APPLICATION OF CAD/CAM IN THE PATTERN DEVELOPMENT FOR A MECHANICAL COMPONENT

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***Abstract*: Foundry is the most basic input industry and stringent demands of quality and quantity are being placed on it with rapid industrialization and growth in the other fields of production. Up-to-date knowledge of materials and processes for casting is necessary in order to be able to produce sound castings economically. Most of the activities in the foundry require lot of human skills and common sense. There are many areas in Foundry in which interactive computer graphical tool of CAD/CAM techniques can be applied to enhance design and manufacturing performance. CAD/CAM system is ideally suited for designing and manufacturing mechanical components of free form complex three-dimensional shapes. In this present work CAD/CAM is utilized in the development of a pattern for a mechanical component.**
Design and development of a pattern mainly consists of three steps:
- **3D modeling of pattern.**
- **Tool path generation.**
- **Actual cutting on VMC Machine**

Index Terms - 3D modeling, CAD/CAM, pattern, VMC Machine, CATIA.

I. INTRODUCTION

1.1 PRODUCT DESIGN AND DEVELOPMENT:

Every organization has to design, develop and introduce new products as a survival and growth strategy. Organizations objective of achieving growth of business is only through introduction of new products. Deciding upon the policies of product to form the basis for competing in market and become the unique selling propositions (USP) of the company. The various product policies followed on the basis of lowest price, highest quality and quick delivery.

All these benefits given for customers require calling for right product selection made on basis of right design and development. The various stages through which a product design and development takes place are conception, acceptance, execution, translation and pre-production.

1.2 STAGES IN PRODUCT DESIGN:

The paper, which has been undertaken, calls for design and development of pattern of a product. The main objective was choosing the right method by taking into account all possible methods right from pattern making to casting machining. The two possible approaches of product design and development are by following methods:
- Through traditional engineering methods.
- Through integration of computer aided design and computer aided manufacturing for automation of product development cycle.

1.3 GOALS OF THE PAPER:
- To introduce the basic theory and tools in computer aided design and computer aided manufacturing with a focus on the integration of these tools and the automation of the product development cycle.
- To be an effective and intelligent user of the state-of-the-art CAD/CAM technology
- To give experience in Computerized Product realization using CAD/CAM as the platform, through the implementation of CAD/CAM-based product design.
- To provide hand-on experience in advanced manufacturing. (Basically Automated VMC machining through the use of an integrated CAD/CAM

2. ADVANCED PRODUCT DESIGN TECHNIQUE:

Design is a process in which incomplete models are embodied into complete ones. Using extensive research made into solid modeling process, feature-based parametric design and design process, we moved our focus to the smooth transition from conceptual design to detailed design, and then to part development. Associative design is currently one of the most important properties available with CAD/CAM systems.

2.1 COMPUTER AIDED DESIGNING (CAD)

CAD through CATIA

The main feature of CATIA is that, it can share the concepts & designs with the entire team, so that the idea shapes up instantly & it is simple, powerful & connected. Some of the widely used features are protrusion, cut, revolve, sweep, and blend.

Advantages of CATIA

- Simple but powerful & hence highly user-friendly while giving high quality. And easy & powerful documentation.
- Feature-base design: In typically 2-D cad application geometric elements are hard to understand, then dimensions are In solid modeling a highly visual 3-D design is created by adding features one at a time until one has accurate & complete representation of the parts geometry which can be better understood
- Aesthetic considerations can be implemented with automatic tolerances & easy dimensioning.
- Automates most of the design work.
- Testing of optimum performance is possible as also force analysis with connected software so lots of time & money saved on creating actual prototypes.
- Simulation of model possible.
- Easily creates exploded drawing.
- It takes only hours not days or weeks to agree the feasibility of the model due to fast connectivity. Drawings powerful & easy web connectivity & hence drag & drop system from the suppliers catalogues saves weeks of selecting & molding the drawing accordingly from part suppliers, can be sent through emails also. Also helps to know what customer wants.
- Late changes are possible because it automatically reflects into all related

2.2 COMPUTER AIDED MANUFACTURING (CAM)

CAM has been applied to variety of other applications like – Press working, Welding, Inspection machines, Automatic drafting, Assembly machines, Flame cutting, Tube bending, Plasma arc cutting, Laser beam processes etc. But Cam systems are widely used in the industry today with the most common application of cam is for metal cutting machine tools. Within this category cam controlled equipment has been built to perform virtually the entire range of material removal processes including – Milling, Boring, Grinding, Tapping etc

CAM through IDEAS:

Now we are going to see about most widely used & powerful CAM software IDEAS. In the volume clear operation we remove large amount of material in less time & with rough finish. There is many other finishing operations face milling, drive part, flow line, etc through which the finishing operation can be done.

Color-coding for tool path

- Rapid – white
- Engage-magenta
- Entry-pink
- Slow-cyan
- Fast-green
- Retract-yellow

Selection of material removing method

To start with the machining we have to select the different parameters as per our requirements like co-ordinate system, surface to be finished, boundaries, tool specifications & machining parameters.

<u>Tool specifications:</u>

The tool should be defined by giving appropriate parameters like holder diameter, shank diameter, holder to tip distance, maximum depth of cut, cutter diameter, etc. The tool specifications will change according to the finish required & the machining process.

<u>Machining parameters:</u>

According to the requirement of finish tolerances allowances the different parameters like cut, feed, speed, tool entry, tool exit, etc are to be defined.

<u>Advantages of Ideas Cam (Generative machining):</u>

- Graphic display of tool path
- More freedom
- Improved operating features
- Online editing
- Optimum tool path generation
- Post processor available for CL files as well the TP file
- Virtual machining can be seen
- Optimum material selection and cost estimation
- Improved quality control
- Reduced non productive time
- Easily machining of complicated shapes
- Compatible with other CAD software.
- Availability of range of operations.

2.3 APPROACHE TOWARDS INTEGRATION

This paper is also built on the integration of CAD/CAM with VMC i.e. (Vertical machining centers) to carry out the machining of the mechanical components. So it becomes important to introduce the fundamental concepts about vertical machining centers. VMC is an advanced concept of machining where the machine offers, the freedom to integrate with CAM software's and carry out the machining with a better control. The following features of VMC can highlight the core advantages of working with VMC.

- ❖ **Accurate: Set tools and detect broken tools on your machine in seconds.**
- ❖ **Flexible: Locate work pieces and set offsets in seconds, even on small high-speed machines.**
- ❖ Cost effective:
  - Save time and reduce operations by accurate inspection on your machines.
  - Reduce tool setting and job set-up times.
  - Cut non-productive setting to a fraction of the time.
  - Reduce your machine downtime and cut more metal.
  - Reduce scrap due to setting errors.
- ❖ Reduce expensive Fixture Costs

No need for expensive alignment fixtures – use simple clamping and the spindle-mounted probe will locate your parts.

- ❖ Reduce operating costs: Operator to machine ratio is reduced.
- ❖ Improve process control
  - Check components and reduce downtime associated with off-machine control.
  - Inspect key features on high value parts – essential for unmanned machining.
- ❖ Detect broken or incorrect tools: Perform tool verification and broken-tool detection, allowing corrective action e.g. Call operator or change for 'sister' tooling automatically.
- ❖ Improve safety: Fully automatic operation so that all machine guarding remains closed during setting or inspection.

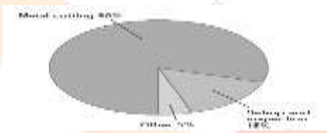

Fig 1. Production time for a VMC

The general description of the particular VMC machine is illustrated as following.

The BATLIBOI CHETAK series of machining centers are built with massive bed, column and saddle manufactured out of fabrications. Adequately ribbed table and spindle carrier are made out of close grain structure and are stressed relieved. These machines are having excellent static and dynamic rigidity, and are offered with cam driven auto tool changer using shortest path, bi-direction tool selection without any hydraulics.

Orientation is given below.

Table, horizontal movement	=	X Axis
Saddle, horizontal movement	=	Y Axis
Spindle Carrier, vertical movement	=	Z Axis

These machines are equipped with maintenance free AC servomotors for all three axes Main spindle is supported in precision angular contact ball bearings, greased packed for life and housed in spindle carrier providing infinitely variable speeds for high speed precision milling and boring for ferrous and non-ferrous materials. The spindle carrier is balanced to avoid drop during power failure. The spindle carrier slides on linear motion guide ways on column through ball screw directly coupled with AC servomotor. The built in automatic power drawbar locks the tool holder in spindle

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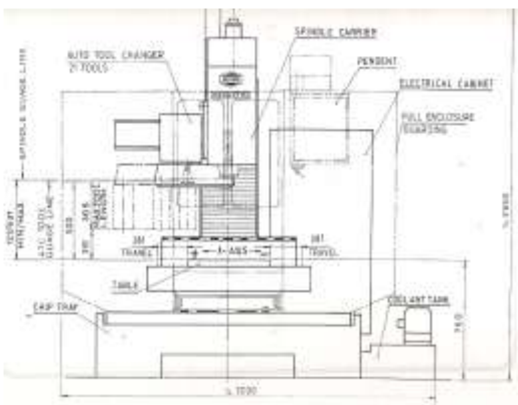

Fig 2.VMC Machine

Machine table is driven through AC servomotor directly coupled to ball screw on linear motion guide ways fitted on saddle. Saddle is driven by ball screw directly coupled to AC servomotor on linear motion guide ways fitted on bed. Suitable covers are provided for protection of ball screw and linear motion guide ways for all axes. A cam driven auto tool changer (ATC) is provided on these machines to facilitate automatic tool change. The tool changer is fitted on the column and moves to and fro for tool change. These machines are provided with removable chip tray positioned in front of the base giving access for easy chip removal. All electrical items are housed in an electrical cabinet mounted on the machine. A conveniently located pendent control is provided for ease of operation

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3. APPLYING THE CAD/CAM TECHNOLOGY IN THE DEVELOPMENT OF AN ALTERNATOR BRACKET PATTERN

3.1. JOB DRAWINGS (ALTERNATOR BRACKET)

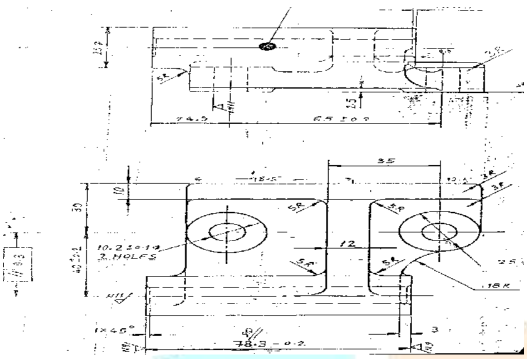


Fig 4. Solid Model **Fig 3. 2D drawing**

After studying the given drawing, we have decided first to find out the casting dimensions and pattern dimensions. Along with that we have also selected the all foundry processes required to manufacture this given job. Steps regarding the selection of foundry processes are as follows,

Assumption made:

1. Production rate 5000 per month
2. Material – C.I. FG200

On base of these assumptions the various factors which are necessarily required are

❖ Selection of suitable molding / casting process.

Green sand molding is being selected for process-

- Adaptive to machine molding
- Economically preferred for making medium sized casting

❖ Selection proper pattern material and types of pattern.

Metallic pattern is being selected to manufacture a working pattern. Material used for pattern is C.I. Justification to choose C.I. as pattern is as follows,

- Durable and Reliable
- Produce good smooth surface
- Can be used on machine molding
- Good machinability.

❖ Selection of suitable match plate size and molding box size.

FOR PATTERN 1:

Match plate size = 250 x 125 x 60 (in mm)
Mold box size = 250 x 125 x 60 (in mm)

FOR PATTERN 2:

Match plate size = 250 x 125 x 60 (in mm)
Mold box size = 250 x 125 x 60 (in mm)

3.2 PREPARATION OF ALLOWANCE TABLE

Contraction Allowance for C.I. is 1mm per 100mm.

Draft allowance is given to all surfaces which are perpendicular to parting line

Draft on external surfaces =10mm/metre

TABLE 1. ALLOWANCES (all dimensions are in mm)

Component Dimension	Machine Allowance	Casting Dimension	Contraction Allowance	Pattern Dimension
90	3	93	0.93	93.93
82.5	3	85.5	0.855	86.355
80	3	83	0.83	83.83
15	3	18	0.18	18.18
12	3	15	0.15	15.15
∅ 25	3	∅ 28	0.28	∅ 28.28

Fig 5. Pattern one

Fig 6. Pattern two

Design of Gating System (for one casting)

FOR PATTERN

Known values:

Specific gravity if C.I = 7.22 gm/cm^3

Volume of Casting = 363.04 cm^3

a) Weight of Casting = Volume of casting X sp.gravity
= 363.04 X 7.22
= 2.62 Kg.

b) Gross weight of Casting (W) = 2.62/0.75 (Assuming 75% yield)
= 3.49 Kg.
= 3.49/0.4536
= 7.69 pounds

c) Pouring Time (t) in seconds = k (0.95 + T/0.853) X √ W
Where, k = Fluidity Factor – 0.7 to 0.75
T = Average general wall thickness in Inches
= 6mm = 0.24 inches
W= Gross weight of casting
= 7.69 pounds

Pouring Time (t) in seconds = 0.73 (0.95 + 0.24/0.853) X √ 7.69

= 2.49 seconds

d) Rate of pouring = W/t = 7.69/4.586
= 3.088 lbs/sec.
= 1.4 Kg/sec.

e) Choke Area (A) = W / (d X c X t X √ 2 g X H)
Where, W = Gross weight of casting in pounds
d = 0.22 lbs/$inch^3$
c = Efficiency factor = 0.72 to 0.78
t = Pouring time in second
H = Effective Head= $(2 \times h \times C - p^2) / 2C$
Where, h = Cope box height (inch)=2.063
C = Total casting height (inch)=1.555
P = Casting height in cope half (inch)=1.063
H = $(2 \times 2.063 \times 1.555) - 1.063^2 / (2 \times 1.555)$
= 1.699 Inches

$A = 7.69 / (0.22 \times 0.75 \times 2.49 \times \sqrt{(2 \times 386.4 \times 1.699)})$
= 0.516 $Inch^2$
= 332.9 mm^2

Pressurized Gating System = 1: 2: 1 = Sprue Area: Runner Area: Ingate Are = 332.9: 665.8: 332.9

f) Area of each ingate = 332.9/2 = 166.45 mm^2

4. SOFTWARE INTEGRATION WITH VMC

4.1 CAM PROCEDURE

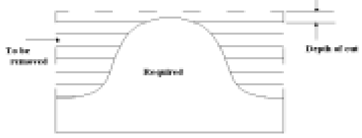
The procedure for doing the cam on the pattern is as follows:

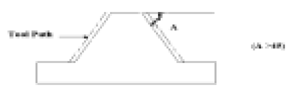
- First the conversion of the models prepared in the CATIA is done in the IGES format.
- After this the model in the IGES format is imported in the Ideas for performing the generative machining.
- The machine zero position is adjusted on the job, at suitable point to carry out the machining.
- After this the first operation carried on the job will be VOLUME CLEAR to get the rough profile of the job. This is a roughing operation in which the maximum material is removed to get job nearer to the finished product
- After performing the volume clear operation the next operation performed on the job will be copy-milling operation which will be required for the generation of the profile to the finished dimensions.
- After copy milling operation the profile milling operation will be performed on the vertical and vertically tapered surfaces of the job to get these surfaces to the finished dimensions.

After performing all these operations on the job we will get the pattern to the finished dimensions. While we are performing these operations on the job and getting the tool paths, we are actually getting the accurate programs for these operations on the computer itself. We are feeding these programs to the V.M.C., by attaching the computer to the V.M.C. directly .The programs which we get on the computer are in the format of "TP file". For feeding these programs to the V.M.C. they are required to be transferred in the "CL file format", which is performed on the computer itself and then this program is transferred to the V.M.C.by connecting computer directly to the V.M.C. through cable.

In this way the cam operation is performed on the remaining jobs also wherever required getting the job to the maximum accurate dimensions by using this latest technology.

4.2 CAM MODULES USED IN TOOLPATHGENERATION





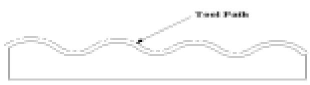


Fig7.Profile mill: - It is a finishing operation **Fig8.Volume clear: - It is roughing operation.** **Fig 9. Copy mill:-It is a finishing**

Maximum stock is removed here **used for vertical walls/sections** **operation for horizontal walls.**

5. GENERATION OF CAM

STAGES IN GENERATION OF CAM

TOOLPATH OF PATTERN ONE

TOOLPATH OF PATTERN TWO

6. CONCLUSION:

This paper is based on applying innovation made in CAD/CAM with manufacturing technology. So the paper group always looked at ways of adopting technology to get cost effectiveness. We worked on the concept of **"**plan for future from strengths of the past**"**. It is seen some of best new ideas come from combining some existing notions and our papers went exactly towards achieving that.

This paper gives platform where we can add an achievement to form the quality of original thinking in product development arena by accelerating design and development process. Design and development using CAD/CAM software gives us an evaluation where virtual component is created into reality on Vertical Machining Center.

Engineering and design change cycles are key issues in every product development cycle. Competitive gain is the most significant type of return on which this paper has been paced. Thus by our paper the competitiveness of a foundry based product design can be improved with reduced time to market, savings in cost, and produced market shares. Thus we can say,

"Returns = Total Cost Reduction + Total Productivity Gains
+ Total Competitive Gains"

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