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Interregional Expert Group Meeting on Computer Applications and Modern Engineering in Machine Manufacturing Industry

Warsaw, Poland, 19-29 September 1977

REPORT

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Explanatory notes

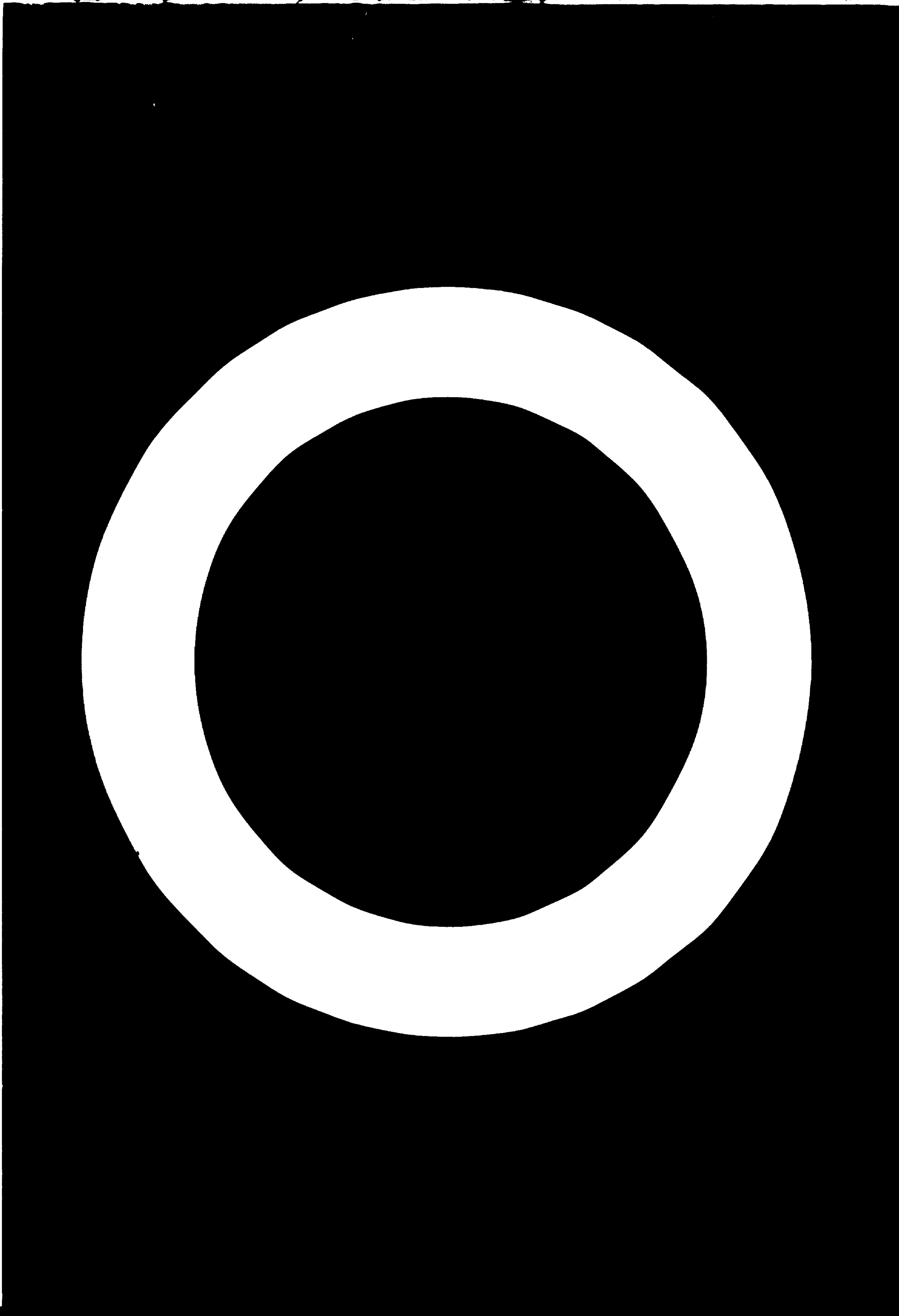
The following abbreviations are used in this document:

APT	automatically programmed tools
CAD	computer-aided design
CAM	computer-aided manufacturing
CNC	computer numerical control
DPM	distributed plant management
FEM	Finite-element method
NC	numerically controlled

Preface

The development of all kinds of machine-manufacturing industries in developing countries is often limited by a lack of sufficiently qualified engineering and workshop personnel, and a lack of technical support for their efforts. It is possible to increase greatly the productiv[illegible] of a design engineer by providing him with suitable, relatively inexpensi[illegible] minicomputer equipment; the products he is designing can be improved considerably by training him to use modern computer-aided engineering analysis techniques such as the finite-element method in construction, stress and displacement analysis; optimization techniques to reduce materials used; and value analysis to improve the economics of the product. It is also possible to lower the qualification requirements for workers and increase the productivity of factories by introducing numerically controlled (NC) machine tools (although more-highly qualified maintenance personnel would be needed). The know-how and policies necessary to introduce such equipment in a developing country environment, and the technical, economic and social aspects of the use of these devices and techniques are a problem of great complexity. To solve this problem, much information is needed from various sources - technical and economic knowledge, data about practical applications in various countries, and other information.

In the Polish People's Republic, the machine manufacturing industry has been developing rapidly in recent years, particularly the shipbuilding industry and the construction machinery industry (the BUMAR Union). BUMAR specialists have a wide practical knowledge of the problems and needs of a rapidly growing economy. BUMAR is co-operating closely at present with large companies in the Federal Republic of Germany, United Kingdom and the United States and uses the most modern technology in practice. It has also started recently to introduce computer-aided design and manufacturing techniques into practical use within the company, with some technical assistance from the United Nations Industrial Development Organization (UNIDO) and the United Nations Development Programme (UNDP). This proves that a transfer of technical know-how in this field is possible, and BUMAR can be used as a "case-study" for other developing countries.



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INTRODUCTION

1. The Interregional Expert Group Meeting on Computer Applications and Modern Engineering in Machine-Manufacturing Industries was held in Warsaw, Poland, from 19 to 29 September 1977. It was organized by the United Nations Industrial Development Organization (UNIDO), in co-operation with the Government of the Polish People's Republic. The Polish agency responsible was the BUMAR Union Research and Development Centre. The facilities provided for the Meeting included a computer terminal.

2. The aim of the Meeting was to promote the transfer of modern technology to developing countries by providing information, studying practical examples, discussion, and the establishment of personal contacts on an international basis.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

3. During the Meeting, a questionnaire was handed out to each participant. The following conclusions were drawn as the basis of the answers to the questionnaire:

(a) All participating developing countries felt there was a need to introduce computer-aided techniques for design and/or control of manufacturing processes;

(b) The application of engineering computer-aided techniques is a necessity for improving:

(i) The level of technological know-how of a country;

(ii) Product design and reliability;

(iii) Production efficiency and cost effectiveness;

(iv) International product competitiveness;

(c) In order to be able to apply the techniques, the developing countries need co-operation or assistance from national and international institutions that have already acquired a thorough knowledge in this field;

(d) Most of the participating countries found that engineering computer techniques could be introduced successfully for the industrial applications that were discussed at the Meeting;

(e) The introduction of CAD/CAM techniques in the manufacturing industries had important social and psychological implications. The effects appeared to be beneficial but needed more thorough investigation.

Recommendations

4. A set of joint recommendations was worked out. Almost all participants took an active part in the formulation of these recommendations.

The recommendations are:

Basic training. To introduce engineering computer-aided techniques in the industry in developing countries, prior academic education should be provided at universities and/or engineering schools in this field, locally or abroad.

Industrial training centres. UNIDO should locate and/or create international industrial training facilities that can be used for the training of personnel from developing countries, each facility should cover specific areas of application.

(The Meeting supported the offer by BUMAR to act as one of these training centres.)

Technical co-operation. It is recommended that efforts should be directed to instituting intensive bi- or multi-lateral co-operation in the field of engineering computer-aided techniques between countries. Co-operation could include:

(a) Exchange of technologies;

(b) Exchange of engineering personnel;

(c) Exchange of software.

National institutions. Appropriate institutions should be created in each country, to be responsible for the introduction and practical application of engineering computer-aided techniques in local industries.

International association. Existing and future national institutions should constitute an international association for the promotion of CAD/CAM techniques in the developing countries with the aim of:

(a) Carrying out a continuous assessment of current techniques and formulating the guidelines for future developments, surveys and evaluations;

(b) Exchanging know-how, personnel and experiences;

(c) Providing mutual assistance in training;

(d) Creating a software library (on a voluntary basis);

(e) Preparation and organizing relevant meetings at the national, regional and interregional levels.

Role of UNIDO. UNIDO should take responsibility and play an active and leading role, in order to achieve the implementation of the recommendations, especially towards the establishment of the international association.

(During the discussion of the recommendations, the Central Machine Tool Institute (CMTI) at Bangalore was mentioned as a possible future training centre for CAM techniques.)

Part one. Report of the Meeting

ORGANIZATION OF THE MEETING

5. Sixteen participants from 14 developing countries from all parts of the world attended the Meeting. They were technical management personnel (technical directors, chief design engineers) of relatively large companies and institutions. The Meeting gave them opportunities for accumulating know-how beneficial for their future activities. They were associated with machine manufacturing industries such as shipbuilding, machine-tool manufacturing, motor vehicles, construction and earth-moving machinery, and mining machinery. Representatives of governmental and industrial research and development and/or educational institutions actively engaged in the practical application of innovative engineering and manufacturing techniques also attended the Meeting.

6. Papers were read at the Meeting by consultants from the Polish shipbuilding, construction machinery manufacturing and other engineering industries. Consultants from industrialized countries and representatives of some specialized industrial companies also attended and spoke at the Meeting.

7. During the Meeting, a series of lectures and panel and small group discussions were arranged. Visits were made to a large Polish factory, the BUMAR Union, equipped with a considerable amount of computer equipment and NC machine tools, and to the Polish shipyards, to study practical computer-aided design and manufacturing applications. Discussions at these factories were also arranged. A visit was also made to the BUMAR CAD/CAM centre in Warsaw.

Adoption of the agenda

8. The following agenda was adopted:

Election of officers

Adoption of the agenda

Presentation and discussion of technical papers

Conclusions; evaluation and adoption of recommendations.

Part two. Summaries of technical papers submitted at the Meeting

Computer-aided design: an introductory survey

M. Zgorzelski

The aim of the paper was to present a general overview of the computer-aided design (CAD) of machines, as an introduction to one of the two main topics of the Meeting.

The need is stressed to develop computer-assisted techniques in engineering in all countries that are developing or intending to develop significant potential in machine manufacturing industries. More and more types of machines cannot be designed or manufactured without computer assistance; neglect of the need for computer-aided techniques leads to a widening technological gap between the developed and the developing countries.

The paper gives a summary of current trends in computer-aided design and draws attention to the main qualitative changes in design techniques caused by CAD: (a) new methods of design associated with mathematical modelling, optimization and simulation; (b) new approaches to design, i.e. the transition from checking designs, through detailed design analysis, to design synthesis; (c) the professional manufacture of software for design; (d) specialized hardware for design (particularly graphical devices); (e) interactive techniques of man-machine communication in the design process.

The paper discusses design engineering as an information process. It is concluded that the most important and most effective function (economically) of CAD is the mathematical modelling of the product and thereby its optimization. The mathematical modelling subject is discussed in more detail. Particular attention is given to the finite element method as being of prime importance in the design of machines.

Hardware problems are reviewed briefly, with particular attention paid to two groups of devices: the computer graphics equipment (graphical monitors, plotters, digitizers etc.) and the programmable desktop calculators, as being of great importance for executing the everyday tasks of the engineer. Needs and problem areas in the CAD field are: a large amount of parallel work with too little information about accomplishments; no international standardization of data structures and CAD problem-oriented languages; the strategies and policies to follow in a developing country to establish CAD/CAM capabilities; the need for international co-operation between the developing and developed countries; and the need for specialized education both nationally and internationally.

Discussion

The discussion of the paper was centred on two problems:

(a) Where the largest economic benefits of introducing CAD are expected;

(b) Whether the establishment of national "centres of excellence in CAD" is essential for the introduction of CAD in a developing country.

It was generally agreed that the largest benefits are obtained through product optimization. There was considerable controversy between those in favor of the "distributed" CAD effort and the supporters of "concentrated" effort. This problem was one of the most controversial subjects of the entire Meeting and a generally acceptable conclusion could be reached on it.

Computer-aided manufacturing in the machine building industry
R. Zielinski

The paper provided a brief introduction to current trends in computer-aided manufacturing (CAM). The trend towards distributed computing and control systems was stressed. The author described the hierarchical structure of computer-aided manufacturing systems, which has three basic control and data-processing levels: the process level, the data level, and the management level.

In the author's opinion, this type of distributed and hierarchical system will dominate CAM in the near future. The author reviewed briefly some forecasts of the future of CAM: he emphasized that by 1985 full on-line automation and optimization of complete manufacturing plants, controlled by computers, will be a reality.

Modelling and optimization of the diffusion of computer technology
W.D. Perriman

In the first part of the paper the author reviewed several earlier attempts to measure the degree of computerization in a country, and seems to be in favour of the classification scheme proposed originally by the United Nations Advisory Committee on the Application of Science and Technology (ACAST) in 1971 and further developed by Barqui *et al* in 1976. The scheme distinguishes four levels - initial, basic, operational, and advanced - and describes the conduct of transitions between levels.

In the second part of the paper, the author states the need for a systematic study of the diffusion of computer technology in various societies and sectors of the economy. IIASA studies of the problem are reviewed briefly. Their ultimate goal is a quantitative model of the computer diffusion process, so as to move the understanding of national development from a static classification to dynamic change and an optimization of resource allocation in computerization.

Discussion

The discussion was centred on the problem of the economic feasibility of introducing CAD/CAM in developing countries.

Design analysis by computer methods

K. Gör[illegible]

The purpose of the paper was to give a general view of some practical applications of the finite element method (FEM) to the solution of day-to-day engineering problems. The ever increasing capacity of computers for handling huge amounts of data with ever increasing speed has made it feasible to attack problems involving previously prohibitive numbers of numerical operations. In recent years, the previously widening gap between hardware capacity and software potential has been closed.

The paper started with a short survey of the structural theory as applicable to FEM. A short description of an FEM programming system - ASKA - was given. Since this package is widely used throughout the world, and was used to solve the problems described, a short review of the problems was given. The problems solved included the following structures:

(a) Thermally loaded components;
(b) Flange calculation of turbine;
(c) A 35000 MP press;
(d) Omnibus carriage;
(e) Tank;
(f) The European airbus;
(g) Static and dynamic analysis of a nuclear reactor;
(h) Dynamic analysis of a complete aircraft;
(i) Longitudinal dynamics of a three-stage rocket;
(j) Detailed analysis of a complete ship.

It was clear from the material presented that the techniques available enable the structural engineer to solve complicated problems that may involve static, dynamic and non-linear effects. The limiting factor is simply the manpower and computer costs involved.

A paper by the author, entitled "Theoretical introduction to the finite element method", was handed out to enable participants to familiarize themselves with the theory of FEM.

Discussion

The discussion concentrated on how to introduce FEM in developing countries. One obvious difficulty was the lack of suitable hardware and relevant software. The large-scale programming systems (ASKA, NASTRAN) need a large computer to be run efficiently. However, there are developments that may overcome the difficulty: a large mini-computer could be used, for example.

Another point raised was the cost of a programming package. Many packages are very inexpensive, whereas others cost a great deal. The main reason is that support and maintenance are an integral part of the expensive systems, whereas the less expensive systems have no support and maintenance. In the long run it is safer to buy a widely used package that is properly maintained and supported.

Trends and tendencies in finite-element method (FEM) applications for computer-aided design

M. Bossak

The paper described briefly the present status, function and system aspects of the finite element method. Some guidelines for the successful application of FEM and the author's opinions on the development trends of FEM and related numerical methods, and development trends of FEM software and the associated hardware were offered. The need for a certain "critical size" for the effort that has to be put into establishing FEM design analysis capability within an industrial organization was emphasized, as was the need for a very thorough training of the personnel who will do the work.

Discussion

The discussion was centred on the above mentioned "critical size" of effort. Some participants criticized the approach as discouraging the application of FEM where resources were lacking, others strongly supported the concept on the basis that too small an effort does not lead to practical design analysis capability and results in mistrust of FEM by management. It was generally agreed that the "small" effort may be good for educational purposes while the "large" undertakings in FEM seem necessary in the industrial environment.

Effective part-programming development

O. Bjørke

The development and testing of part-programs become more and more important as the use of numerically-controlled machine tools increases. The paper describes computer aids to making part-programming development and testing more effective. It is based on a hierarchical computer hardware structure.

The accepted control philosophy in the 1960s was the use of hard-wired numerical control systems. Though the technology changed significantly during that decade, system behaviour did not. The operational capacity of hard-wired control systems did more or less stabilize at a certain level of sophistication, and the features available today are a result of what was found to be useful during the past decade. The range of features has nevertheless been restricted by the cost of implementation on hard-wired systems.

The control philosophy in the 1970s was the use of on-line control systems, where the controller is based on a general purpose digital computer. The reasons for installing CNC are: increased flexibility, a wider range of user functions, diagnostic possibilities, tape-correction possibilities etc.

Once a number of NC and CNC systems are in operation, the need for better programming and debugging aids becomes clear. At that point a programming centre equipped with graphic displays, teletype, paper tape reader and punch, and disk may be bought; at first, the centre can be run separately.

Finally, a behind-tape reader module can be added. One or more alpha-numerical screens will then be needed in the workshop; the system will then have reached the DNC-level.

The author introduced the concept of distributed cells, which may be an alternative to existing approaches.

The size of firms in developing countries should be such that they can cope with the problems of product-development and marketing as in industrialized countries. Production facilities can be divided into cells and can be spread geographically around the provinces. Technology used ought to be workforce-intensive and capital-extensive, and processes should be designed to fit the existing level of skill. Worker training is a critical problem.

In order to handle the product flow between a cell and the parent company, a well-developed communication system is needed. A cell placed in a smaller society where people tend to know each other may be an advantageous environment for solving many of the social problems of today. A small society might be expected to take pride in running the cell properly.

Distributed plant management systems for computer-aided distributed plant management

J. Duch

Until recently, if computerized process control and factory data management were needed, two separate systems had to be installed. The approach was neither efficient nor economical.

Digital equipment's systems approach to the problem resulted in the development of distributed plant management (DPM) systems.

System overview

DPM systems combine factory data management and input/output processing into a single efficient plant management operation.

The DPM concept combines: on-line processing, microprocessor control, real-time data acquisition, distributed computing, and hierarchical computer systems through one low-cost communication link.

A DPM factory data management subsystem collects data from machines and employees at interactive terminals. An I/O subsystem monitors machines and processes with real-time digital and analog I/O interfaces throughout plant operations. Sharing a common set of modules, the I/O subsystem can function in distributed or local modes. The dataway links remote I/O devices to its minicomputer-based host.

DPM systems components

Host computers. The DPM-60-series hosts, based on the PDP-11/34 minicomputer, are intended for entry-level systems or special-purpose small systems. The 60-series hosts support two dataways, and have magnetic tape and cartridge disk devices, 192-kilobyte memories, hardware floating point accelerator, battery backup, and a console terminal.

The DPM 80-series hosts are based on the PDP-11/70 computer. They control four dataways, and have 256-kilobyte memories, magnetic tape and cartridge disk devices, hardware floating point accelerator, and a console terminal.

Any host can be equipped with a FORTRAN IV-PLUS or COBOL language processor. All run under real-time, event-driven operating software.

Communication among system components

The system components are tied together with the dataway link.

The dataway is a multidrop communication bus using a twisted-pair cable to link terminals, hosts, and I/O subsystems into integrated management system. The dataway is microprocessor controlled thus relieving the host of communications handling load.

It reduces plant wiring costs both initially and in modification and expansion. It allows the manager to access the system's unified data base.

Up to 63 devices can be addressed by each dataway controller in a DPM system host.

Each dataway can be up to 15,000 feet (4,500 meters) long. Any device along the run can be removed and replaced without disturbing the system.

Factory data management

In principle there are three types of terminals available for putting data into DPM data base:

Time-and-attendance terminal with badge reader and time-of-day display

Basic work station for use in locations where a few types of transactions take place (including badge reader, time display and backlighted message panel, a punched card reader, a transaction key, and an alphanumeric display and keypad)

Area work station (including the elements of the above plus eight transaction keys)

A variety of other terminals can simply interface to the dataway through the four-port ASCII terminal multiplexer.

I/O subsystems

I/O subsystems are built around a common mechanical approach and common set of process I/O modules. They are microprocessor controlled and include power supply, process I/O handler and field termination for interfacing industrial field signals via standard screw terminals.

Discussion

The discussion concentrated primarily on the costs of introducing the DPM system into an existing factory and the level of know-how necessary to assure effective and economic usage.

Component design and manufacture using computers: the present position

T. Allan

The purpose of the paper was to set out what is readily available in three areas of the design and manufacturing industry: analytical, graphical, and numerically controlled manufacturing.

The term analytical is used in the paper to identify the area of design where in the past manual or slide-rule calculations were involved. This is probably the area in which most developments have taken place. Analytical techniques include:

(a) A one-to-one translation of algebraic design routines;

(b) Handling tabular and graphical data;

(c) Using principle from code of practice, but redrafting method to suit computer;

(d) New analytical techniques for the computer, especially the finite element method. The finite element can be applied to many engineering problems and results in a degree of understanding and knowledge of structural and component behaviour previously possible (sometimes) only with experimental investigation. The fact that the method is embodied in a common philosophy and approach makes it an attractive tool for the design engineer to study and use;

(e) Three-dimensional space and mapping, including orthographic and perspective projection;

(f) Data structures for building and modifying drawings;

(g) Menu systems for assembly drawings;

(h) Analytical solution for geometrical problems.

The paper gives a review of the numerical control production phase, mentioning in some detail the following topics:

(a) Part-programming (with an example). The first step consists of writing a series of statements about the shape of the component and instructions about the movement of the cutting tool. A number of languages have been developed for this purpose; the best known is probably the APT (automatically programmed tools) package;

(b) Post-processors are usually necessary when converting co-ordinate values into control pulses. Unfortunately, there are a number of different codes for this purpose;

(c) Organization for automating the NC process is discussed, different ways and means to achieve this purpose are stated. The problem of three-dimensional surfaces is covered, and concepts for integrated CAD and manufacturing are introduced.

The paper includes a list of references.

Discussion

The paper initiated a prolific discussion concerning education in the CAD/CAM field. It was stressed that too much attention was given to concepts for industrial training, while the concurrent need for trainees with a basic training in the relevant field was not mentioned.

A computer-aided manufacturing system applied to batch manufacturing

G.P. Putman

The paper was devoted to the description of the CAM system developed by the Illinois Institute of Technology Research Institute and applied at a United States government manufacturing facility in Rock Island, Illinois. The author makes a clear distinction between the term CAM and the CAM system: CAM means a combination of computer technology with manufacturing technology while

CAM system (according to the author's definition) means that the entire manufacturing process and the most important associated functions (planning, scheduling, loading, management etc.) are computer controlled. Some CAM systems under development in Japan and the United States are described. The author concludes that, although CAM systems carry out very complex control functions they are not still the "ultimate" solution to manufacturing problems: manufacturing is still too complex an activity for "total" answers. The number of variables involved is typically very large, and it is almost impossible to exercise effective and simultaneous control over all of them.

Discussion

The discussion concentrated on the economic aspects of the approaches presented.

Applied optimization: a review

K. Urbaniec

The paper introduced participants to the fundamentals of mathematical optimization techniques and their practical application in the CAD of machines.

The author discussed the structure of optimization problems and the methodology of solving them. Available mathematical methods and associated computer software were described. Several practical examples of simple, intermediate and complicated problems were discussed. In his conclusions, the author stated that optimization methods were a very powerful decision-making aid in engineering design, the allocation of economic resources, production scheduling, and the control of complicated systems. In the author's opinion, decision-makers trained in disciplined thinking and aided by computer methods can approach even the most intricate practical problems and solve them optimally.

Discussion

The discussion started with some controversy between participants who were in favour of detailed engineering design analysis techniques, such as the finite element method, and those who supported the idea of optimal design synthesis. After the discussion it became clear that the two approaches to CAD are complementary rather than contradictory.

A special-purpose [illegible] part-programming processor for numerical control

A.[illegible] De Barr and A. Rhodes

The paper described a special processor program developed by the Machine Tool Industry Research Association in the United Kingdom for economically feasible programming of turning operations for very small numbers of parts manufactured (even single parts in certain cases).

The program, written in FORTRAN and running on a small computer (32 k store), allows the programmer to prepare the NC program in a much shorter time than with manual programming and is cheaper to use than large NC programming systems available through DP bureau services.

Some design principles for computer-numerical-control machine tools

R.L. Palmer

The purpose of the paper was to describe and analyse problems associated with the change of classical numerical control (NC) for machine tools into computer numerical control (CNC).

Flexibility is a key word for the future manufacturing industries. Microprocessors, the heart of the CNC system, are taking over most control functions in the manufacturing process, and assuring the desired flexibility. This in turn is widening the capability of the manufacturing system to cope with increasing complexity of manufactured machines. The features of CNC machine tools are increasingly being appreciated - they include the ability to carry out calculation, to store data, to modify, and, where necessary, cross-check and compare lists of information. The most important characteristic of CNC is the ability to interact with the machine operator. It can augment the skills, experience and understanding of the machine operator, and is an "aide-mémoire" and a mentor to the unskilled.

Because of all these properties, CNC machine tools should be seriously considered wherever investment is made in the machine manufacturing industry.

Case-study for the introduction of computer-aided design (CAD)

M. Sörensen

The speaker described the UNIDO-funded CAD project at BUMAR in Warsaw. The main topics covered were:

(a) Statement of work;

(b) Workshops, seminars and training;

(c) Problems of hardware selection;

(d) Software evaluation;

(e) Fellowship programme.

These topics covered the following fields of engineering:

(a) Application of computer methods in structural engineering;

(b) Application of numerical control;

(c) Planning and control;

(d) Modern software technology;

(e) Simulation of dynamic and hydraulic systems;

(f) Hardware and system software;

(g) Computer-controlled testing.

Discussion

The main topic of the discussion was how to assure the acquisition of good software that could be maintained and user supported. Some particularly important points identified were:

(a) Ensurance of fulfilment of the user's real needs;

(b) Contractual arrangements;

(c) Compatibility with other activities;

(d) Program-technology and program-documentation;

(e) Implementation support;

(f) Educational support;

(g) Maintenance and up-dates;

(h) Credibility of seller.

The production-control system developed at the Fadroma factory (BUMAR) by ZETO, Wrocław

Mr. Muszyński

ZETO is a professional DP service organization equipped with a Polish-made ODRA 1305 computer system (an ICL 1900 series compatible machine). The system can be used in remote job entry mode from many terminals installed in the town of Wrocław or its neighbourhood (this teleprocessing network is called POLRAX 2).

The Fadroma factory, which is also located in Wrocław, used the ZETO services through POLRAX 2. All basic production control functions are performed by the system developed by ZETO for Fadroma.

Economic and technological aspects of computer applications in engineering industries in India

S. Vasantha Kumar and T.P.S. Iyer

The aim of the paper was to give an overview of the present status of CAD/CAM in India. The authors point out the need for CAD/CAM, if the technological gap between the developed and the developing countries is not to become wider.

The paper describes work on CAD, particularly in the field of structural analysis and in electronic integrated circuit design. The work on CAM includes computer-aided scheduling at Hindustan Machine Tools Ltd, NC machine tools with computer-aided programming, and some work and CNC and DNC. The work on computer-aided NC programming is described in detail. The authors stress the need for post-processors to be prepared locally, rather than purchased from aborad. In a developing country environment. this seems to be cheaper and faster. They also advocate concentration of programming effort upon one programming language (in their case an APT language). The paper argues strongly in favour of establishing at the Central Machine Tool Institute in Bangalore a "centre of excellence" for CAM and CAD in India.

Application of computer-aided techniques in engineering industries in Latin-American countries

R.S. Apostoli

The author described activities of the research centre in Cordoba, Argentina.

The purpose of the written presentation was to show a synthetic plan of the application of engineering computer-aided techniques in industry in Latin American countries, so as to give an idea of the current situation. An estimate of future developments was also given.

Kongsberg Vaapenfabrikk

Mr. Kaara

The speaker described his company's products, which included a.o. drawing tables, numerically controlled systems and gas turbines.

He then concentrated on drafting systems that were particularly suited to CAD and the preparation and checking of numerically controlled paper tapes.

Discussion

Several participants were interested in the economic aspect of introducing such sophisticated hardware and relevant software. The costs of such tools were found to be quite high. What would be the benefit in effectiveness by introducing such tools, and would this give a satisfactory return on investment. No general answer could be given to the question of the cost-benefit relationship when such tools were introduced, since results can vary widely from case to case.

Demonstration of selected engineering software
Univac

UNIS

UNIS (Univac Industrial System) is a production planning and control system that is adaptable to existing factory structures without deep changes in the organization. It is a system that brings the right material in the right quantity to the right place at the right time at the right cost. UNIS covers several tasks, e.g. product structure, material planning, scheduling and loading, and cost accounting. There is a data base included in the system that provides for: no redundancies, multiple uses of data items, independence of processing mode, integrity, flexible data structure, integration, and ease of use.

The system has many possibilities for input and output. There are paper tape, punched cards and video for input, and paper tape, mag-tape, discs and printer for output.

Various data are stored in the UNIS data base, for example:

Product structure
Operation plans
Alternate operations
Work centres
Alternate work centres
Tools
Customer and vendor data
Customer orders
Manufacturing orders
Purchase orders
Order networks
Material requirements
Material reservations
Work in process
Accounting data

UNIS consists of a set of powerful building blocks. Each building block serves a particular function within the production control system. The building blocks are classified according to their level of sophistication as: model installation programs, extended functions, public functions, privileged functions, and software tools.

UNIS offers the user complete information, quick reaction for changes of products, lowering of stock costs, better utilization rate, and a reduction of run-through-times. The user can write his own subroutines, which can be included in the system.

UNIS is based on an integrated data base, and is maintained by a standard data management system (based on CODASYL report). It is modular in a true sense and is on-line oriented.

Another Univac system, ASET, is an educational system. It is used for training people in computer languages such as BASIC, FORTRAN and COBOL. The lectures are written in many different languages. The person who is going to be trained sits in front of a video display and reads lecture after lecture. He has the chance to switch back if he does not understand, and to do examples where the system controls his answers and corrects him if necessary. The subject of the lecture can be almost anything, because the system is not a set of courses, but a tool for the author to write lessons where the person to be trained has to answer special questions. The use of the system at a school in Chicago had shown that lessons in front of the video were much more efficient than normal teaching methods. The system could also be used for training instructors.

There was a demonstration of the system. One Uniscope video was connected via a telephone line to a Univac computer in Warsaw. The participants were able to try out courses and languages.

Discussion

In the discussion it was mentioned that data base is not a new development of data management, because engineers had known the idea for 15 years. The efficiency of the system depends on the size of the factory and the number of different products. Smaller factories with few products cannot use the system because it is too big and needs too much core. It was mentioned that to choose the UNIS system binds the user to Univac computers, because there are many difficulties involved in changing to other systems on other computers.

Part three. Visits to factories and installations

Stalowa Wola

Huta Stalowa Wola is the largest of the BUMAR factories. It manufactures heavy crawler tractors, cranes, loaders, concrete mixers etc. It is located at the town of Stalowa Wola, about 300 km from Warsaw. The mechanical manufacturing factory and the associated steel mill employ altogether about 25,000 people. Several hundred of each type of construction machinery are produced; the output of certain subassemblies (e.g. gearboxes) is in the thousands.

The programme of the visit included:

(a) A general survey of one of the mechanical manufacturing factory departments (gearbox and axle manufacture) with particular attention paid to the operation and use of NC machine tools installed there (almost 100);

(b) A visit to the heat treatment line (computer controlled) and to the crawler tractor assembly line;

(c) A visit to the computing centre equipped with an IBM 370/145 computer;

(d) Lectures by the chief of the computing centre and the chief of the manufacturing engineering department.

The shipyard computer centre in Gdansk (ZIPO)

United Polish Shipyards designed and developed ASTER, which is based on the Spanish shipbuilding system FORAN. The software is written in FORTRAN IV. The primary functions of ASTER are:

(a) To represent digitally the ship's hull configuration, to facilitate the design of lengthwise parts, shell plate expansion, NC "burning" tapes etc.;

(b) To route cable throughout the ship in such a way as to optimize the total length of cable to be used;

(c) To aid in detailing the piping configurations to be used in the construction of a ship.

The following hardware systems were demonstrated in action:

(a) ICL 2903 - for running basic ASTER system;

(b) Kongsberg SM4 minicomputer and drafting table for fairing, line drawings etc.;

(c) WANG Mini - for engineering design calculations;

(d) Two ICL System 4 computers (4/50 and 4/70).

The shipyard at Gdynia

The following facilities were visited during the tour:

(a) The MOLD loft, where a few items require drawing in the conventional way (by hand) - most of these tasks are done with ASTER;

(b) The plate shop, where multi-head NC flame burners cut the various steel plates;

(c) The steel plate storage yard, which is being automated to place the following functions under computer control:

(i) Plate storage;

(ii) Plate selection;

(iii) Inventory control;

(iv) Plate cleaning and priming;

(v) Routing to the flame burners;

(d) The plate rolling and forming shop;

(e) The automated welding shop where hull sections are automatically "butt" welded and stiffeners are automatically welded to plate sections;

(f) The steel fabrication shop;

(g) A large newly-constructed dry dock, which has capacity for building ships at once. It handles about 20 new ships a year. A 900-ton gantry crane (the world's largest), built in Finland, was observed in operation lifting huge hull sections in place prior to final ship assembly.

The BUMAR CAD/CAM centre in Warsaw

The BUMAR CAD/CAM centre was established in 1975, with the aim of developing CAD/CAM capability and introducing the techniques into the Polish construction and earthmoving machinery industry, grouped into the BUMAR Union. At present the centre employs about 50 people. The equipment consists of a Digital Equipment PDP 11/70 with 384 kbyte core size and a large set of peripherals, a BENSON 222 flatbed off-line plotter, and a remote job entry IBM 3780 terminal linked to an IBM 370/145 computer system.

The activities of the centre are mostly on the design analysis side, with finite element technique, simulation and optimization of design being the prime directions of research and practical CAD application. In manufacturing, the main direction is the computer-assisted programming of NC machinery, using various software and system concepts. The Centre also works on information systems for engineers; one being designed at present is for engineering drawings and other documentation storage and retrieval.

The computer installation was demonstrated in operation. The capabilities of the PDP 11/70 IAS operating system were demonstrated, particularly for the interactive type of man-machine communication from various types of terminals. Some simple engineering analysis programs running on a Hewlett-Packard 9820 desktop calculator were presented, as was a large system for NC flame cutting operations running on the same type of equipment. Some results of large-scale finite element analysis of structures (crane frame) using the ASKA system were also demonstrated.

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