College of Engineering
   Coimbatore

5. **INDUSTRIAL PLANT DATA TRANSMISSION VIA FIBRE OPTICS LOCAL AREA NETWORK**

   Shri. Kapil Solanki
   Shri. V.C. Bhandari
   Instrumentation Limited
   Kota

6. **ECONOMICAL PROCESS INFORMATION MANAGEMENT SYSTEMS**

   Shri. M.V. Rao
   Larsen & Toubro Limited
   Madras

APPENDIX B:Contents of the Course

Professor D. Popovic
University of Bremen
Germany

Bremen, 1989

PROCESS IDENTIFICATION, MODELLING AND ADVANCED CONTROL OF INDUSTRIAL PLANTS

1. Introduction:Motivation and Basic Terms

- Mathematical Model of the Plant
- Model Order and Model Parameters
- System Identification and Parameter Estimation
- Model-Based Process Control
- Prerequisites for Model Building, System Identification and Advanced System Control

2. Classification of Systems, Models and Methods

- Systems Classification:linear, non-linear, lumped parameters, continuous, sampled, deterministic, stochastic
- Models Classification:physical, mathematical, static, dynamic, linearized, adaptive, reference, predictive
- Classification of Methods:deterministic, stochastic, parametric, non-parametric

3. Model Building Approaches

- Theoretical Analysis of the System:balance equations for flow and energy, transport equations for mass and heat transfer, heat exshanging process, reaction kietics
- Chemical Reactor:geometry(tubular, stirred-tank), boundary conditions, initial values, process variables (input, output, internal, control), disturbations
- examples

4. System Identification Procedures

- Design of Identification Experiment:building of error equation, choise of test signal, selection of sampling rate, estimation of total sampling time, definition of performance index, selection of methods to be used
- Model Verification, Validation and Improvement

5. Parameter Estimation Method

- Prony Method:basic model, system order determination, parameter estimation, determination of initial energy stored within the system, measurement noise suppression, optimization of experiment
- Least Squares Methods:problem formulation, derivation of basic model, error equation and penalty function, determination of best estimate, derivation of recursive version, software implementation aspects
- Maximum Likelihood Method: some introductory considerations

6. Advanced Process Control

- Set-Point Control: static and dynamic optimal control
- State Feedback and Multi-Loop Control
- Adaptive and Self-Tuning Control
- Multi-Level Control
- Implementation of Control Algorithms·direct digital control(DDC)
- Examples