INTELLIGENT MANUFACTURING SYSTEMS

Dr. Surender Kumar
Professor & Head
Department of Production Eng.
B.I.T. Mesra, Ranchi

1. Introduction

The goal of intelligent manufacturing system is akin to any normal manufacturing system satisfying customer needs at the most efficient level for lowest possible cost. The involvement of computers as in the computer-integrated manufacturing has been for more than 20 years; the incorporation of computer technology does not necessarily result in intelligent manufacturing system. It is the introduction of human like decisions making capabilities into the manufacturing system that makes it indeed intelligent. In particular knowledge base systems have dominated the manufacturing landscape of late 1990's CIM was all rage in 1980s, FMS in 1970s,

Manufacturing technology will play an important role in future human developments if it is based on new knowledge based applications. The impact of knowledge-based system on manufacturers is already in front and all of us to see and experience. Any organization must make full advantage of the knowledge at its disposal. This goal translates into the effective use of knowledge ranging from design to production and maintenance. To this end, the knowledge captured in disparate modules in the organization must be liberated and directed synergistically to support integrated systems for engineering and fabrication. There is a lack of awareness of tools and techniques to be used among manufacturers. Manufacturer's often use existing tools rather than investigate benefits of modern intelligent manufacturing techniques. Intelligent system vendors can help the situation by improving their shells to fit defined requirements for successful manufacturing applications.

2. CONCEPT OF MANUFACTURING

Manufacturing is defined very broadly as the process by which material, labor, energy, and equipment are brought together to produce a product having a greater value than the sum of the material put in. This can be shown as a system, as indicated figure 1. Here the input is shown as material labor, energy and capital. The capital input provides the equipment and facilities required for combining the material, labor, and energy. Output includes product, but there is always some undesirable output -waste and scrap—which should not be forgotten. Also shown in Figure 1 are external influences that should not be ignored. External influences can include government action, natural occurrences (e.g., storms, floods), and of course competition. Most people directly involved in manufacturing do not normally consider steel mills or refineries or textile mills as ' manufacturing'. To most people the production of automobiles, airplanes, refrigerators and electronics would be better accepted as manufacturing. This understanding of manufacturing would include mechanical and electromechanical products, including all components and parts. With the focus on mechanical components, metal forming and cutting are central to many of these

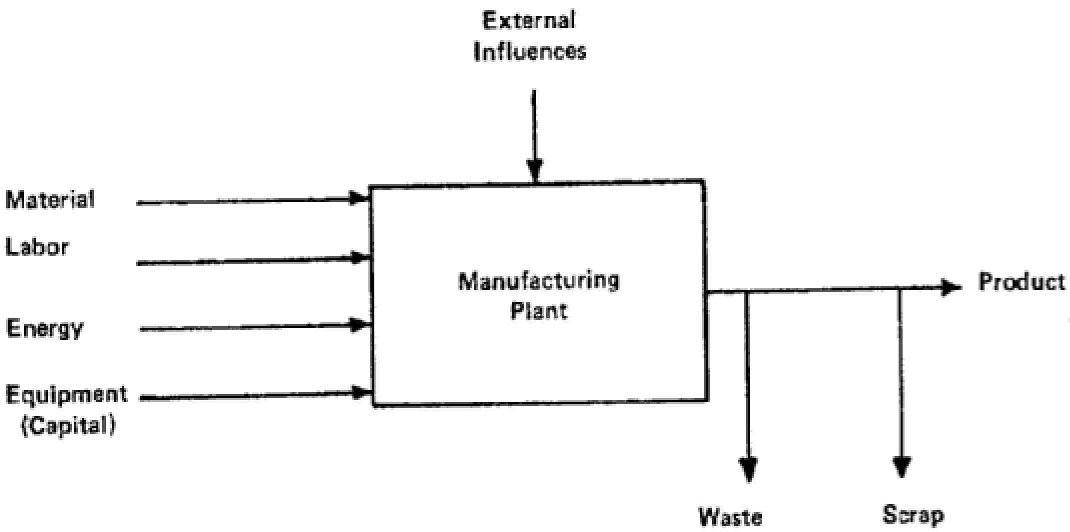

FIGURE 1. Manufacturing system.

operations, and those processes will be considered here to offer an appropriate view of manufacturing.

Before delving into manufacturing technology and application issues, it is important to have an understanding of the mission of manufacturing functions. What are the inherent objectives of manufacturing? In a broad sense they are (1) production, (2) productivity and (3) quality.

The first and most elementary objective of the manufacturing function is of course, production. Implied is the simple objective to innovate and apply tools methods, and processes using diverse engineering and scientific skills through which prototypes can be made and then replicated as commercial products. The second objective is to attain productivity efficiencies in order to minimize production costs. In this case economic consideration and process value analysis dominate. The third objective of manufacturing is to assure the highest product quality. Finally, a new objective cold be added – flexibility, i.e., the ability to produce more than one product with high productivity and of superior quality.

To attain these inherent objectives, a number of operational factors have to be considered. The opportunities to coordinate and control them have to be planned. For a situation requiring attention to technological change the operational input factors for manufacturing can be summarized as attitudes, resources and technology.

Is it the rapid growth of computer products? or the result of new electronics technology? or is it an effect of a new silicon semiconductor stemming from materials technology? or perhaps it is the result of process technology, which has allowed for rapid chemical vapor deposition of integrated circuits on a chip? Automated assembly of chips and microprocessors into a personal computer may have had something to do with it. It all blurs into advanced technology as far as the general public is concerned. In line with the practical definition of manufacturing, to professional practitioners or those studying the subject more deeply, manufacturing technology has distinct role and can given its own definition.

Manufacturing technology is the embodiment and integration of needed element of science and engineering into a functioning whole to convert product concepts and specification into practical reality for the product's in tended use. As a practical matter, manufacturing technology, as distinct from chemical process technology, deals with fabrication from available materials rather than synthesis of a new one. Manufacturing generally refers to discrete parts and operations. However, as batch operation are handled with greater automation, the overall effect begins to blend individual stages into a continuous flow from input to output just as in a continuous fluid stream in chemical process. Therefore , although batch process technology dominates, continuous –flow concepts are becoming a part of the scope of manufacturing technology.

Manufacturing technology does not necessarily follow the scientific disciplines and technology implied in the product being manufactured within the industry. An example is that of the new microelectronics and semiconductor industry. Here electronic engineers and mathematicians develop the product features, but the production process depends on chemical engineers and material scientists.

3. DEVLOPING AREAS OF A MANUFACTURING SYSTEM

The treatment of the subject matter follows a general rule that technology that became commercial within the past five years is probably still new to many, On the other hand, technologies expected to be available within the next five years need attention. Awareness of the yet- to-come may prepare for quicker technology transfer when this do become current. The focus of the technologies appropriate for manufacturing is on mechanical products and their components. However, a great deal of overlap is expected with all manufacturing industries. A schematic outline of the topic, which requires support and manufacturing development tools, is given in Figure.2.

For uniformity in presenting batch manufacturing technology features in this text, the individual operation are divided into one primary and three secondary processes. The principal process is supported by preprocess finishing operations, and the generally grouped secondary processes, as shown in Figure.3. This break down of manufacturing best fits the definition of manufacturing described earlier.

Within the context of development and adoption of new technology into the manufacturing section, manufacturing technology must be considered in its broadest context. In medium sized manufacturing companies, the focal point manufacturing technology can be the production, sales engineering, quality control, development, research, or other functions. Large industries are more likely to have an organized plan to innovate manufacturing processes. Whatever the actual name of the technology department – Development, Applied R&D, Advanced Engineering, Manufacturing Technology, Manufacturing R&D justification is an issue. Stimulus can come from technological argument or market situation.

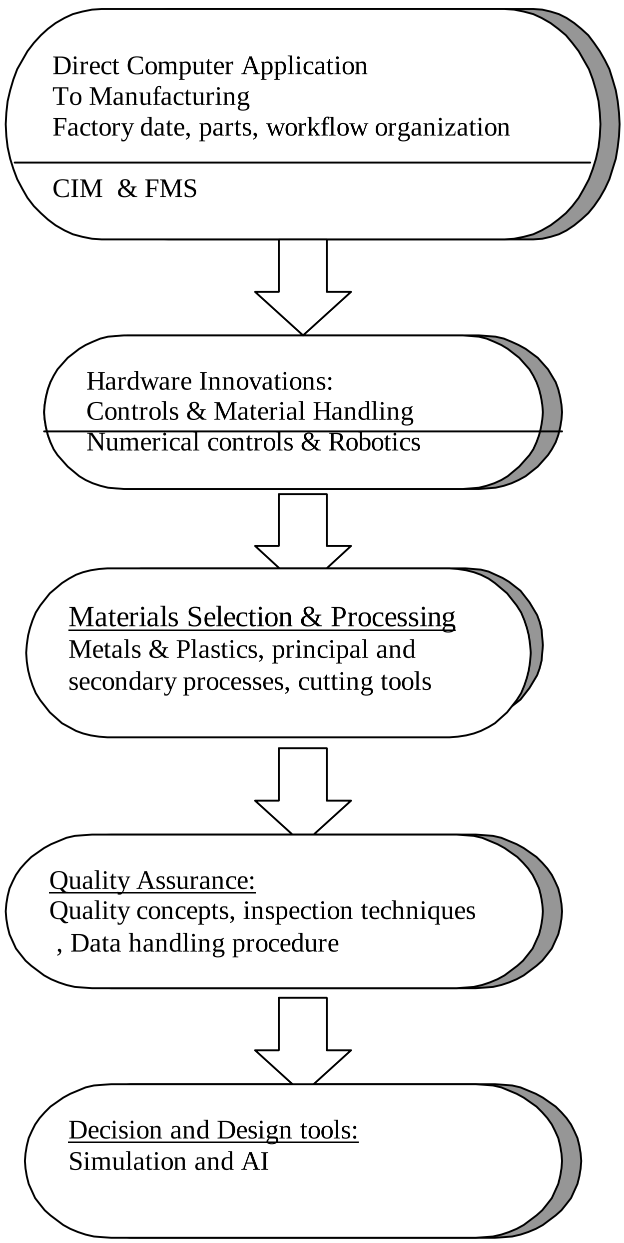

Figure.2. Outline of the various topics, which requires intelligent manufacturing Development tools

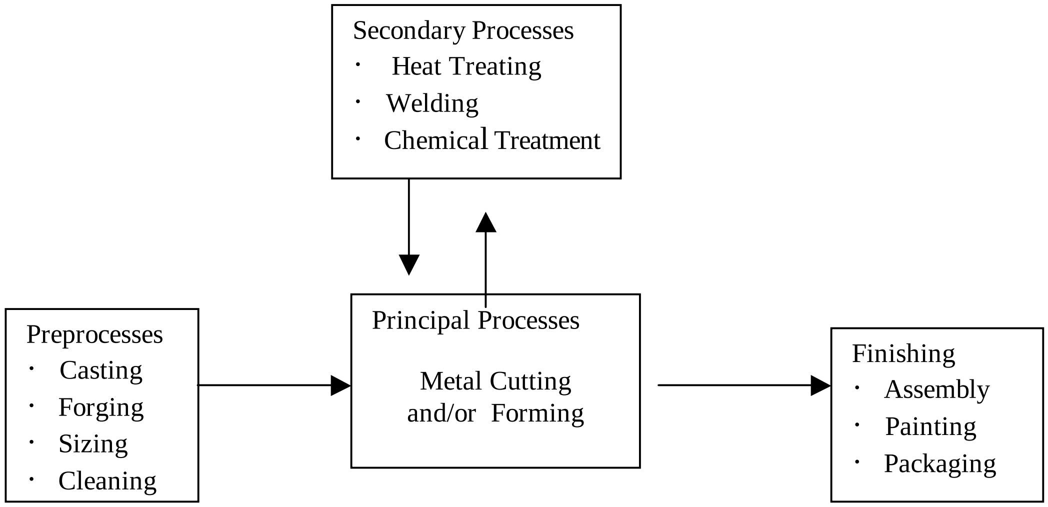

Figure.3 Extended View of machining

4. INTELLIGENT MANUFACTURING SYSTEM

An intelligent Manufacturing process has the ability to self regulate and/or self control to manufacture the product within the design specifications. An integrated concept with factories of future, where products are produced in an artificial life environment adds value to this. Researchers working on implementation of EXPERT SYSTEM,, have come out with this concept of adding intelligence. On a experimental basis it has been tried out on computer aided drafting system at University of Texas. Recent developments in feature based solid modeling techniques for design representation and AI applications have shown a potential to substitute EXPERT SYSTEMS for some decisions currently handled by a designers knowledge of design rules and practices.

The first effort in this endeavor through the Knowledge Based Systems, and expert systems were not sufficient enough to generate the required level of intelligence owing to their dependence on symbolic representation of the knowledge and the human expertise required to encode them efficiently. However the advent of ANN in 80's as self organizing dynamic systems and model free estimators, emergence of Fuzzy Logic Systems for modeling of uncertainty and human like reasoning and the acceptance of GA as global optimization technique for hard problems has led to the realization of Intelligent Manufacturing system as a feasible proposition in the current decade.

Intelligent manufacturing can be achieved in three basic ways.

- Existing manufacturing processes can become intelligent by monitoring and controlling the state of the manufacturing machine.

- ❖ Existing processes can be made intelligent by adding sensors to monitor and control the state of product being processed.

- ❖ New processes can be intelligently designed to produce parts of desired quality without the need of sensing and control of the process.

Intelligent Manufacturing system

1. Uses technology which can minimize the use of human Brain
2. Regulation for product mix and priority production, self regulated.
3. Self controlled operations with automatic feed back mechanism.
4. Monitoring and control of the manufacturing machine.
5. Monitoring and controlling the state of product being processed.
6. New processes with intelligence can be made to produce parts of desired quality with out the need of sensing and control of process.

5. STAGES OF DEVELOPMENT OF SUBSYSTEMS OF IMS

Subsystems	Stages	Tools used
1. Design Stage	Development in progress	CAD modeling tools i.e. Auto CAD
2. Prototype Stage	Developed according to demand	CASE tools with CBR.
3. Procurement Stage	Developed with on live technologies to cater for JIT with vendor certification.	Any vendor interactive software
4. Process Stage	Scheduling tried out with . Genetic algorithms . case based reasoning	Genetic algorithms * Case tools. * Fuzzy composite logic tools.
5. Machining CENTRE	Artificial intelligence tried out, in progressive stage of development.	
6. Material handling	Developed with incorporation Systems of AGVs, guidance of AGVs and sensors being developed	
7. Storage System	Developed with inventory Expert systems.	
8. Marketing	Developed according to inputs from marketing parameters i.e. demand	Fuzzy logic + simulation algorithms

6. Tools used for intelligent manufacturing

Following are the tools generally used in intelligent manufacturing:

- Fuzzy logic
- Genetic Algorithms
- Neural Net Works
- Case tools
- Simulation Algorithms.
- AI

a) SCHEDULING WITH NEURAL NETWORK

Artificial Neural Networks aimed towards the modeling of networks of real neurons (i.e. animate brains) motivated by their robustness, fault tolerance, flexibility and the learning ability of the biological brains, the building blocks of the ANN variously called as neurons, processing elements etc. do have striking similarities with their biological counterpart.

An interactive tool for short term production scheduling with system features and graphical interface that allows operator to interactively control the schedule generation and see influence on key parameter.

A constraint management subsystem checks that the current schedule agrees with the restriction imposed from the production environments and if not, the reason for conflict is identified and presented to planner for rectification. This knowledge base system is able to effectively react to unexpected events or delays. Neural network techniques come into play, repairing an inconsistent schedule towards a consistent or an optimal schedule.

b) CASE BASED REASONING

This is extensively used as a tool to interpret the process parameters. Human experts need to be consulted to interpret analytical results of the process,. Providing an opportunity to improve on the procedure with an expert system. Case based reasoning represent knowledge as ‘cases’ i.e. examples of past problems and solutions.

C) INTELLIGENT DESIGN AND ANALYSIS SOFTWARE

The expert system produce4s optimal design parameters without violating any material or machine constraints. This is actually an extension of CBR (case based reasoning)

d) FUZZY LOGIC

Fuzzy logic system provides a means of expressing the linguistic variable in suitable form for processing using a Computer Fuzzy logic Control of processes offer flexibility by which process states and control actions can be described directly from the experience and advice of the human operators, thus making it possible to apply practical operational experience in the computerized control of complex multi-variant process. It provides a mathematical framework to capture the uncertainties associated with human cognitive systems such as thinking and reasoning. The control rule is formulated as linguistic expressions involving every words like High medium, low etc.

e) GENETIC ALGORITHMS

GA is powerful probabilistic heuristic procedure for global search and optimization in multi-parameter search spaces, based on the mechanics natural genetics. It is to exploit historical information to locate new points in the search space with expected improved performance.

This is also used as a tool for optimal assembly planning. Genetic algorithms referred to as an ADAPTIVE COMPUTATION are based on the evolutionary concept of natural selection and survival of fittest.

In simple terms, genetic algorithm generates new rules to replace the least useful rules already in place. These software tools allow user to solve complex problems, such as scheduling large number of conflicting tasks, finding the shortest route that connect a number of location, or streamlining communications network.

The genetic algorithms are used to optimize the search routine used in assembly planning with the goal of improving the assembly process of mechanical product thereby minimizing time and cost.

f) ARTIFICIAL INTELLIGENCE

This tool is an attempt to increase the number of human characteristics, computer and computer-controlled systems. It is basically an ability to imitate the human intelligence. The sub tools used are

- An algorithm is a computer program that solves selected problem within given time frame.
- Early vision Computer calculations that allow systems to see by providing low-level data.
- Higher level vision Computer calculation that allows systems to accomplish higher level such as smart improvement within an environment object recognition and reasoning about objects.
- Knowledge Engineering. A process by which knowledge is collected from experts

7. IMAPCT OF ARTIFICIAL INTELLIGENT IN MANUFACTURING

The inventions of automation and artificial intelligence have brought about a technological revolution in the operator-machine system relationship. These technologies have made it possible to reduce safety risks and to implement cognitive capabilities, such as speech understanding, logic deduction, picture understanding, reasoning about expert knowledge, problem solving, and decision making in machines.

With automation most of the physical human work is transferred to machines. Optimal controllers are developed to take over skilled-based activities. The human role shifts from the doer to that of a monitor and problem-solver, awkward postures of the human body, excessive manual force, and high rates of manual repetition are less impacting.

In recent years, numerous articles have appeared in the trade press that discusses the manufacturing application of AI. The quantity of information alone has been overwhelming, and the fact that it involves concepts with constantly changing parameters has created even more confusion. The popularity of AI underscores the need for a better definition of the discipline. The problem of defining AI is its multidisciplinary origins, with no single fundamental concept having clearly set the initial limits. One definition that often appears states that AI encompasses any technology that involves making a machine behave in way that would be considered intelligent human behavior. Of course, this requires a further definition of what is meant by "intelligence" Another definition state that AI is any technology that enables a computer to respond to situations that were not anticipated by its programmer

Artificial Intelligence (AI) is the science of making machines do things that would require intelligence if done by humans. Techniques such as expert systems, fuzzy logic, and artificial neural networks are quite common. AI technology offers the potential to transfer rule-based and knowledge based functions from humans to machines and computers. Examples of these functions are monitoring the state of the machine and environment; if operational conditions of the machine change, self-adapting mechanisms enter to modify goals; when goals change a set of suitable plans is developed to react and alternative plans are evaluated; after simulating the effect of alternate plans the optimal solution is implemented.

A description of an intelligent operator-machine system is outlined in Figure.4 Several points are key to a successful realization of such systems.

1. Reliable symbolic representation schemes must be developed.
2. Appropriate levels of operator alertness must exist.
3. When the system works in the automated mode, the operator must stay in the loop to minimize reaction time for take-over in case of system failure.
4. The operator must be able to intervene at all three levels of interaction (skill-rule and knowledge-base) to serve as a backup in case of failure of the automation system.
5. The display and interface system must be laid out to ease communication between worker and machine on the three levels of interaction.

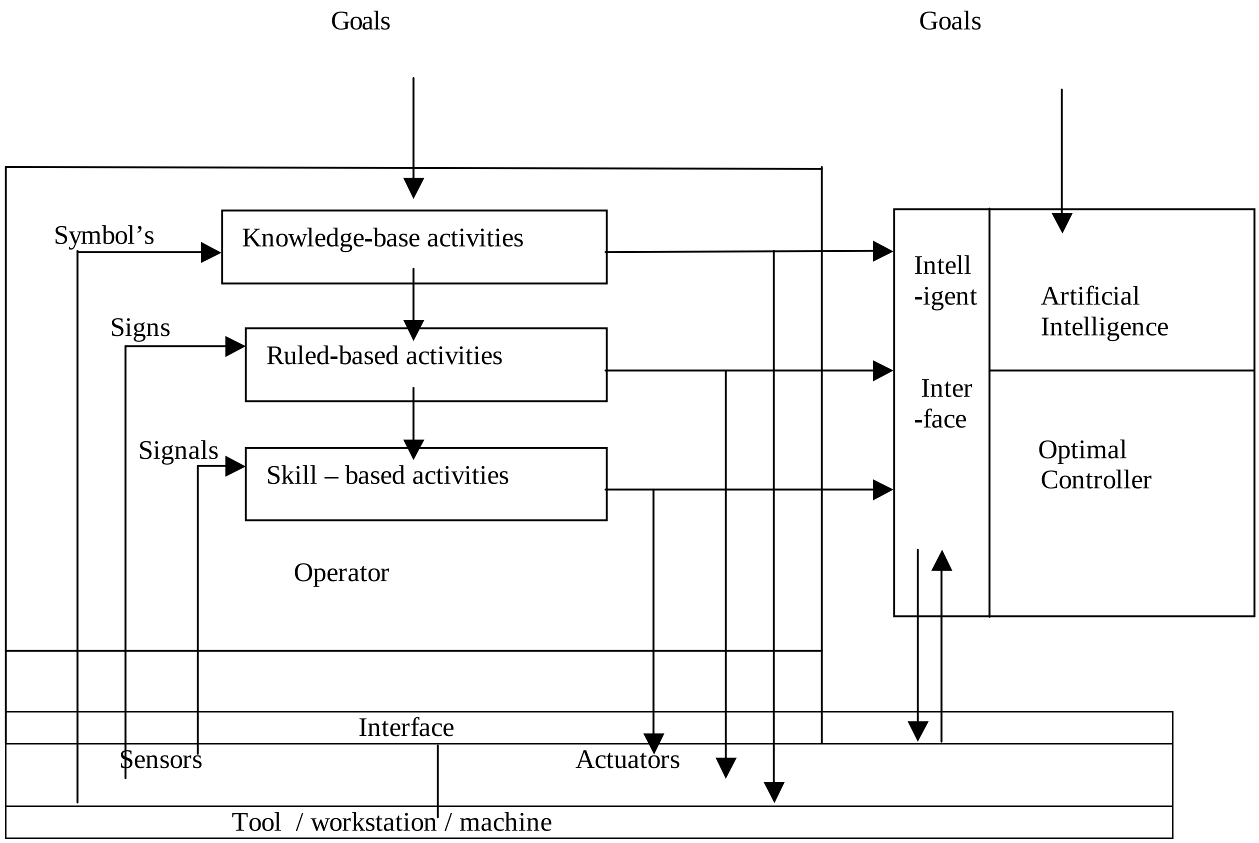

Figure.4. Description of an intelligent operator-machine system

8. USE AND APPLICATION OF AI IN SPECIFIC MANUFACTURING AREAS

The use of AI is increasing very rapidly in manufacturing. Manufacturing will change more in next 15 years than it has in the last 75, largely due to the application of computer-aided technology that has been developed during the last 10 yr. The tools of this technology include:

- Computer-aided design(CAD)
- Generative process planning
- Robotics / material handling
- Computer-aided manufacturing (CAM)
- Automated Standards
- Manufacturing resources planning
- Group technology

AI is indicated as the technology that will tie these tools together. The generic application of AI, including the following items directly related to manufacturing:

- Fault diagnosis and repair (machines and systems)
- Operation of machines and complex systems
- Management (Planning, scheduling, and monitoring)

- Design (systems, equipment, intelligent design aids, and inventing)
- Visual perception and guidance (inspection, identification, verification, guidance, screening, and monitoring)
- Engineering (chemical and biological synthesis planning, and intelligent design aids)
- Industrial (factory management, production planning and scheduling, intelligent robots, process planning, intelligent machines, and computer aided inspection)

AI Technology	Application
Expert system	Design Maintenance Process control Monitoring alarm analysis Equipment diagnosis Process planning Scheduling
Machine Vision	Inspection Identification Measurement
Robotics	Welding Material handling Part positioning Assembly Spray painting
Natural language understanding	Database information retrieval
Voice recognition	Data entry Inventory control Quality Inspection NC programming Robotics
Speech synthesis	Control room alarms

These references provide a general view of how AI can be applied.

Some of the specific areas are explained below:

a) <u>AI in process planning</u>

The process-planning system consists of two components

1) a knowledge base and
2) an inference engine.

Declarative knowledge (facts) is represented in the form of frames, and procedure rules are represented in the form of production. The fact in the knowledge base may be broadly classified as follows:

(1) Facts about workpieces and machined surfaces,
(2) Facts about machine tools,
(3) Facts about machining operations, and
(4) Facts about tooling.

The rules in the knowledge base may be categorized as follows:

(1) Rules for identifying machined surfaces on a workpiece,
(2) Rules for consistency checking of tolerancing,
(3) Rules for selecting operations,
(4) Rules for sequencing operations,
(5) Rules for selecting machines,
(6) Rules for selecting tools,
(7) Rules for selecting machining parameters, and
(8) Rules for adding new rules in the knowledge base.

Basically Turbo-CAPP employs a backward-chaining inference mechanism for

(1) collecting candidate rules (the conflict set),
(2) Scheduling the rule-firing sequence,
(3) Selecting an appropriate rule,
(4) Processing command(s), and
(5) Modifying the knowledge base accordingly.

Both sequential and parallel processing of candidate rules are employed in Turbo-CAPP (Wang, 1986).

In the process of creating process plans and NC code, the system must acquire knowledge from the user from time to time. Several modules performing knowledge acquisition are (1) the tolerances input module (TIM). Which is used to acquire geometric dimensioning and tolerancing data for the planned part; (2) the machine-description module (MDM), which is used to acquire machine-dependent facts; and (3) the process-manipulation module (PMM), which allows the user to add new process (es) into and/or delete existing process (es) from the knowledge base.

Turbo-CAPP is currently implemented in PROLOG to run on an IBM PC Based on various input conditions, the geometric features, the machine capabilities, available tools, workpiece, and tool material data, etc., Turbo-CAPP generates reasonably good process plans for the machining of symmetric rotational workpieces. The system allows the user to manipulate the knowledge base. The change is then reflected in the planning results. Several rotational parts have already been process planned (including NC tape generation). The process typically takes 2 to 5 minutes per part of planning time (Wang and Sysk, 1987).

Their are several other AI-based process planning systems.

- CMPP (Sack, 1982), which was developed at United Technologies Research Center, is process-planning system for planning cylindrical parts (although some noncylindrical features are allowed). In addition to generating process plans, CMPP presents a unique feature. It performs dimension, tolerance, and stock-removal analysis based on a sophisticated algorithm with the objective of optimizing tolerance capabilities of shop equipment. Moreover, it also selects appropriate dimension reference for each machining operation. Perhaps the only limitation of CMPP is the geometric coverage-cylindrical parts.
- AMPS (Chang et al., 1988; Kanumury et al., 1988) is an automatic process-planning system for prismatic parts. It was developed as part of an integrated design-manufacturing-inspection system called QTC (quick turnaround cell). AMPS utilizes a feature-based-design solid model as input. A feature-refinement module analyzes the design model and reasons the final machining features and their precedence relationships. Setup planning and fixturing method planning are part of the process planner. The end result of the system is the preparation of a detailed process plan and part programs for the designed part. No human decision-making is necessary for the entire planning process. In AMPS, the feature-refinement module converts the solid-model information into a symbolic representation in a frame structure. Process knowledge is represented in rules. As ES (expert system) shell, KEE, a computer program, is used for the implementation.

b) AI in manufacturing planning and control

Manufacturing planning and control involves managerial decision making on three main levels of activities. Decisions at

(1) the strategic level of production and inventory planning and control are really crucial and should be made with utmost care.

(2) At the tactical level of manufacturing operations planning and control, the batching and loading problems are the central focus.

(3) The operational level of process and material flow planning and control is concerned with the detailed decision making required for real-time operation of an automated manufacturing facility. The dynamic nature of the manufacturing environment stems from the highly variable nature of factors such as customer orders influencing the strategic level, material and capacity constraints in the tactical level, and machine or workstation availability in the operational level. In order to aid manufacturing managers in achieving productivity goals, various concepts of information systems and computer control have between developed.

Traditionally, the manufacturing environment has been controlled by process controllers, shop-floor computer controllers, and other computer aids for various planning tasks. Although computer technology can rapidly process large quantities of data using sophisticated logic, many of the necessary decisions must wait until human operators can sift through the data, become familiar with the system status, and select proper actions. AI techniques can provide better planning and control and a higher productivity.

Many AI-based systems have been developed to deal with various planning and control problems in manufacturing systems. In this section, several systems are categorized and described in the following: AI in part design, AI in process design, and AI in process execution.

c) AI in part design

Engineering design may be defined as a process in which scientific principles technical information, and creativity are all combined in order to produce an optimum and product that will serve its intended purpose. Design engineering involves a number of distinctive phases, beginning with the definition of particular problem and ending with the selection of an optimum solution. Various approaches to engineering design have produced different decompositions of this process. Commonly, engineering design is broken into three main phases, as illustrated in Figure.5.

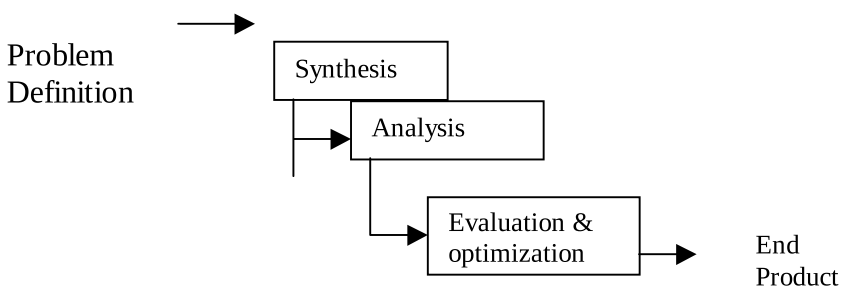

Figure.5. Decomposition of engineering design.

Synthesis (preliminary design) is an essential feature of all design work; this task deals with the formation of design alternatives. Synthesis involves searching and checking of subsystems. The end result of this phase is the selection of one or, at most a few preliminary design alternatives that satisfy the key constraints of the particular problem.

During the analysis phase a selected design alternative is studied using mathematical and other scientific procedures in an effort to determine the suitability of the design to the intended environment. Important aspects of this phase are the selection of the proper analysis procedures, the correct use of these procedures, and the appropriate interpretation of the results.

The evaluation and optimization phase of the engineering design process involves the evaluation of the analyzed design alternative. At this point, backtracking and repetition of previous design phases are often required to produce a feasible, acceptable, or optimal design solution to the specified problem.

With the introduction of the computer as a powerful tool for the engineering design process, attention has shifted from pursuing study on design methodology to the development of software to aid engineers in the design process. Traditionally, these aids have been limited to the well-structured aspects of design such as ANALYSIS and graphics. Advancements in AI research and the subsequent emergence of expert systems provide a new powerful tool for the development of computer programs that can be used as aids for the solution of ill-structured phases of the engineering design process-preliminary design.

The first step in part design is a conceptual one dealing with synthesis, which is ill structured. Here the basic ideas of the product from the design standpoint are generated and tested. The second step in part design is a detailed one, involving analysis. Each part-design concept is placed under the engineering microscope for detailed consideration.

Their are several intelligent simulation software's for part design some of them are as follows:

- The I-DEAS drafting and solid modeling program (from S D R C U.S.A)
  The I-DEAS software is an integrated drafting, solid modeling, design and manufacturing solution, which provides you with greatest design flexibility.

- The ANSYS Finite Element Analysis (FEA) program (From ANSYS Inc. U.S.A.)
  The ANSYS program from ANSYS provides the full range of engineering design analysis and optimization capabilities- solid modeling, preprocessing, solution, post processing, graphics and design optimization features. The ANSYS program enable users to generate innovative design options by helping determine all aspects of design : displacements , stresses , forces , temperature distribution, magnetic field strength , fluid flow, pressure distribution , material saving and other important design considerations.

- The FLOTRAN Computational Fluid Dynamics program.
  The FLOTRAN Computational Fluid Dynamics (C F D) program is a powerful engineering tool that enables users to solve fluid flow and heat transfer problems.

- The ADAMS mechanical simulation and prototyping program (From MDI U.S.A)
  ADAMS enables the user to predict the behavior of mechanical system undergoing large displacement motion. ADAMS empowers you to perform four important types of analysis: Kinematics, Static, Quasistatics and Non-linear and linear Dynamics.

- The LS-DYNA program (From Livermore Software Technology Corp. U.S.A)
  LS_DYNA is a general purpose, explicit FEA program used to analyze the nonlinear dynamic response of three-dimensional inelastic structures._The various application areas of LS-DYNA are – Crashworthiness, Metal forming, Metal cutting, Penetration, Glass Forming, Plastics forming etc.

- The DATAMINE mining program (from DATAMINE U.K)

  The DATAMINE is typically used in data capture and analysis, exploration, geology, geochemistry, surveying, ore body modeling, underground and open pit mine design and production planning and also in related areas such as environment studies.

- The MENTOR GRAPHICS electronic design program

  The MENTOR GRAPHICS Corp. (MGC) is the world's leading provident of Electronic Design and Automation tools. The MG software are available for all application in electronic design PCB, IC, ASICFPGA, DSP, Mixed Analog Digital Design, Air flow, Heat transfer and so on.

- The MOSS Infrastructure development program (from MOSS SYSTEMS Ltd. U.K)

  The MOSS software can be used extensive for feasibility study, planning and design of basic infrastructures like highways, tunnels, bridge and railways.

- The MARc K7

  The MARC K7 allows the user to perform a wide variety of structural, fluid and coupled analyses using the finite element method. These procedures provide solutions for simple to complex linear and nonlinear engineering problems.

- DEFORM systems include Automatic Mesh Generation (AMG)

  DEFORM systems include Automatic Mesh Generation (AMG) which allows users to specify remeshing. Criteria and optimization criteria for an intelligent mesh, based on solution behavior. The AMG system is optimized to meet the severe requirements of large deformation modeling. Forming equipment models are coupled into the simulation engine. The energy loss of a hammer, screw press or power limits of hydraulic press can be included in the analysis.

  Corner unfill, load requirements and die pressure are available output. Graphical output includes deformed mesh (to demonstrate material flow), nodal velocities (to quantify local material flow at any time during the process) and field variables, which are easily available. Graphics can be exported to word processors or other programs for reports or presentations.

  DEFORM include sophisticated animation creation and reply capability, which allows users to graphically demonstrate material flow and the change in field variable in a "real time display format.

- MSC / Superforge

  MSC / Superforge accepts geometry data from all major CAD system providing a seamless transition from CAD to analysis.

  The Graphical User Interface speaks the language of the process engineer, bridging the gap between the shop floor and the engineering analyst process characteristics such as metal flow, die filling, flash and tooling loads can be predicated by computer simulation, then passed along to the shop floor for recommended process changes.

  With its finite volume technology, MSC / Super Forge has been successfully used in industry to simulate many 3-D forging processes which are beyond the scope of finite element based forging simulation technology. These processes include the multi-stage forming of complex 3-d parts such as crankshafts, connecting rods, valve craps and axles.

d) AI in Process Design

The process-design stage exhibits a high degree of similarity to the part-design stage except that the focus of attention is on designing processes by which to manufacture parts rather than designing the parts themselves.

In the context of AI-based process design, the following systems have been developed

- ❖ The Mdonnell Douglas Research Laboratory is investigating AI-based parts to assist process designers. An example can be taken from the study of the metal-joining problem. When a part designer has decided a weld is required, a process designer must specify the details of a welding-process plan. This plan is based on decisions about the welding process to be used., heat treatment requirements, joint preparation before welding, cleanup after welding, and parts jigging, to mention but a few.

- ❖ Embodies a constraint-directed reasoning approach to job-shop scheduling in the process-design stage of manufacturing. The system has been developed and implemented by Fox and co-workers at Carnegic-Mellon University (CMU) (Fox, 1981), ISIS was developed for factory scheduling. The system uses a variety of representation and search techniques for reasoning with constraints. ISIS provides a general solution to the shop-scheduling problem and has been developed within the environment of the Westinghouse turbine component plant.

- ❖ In another project at CMU, Fox and co-workers have developed a knowledge-based system (KBS) capable of interactively modeling and simulating factory organizations (Fox, 1984). The system includes a number of features aimed at producing simulations that are easier to build and that produce more understandable results than currently available simulators.

- ❖ Wysk et al. (1986) presented an AI-based control and scheduling system for FMS. The system is able to (1) generated potential scheduling alternatives based on real-time shop information and scheduling, (2) update performance rules based "simulation experience," and (3) affect the control on a variety of FMSs.

e) AI in Process Execution

The first step in process execution is one in which raw materials and tooling are brought together with manufacturing equipment such as NC machines to produce parts. This step also includes finishing the parts, inspecting and/or testing, and placing the parts in storage until required. The second step in process execution includes bringing together parts and tooling along with other manufacturing facilities such as robots to assemble products. Again, finishing, inspecting, testing, and storing may be required.

Several AI-based systems for the process-execution problems of manufacturing have been reported:

- Fox and coworkers at CMU have developed an AI system, PDS, for the online diagnosis of malfunctions in machine processes (Fox, 1984). The operation of the system is based on information acquired from tens or hundreds of sensors attached to the machine(s). Although this is the only wait to obtain large amounts of timely information, it introduces further problems since no sensor is error-free and sensor performance degrades over time. Therefore, PDS reasons about the sources of its information in addition to performing diagnosis based on the information.

- Gini et al., (1983) have proposed CAMA (computer –assisted maintenance) as a knowledge-based consultation system for automatic maintenance and repair. Further efforts by the same researchers have been aimed at automatic error recovery in robot programs operating

9. STEPS FOR IMPLEMENTING AN INTELLIGENT SYSTEM SOLUTION

Steps for implementing an intelligent system solution in manufacturing are as follows:

- Select an existing software that will first augment an expert system and then integrate with task solution software.

- Collect trade standards, heuristic rules, past experiences and recommendation from books, experts and standard codes.

- Organize a complete set of rules governing this task, and describe them in a formal way acceptable to a list processing software.

- Generate a list of features and other part attributes called for in the rule set.

- Generate relevant data by extracting the features and other necessary part attributes from the model data of an object.

- Organize the rules governing this task into a knowledge base.

- Implement an inference engine as a reasoning mechanism to find a solution on the knowledge base and the external data.

- Incorporate the results into the model and its representation to obtain a final solution.

10. CONCLUDING REMARKS

As mentioned previously, the application of AI includes (1) problem solving (2) logical reasoning, (3) natural language processing, (4) automatic program generation, (5) robotics, (6) computer vision, and (7) expert systems. Many, if not all of these applications are required in manufacturing. It is believed that manufacturing will become a dominant customer of AI technology.
Although AI has shown great potential in manufacturing applications and will definitely continue to be a focal point for man researchers, several critical issues remain to be resolved: (1) Flexible knowledge representation: an important issue in designing an AI application is the selection of a suitable knowledge representation scheme. Current AI systems, with only a few exceptions, employ either production rules or frames. Any real-world problem, especially in manufacturing, requires a more complicated and effective knowledge-representation stricter. This may, imply a demand of efficiently combining the strengths of two or more existing schemes into a powerful one. (2) Learning procedure: several AI systems are capable of learning new knowledge. However, the learning procedure used are very limited. For example, newly learned knowledge may be contradictory to the knowledge already in knowledge base because of the lack of a consistency checking mechanism. (3) Handling of uncertainty: uncertainty is a norm rather than an exception of real world. When one tries to model a real world problem, the inclusion of uncertainty variable already exist, their weaknesses are obvious. For example, it is well known that membership functions are the essential element in a fuzzy set application. However, deciding a membership function so that the function can precisely describe the problem being modeled requires much research effort. Before a generalized scheme for constructing the membership function is available, the fuzzy set application remain difficult.

It is not clear what application will dominate in the near future, although process control appears a likely candidate, process control applications may be more mature at this point, due to the possibility of making small meaningful test cases.

During the next few years many problems must still be faced in the application of AI to manufacturing. Included in the list are:

1. Understanding how to pick problems that are within the capabilities of the available tools and experience.
2. Real –time issues which will surface as bugs when current tools are applied in increasingly stressful situations.
3. Integration issue, both with in-place software and with the total factory organization.

In general, more must be learned about AI by manufacturing engineers, and more must be learned about manufacturing requirements by AI practitioners. Manufacturers should not jump into using an AI / ES approach instead of conventional techniques without carefully considering the trade – off. There will be cases that will be better handled with conventional techniques.

Usually, these will be such that a solution can be expressed as an algorithm. It may be possible, however, that the flexibility of the expert system approach will be the most import consideration.

Bibliography.

1. Deb S.R and Chattopadhayaya," Proc. 3rd SERC school on 'Advanced Mfg. Tech.' ", Jadavpur Calcutta, 1997.
2. Kumar Surender," Industrial Robots and CIM", Oxford and IBH Publication Co, New Delhi.
3. Kumar Surender and Jha, A.K, "Computer Aided Design and Manufacturing", Dhanpat Rai and Co. Ltd., New Delhi.