Computer Aided Process Planning Technique in Casting Industries: An Overview

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Abstract

The cost reduction with improved quality of product made by casting is very important factor in the present competitive global market. This research introduces an approach of Computer Aided Process Planning technique for reducing cost and quality improvement of casting products in the Computer Integrated Manufacturing (CIM) environment. Computer aided Process planning involves deciding the methods, materials and machines for various steps, requirement of trained labours & making the process plan sheets used in casting process. This research will give an off-line control of designing, production & making process plans at the early stages and thus enables early prediction and prevention of manufacturing processes associated with the design for reducing the cost of the products with improved quality. In present work the CAPP technique with the software 'Kform Project Manager v.2.5' for making the process plan is introduced as an overview.

Keywords:

CAPP, CAD, CAM, CIM, FEM, Off-line control sheets, MCU, NC, Stereo- lithography.

1. Introduction

CAPP [**1, 2, 3**] is a highly effective technology for discrete manufacturers with a significant number of products and process steps. The first step is the implementation of GT [**4, 5**] or FT [**4, 5**] classification and coding. Commercially available software exists to support both GT and CAPP [**3, 4, 5**]. As a result, many companies can achieve the benefits of GT and CAPP [**3, 4, 5**] with minimum cost and risks. Effective use of these tools can improve a manufacturer's competitive advantage too. Technological advances are reshaping the face of manufacturing, creating paperless manufacturing environments in which computer automated process planning (CAPP) will play a preeminent role. The two reasons for this effect are: costs are declining, which encourages partnerships between CAD [**2, 3**] and CAPP developers and access to manufacturing data is becoming easier to accomplish in multivendor environments. With the introduction of computers in design and manufacturing, the process planning part needed to be automated.

The shop trained people who were familiar with the details of machining and other processes were gradually retiring and these people would be unavailable in the future to do process planning. An alternative way of accomplishing this function was needed and Computer Aided Process Planning (CAPP) [**3, 4, 5**] is an alternative. Computer aided process planning is usually considered to be a part of computer aided manufacturing.

However computer aided manufacturing is a standalone system. In fact a synergy results when CAM is combined with CAD to create a CAD/CAM [**1, 2, 3, 5, 6**] system. In such a system CAPP [**3, 4, 5**] becomes the direct connection between design and manufacturing. The goal is to find a useful reliable solution to a real manufacturing problem in a safer environment. If alternate plans exist, rating including safer conditions are used to select the best plans.

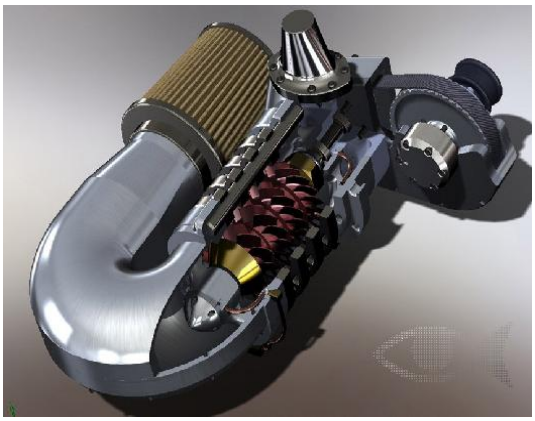
1.1. Computer Aided Design (CAD)

A product must be defined before it can be casted. Computer Aided Design involves any type of design activity that makes use of the computer to develop, analyze or modify an engineering design. There are a number of fundamental reasons for implementing a computer aided design system, which may be proven as a better design.

(a) Increase the productivity of the designer: This is accomplished by helping the designer to visualize the product and its component subassemblies and parts; and by reducing the time required in synthesizing, analyzing, and documenting the design. This

productivity improvement translates not only into lower design cost but also into shorter project completion times.

(b) To improve the quality of the design: A CAD **[1, 2, 3]** system permits a more thorough engineering analysis and a larger number of design alternatives can be investigated. Design errors are also reduced through the greater accuracy provided by the system.



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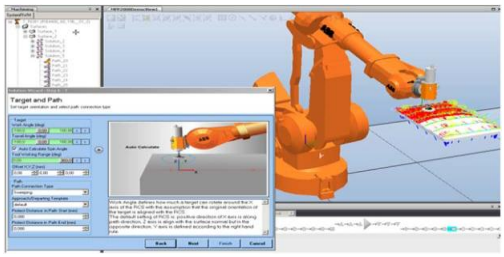
1.2. Computer Aided Manufacturing (CAM)

By the time computer use in design began, numerical control technology (NC technology) had matured to become cost effective for applications in casting and machining. An important aspect in numerical control is part-programming. A part-program is simply a set of statements comprehensible to the machine control unit (MCU) [**7, 8**] that oversees slide and tool movements and other auxiliary functions. In the case of components with complex geometries, many part-programs had to carry out lengthy calculations for which it is logical to use computers. This gave rise to machine control units (MCU) with built in microprocessors- the building blocks of computers. The use of computers in extending the applications of NC technology, especially to part-programming was earlier termed Computer Aided Machining (CAM) and the associated technology was called Computer Numerical Control (CNC) [**9, 10**]. Later Computer Aided Machining became an acronym for Computer Aided Manufacturing (CAM). Earlier Computer Aided Manufacturing used to denote computer use in part-programming only. Today it means any non design function of manufacturing that is computer aided. In figure 2, CNC welding machine assisting in casting products.



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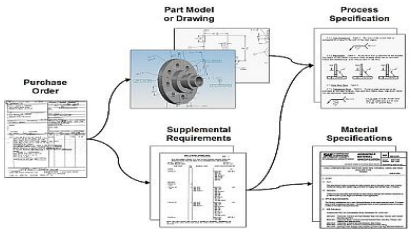
1.3. Computer Aided Process Planning (CAPP)

A number of cost reducing with estimation approaches are available today for estimating product cost at design stage with the reduction of cost. These include intuitive, analogical (Duverline and Castelain 1999, Wang et al. 2003) [**3**], analytical (Feng and Zhang 1999) [**4**], feature based (Feng et al. 1996, Ou-Yang and Lin 1997) [**5**] and parametric (DoD 1999, Farineau et al. 2001) [**6, 7**]. The intuitive method is based on the experience of the estimator. Process planning translates design information into the process steps with instructions to efficiently and effectively manufacturing the products (figure: 3). As the design process is supported by many computer-aided tools, computer-aided process planning (CAPP) has evolved to simplify the process planning and achieve more effective use of manufacturing resources. Process planning is concerned with determining the sequence of individual manufacturing operations needed to produce a given part or product. The resulting operation sequence is documented on a form typically referred to as a route sheet containing a listing of the production operations and associated machine tools for a work part or assembly. Process planning in manufacturing also refers to the planning of use of blanks, spare parts, packaging material, user instructions (manuals) etc.



1.4. CAPP Benefits

Significant benefits can result from the implementation of CAPP. In a detailed survey of twenty-two large and small companies using generative-type CAPP systems, the following estimated cost savings were achieved:

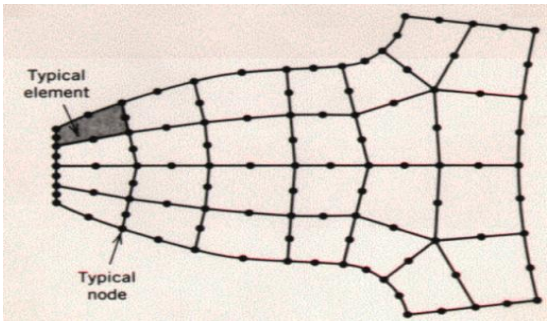
- Reduced process planning and production leadtime; faster response to engineering changes
- Greater process plan consistency; access to up-to-date information in a central database
- Improved cost estimating procedures and fewer calculation errors
- More complete and detailed process plans
- Improved production scheduling and capacity utilization
- Improved ability to introduce manufacturing technology and rapidly update process plans to utilize the improved technology.

CAPP, thus, results to a highly effective technology for discrete manufacturers with a significant number of products and process steps. Rapid strides are being made to develop generative planning capabilities and incorporate CAPP into a computer-integrated manufacturing architecture. The first step is the implementation of GT or FT classification and coding. Commercially-available software tools currently exist to support both GT and CAPP. As a result, many companies may achieve the benefits of GT and CAPP with minimal cost and risk. Effective use of these tools can collaborate to manufacturer's profit.

1.5. Finite Element Modeling (FEM)

FEM [**11, 12, 13]** is a numerical technique to find out the approximate solution of partial differential equation (PDE) as well as of integral equation. The solution approach is based on eliminating the differential equation completely or rendering the PDE into an approximating system of ordinary differential equations, which are then numerically, integrated using standard techniques such as Euler's method or Runga-Kutta.

In FE modeling first we divide the whole structure is divided into pieces (elements and nodes) as shown in figure (4), after that behavior of physical quantities on each element is described. Further assembly of elements at the node to form an approximate system of equations for the whole structure is done. Solve the system of equations involving unknown quantities at the nodes (e.g., displacement) now at the end calculate desired quantities (e.g., strain and stresses) at selected elements.



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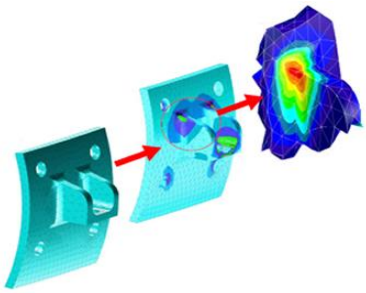
FEM [**11, 12, 13**] now a days integrated with CAD software. FEM analysis allow user to virtually analyze or simulate the product with an actual conditions (stresses and actual forces). This will help designer to modify and optimize the design of product for the sake of increasing its reliability. In figure (5) Finite element analysis of a product is shown, here we can see how the stresses are generated and at which portion stresses are maximum. By FE analysis we reached to the conclusion that the portion which has maximum stresses is most likely to fail.

So we have to pay bit more attention to design this portion.



2. Casting Methodology for improvement of Quality with Cost Reduction

For carrying out efficient solid modeling of casting process the software application would require the facetted model in stereolithography tessellated language format. This format would make the representation to be given as input in a simpler and efficient way. The stereolithography tessellated language format also helps in generation of mesh which further helps in the process of analyzing

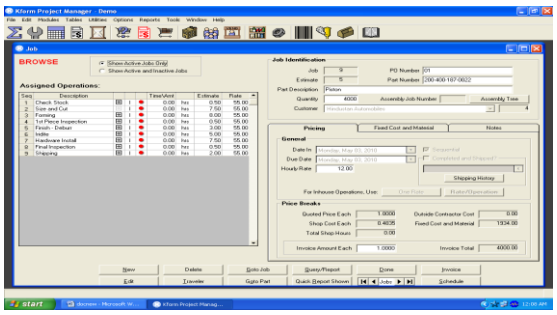
stresses, filling of moulds and during solidification of castings. Proper care and steps must be taken to speed up the process of analysis. In this direction to name one could be to remove minute filets in model before transferring the stereolithography tessellated language file. The above steps help in reducing the file size and there by helps in achieving speed in analysis with efficiency in process by reducing the errors generated during analysis.

2.1. Software Used

The complete job estimation and costings are obtained by using software **"K-form Project Manager v.2.5**" (shown in Fig. 2.1). This software includes a complete information starting from order in and order out in any organization working in CIM environment by using CAPP technique. This enables the cost reduction with improved quality in the limited time period and also it forms the various route sheets which will be processed in the manufacturing unit for completion of the job step by step. So by using this software the time taken in the process can be minimize and also complete information is available on a single work-station in the organization, which can be managed by a single trained person. Hence it reduces the cost of administration required which directly effects the cost of the final product. The main inputs to the software are as follows:

1. Part description with quantity and time of supply.
2. Raw material required in casting as well as in machining processes.
3. Processes required step by step for making the product.
4. No. of skilled workers & staff with their wages.
5. Other administrative expenses & overheads.

By using the inputs, abovementioned, the software automatically prepares the estimate and costing of the products with the complete route sheet to be followed in the manufacturing unit at every stage of processing.



3. Conclusion

This research concludes that this approach to CAPP technique for cost reduction and quality improvement of casting products in the CIM environment is the requirement for the present and future competitive market for any organization. Because CAPP involves deciding the methods, materials and machines for various steps, requirement of trained labours & making the process plan sheets used in casting process at the early stage of the production of any casted product by using CAPP software at a single work-station. Hence in this technique a very low administration is required, which directly affects the cost of the product. Also, the time taken at various products can be estimated & reduced at the early stages, so it increases the productibility of the organization with the reduction of the cost. Also at early stages, by using the casting analysis for the product to be cast reduces the cost of the product with improved quality.

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