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Developing A Die/Mold Through The Phases Of Process Engineering Using Computer Aided Process Planning (Capp)

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Abstract: *The Die itself needs a well-defined process while being transformed from a stock of material or while it is being assembled with the help of standard components. The varied elements of a die ranging from the standard Die set, the die-block, the punch plate with the punch holder, compression springs and the other elements necessary for assembling the die calls for a make-or-buy decision. While standard parts are preferred to be bought out, the components to be manufactured in-house necessitates an elaborate `Process Plan' for yielding the most economic die with the prescribed specs for quality Sheet-metal die is an inseparable constituent of the development process of any given automotive or consumer appliance. In most of the cases, this accounts for a high proportion in the tooling needs of the large size and structural member in any automotive like the chassis and the BIW. Many other brackets and gussets along with peripheral clips etc are invariably made of Sheet-metal due to the strength characteristics complimented by this material and the process of stamping.*

Process planning is responsible for the conversion of design data to work instructions through the specification of the process parameters to be used as well as those machines capable of performing these processes in order to convert the piece part from its initial state to final form. The output of the planning includes the specification of machine and tooling to be used, the sequence of operations, machining parameters, and time estimates. Doing all this with computer-aided assistance is called computer-aided process planning (CAPP).CAPP uses computer software to determine how a part is to be made.

Keywords: *Process Plan, Operation Sheet, CAPP, Sheet-metal Die,*

I. Introduction

In general, it is found that the Die (or a Mold) goes through a series of processes which are generally recommended and sequenced at random depending on the availability of the material, machine or the resource. This poses a problem for sequential and timely processing of the Die/ Mold coupled with quality issues. Most of the machining operations are Computerized control including Wire-cut, EDM, VMC machining followed by CMM inspection and so on which has a huge influence over the cost of the Die. As a result, the overall cost of the Die is high

The point to consider here is that even the Die itself needs a well-defined process while being transformed from a stock of material or while it is being assembled with the help of standard components. The varied elements of a die ranging from the standard Die set, the die-block, the punch plate with the punch holder, compression springs and the other elements necessary for assembling the die calls for a make-or-buy decision. While standard parts are preferred to be bought out, the components to be manufactured in-house necessitates an elaborate `Process Plan' for yielding the most economic die with the prescribed specs for quality.

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II. Developing Die through Capp

1.1 Process and Process Engineering- A process is no more than the steps and decisions involved in the way work is accomplished. A process is any orchestrated sequence of activities and associated tasks required to meet goals or objectives. Inputs to the process become outputs. Simply put ,Process engineering is the bridge between Design and manufacturing and it can be brought out by computer aided process planning (CAPP).

1.2 Introduction to CAPP- is a systematic approach to identifying and eliminating time and cost in operations through Process Engineering .During the last several decades, there has been considerable interest in automating the `Process Planning' function by computer systems. An alternative approach to process planning is needed, and Computer Aided Process Planning (CAPP) systems provide this alternative. CAPP plays a bridge between design and manufacturing by translating design specification into manufacturing process detail. Hence, the main focus of this paper is to interpret the basic study of CAPP system for die making process. The output of the planning includes the specification of machine and tooling to be used, the sequence of operations, machining parameters, and time estimates. (CAPP).CAPP uses computer software to determine how a part is to be made. If group technology is used, parts are grouped into part families according to how they are to be manufactured. For each part family, a standard process plan is established. Products and their components are designed to perform certain specific functions. Each product has some design specifications which ensure its functionality aspects. The task of manufacturing is to produce components such that they get together the design specifications. The process planning acts as a bridge between design and manufacturing by translating design specifications into manufacturing process in detail. During the various process planning steps in Shape Depositiom Manufacturing[1], the CAD model undergoes a series of geometric operations. In order to withstand the complex geometric operations, a powerful geometric engine should serve as a backbone for the process planner. The process starts with the selection of raw material and ends with the completion of part. Synergy results in when CAM is integrated with CAD to form CAD/CAM systems than a stand alone CAD or CAM systems. In such a system CAPP becomes a direct connection between design and manufacturing.

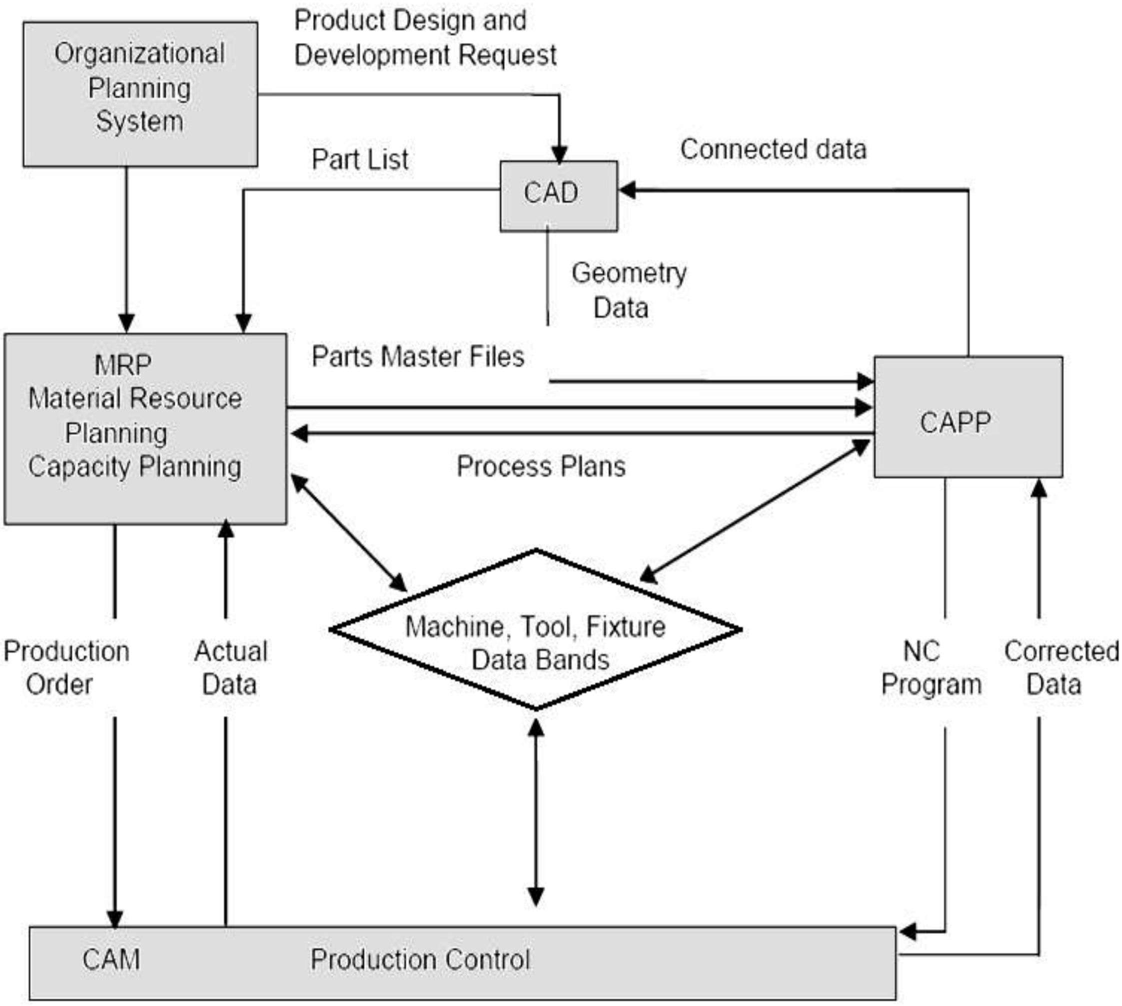

Fig.1- Frame Work Of Process Planning

1.3 CAPP SYSTEMS:

Computer-aided process planning systems are designed around either of two approaches:

1) Retrieval systems and
2) Generative systems

Retrieval CAPP Systems - Also known as variant CAPP systems, based on GT and parts classification and coding, a standard process plan is stored in computer files for each part code number, The standard plans are based on current part routings in use in the factory on an ideal plan prepared for each family. For each new part, the standard plan is edited if modifications are needed

Generative CAPP Systems - Rather than retrieving and editing existing plans from a data base, the process plan is created using systematic procedures that might be applied by a human planner, In a fully generative CAPP system, the process sequence is planned without human assistance and without predefined standard plans, designing a generative CAPP system is a problem in expert systems - computer programs capable of solving complex problems that normally require a human with years of education and experience

1.4 IMPORTANT CHARACTERISTICS OF CAPP:

CAPP systems usually serve as link in integrating the CAD and CAM. Though, it is only the partial link due to lack of part feature information provided by existing CAD or drafting system. Part feature information is an essential data for CAPP. In other words, it is a tedious job for CAPP to understand the three dimensional geometry of the designed part from CAD system in terms of their engineering meaning related to assembly and manufacturing. in general, all CAPP planning method and systems suffered from such type of problem and is referred as feature identification in CAPP. Therefore, the main objective feature credit is to bridge the space between the database and automated process planning systems by automatically distinguishing the feature of a part from the geometry and topological data stored in the CAD system. Hence, the features play a vital role in CAPP. In order to identify features and to solve CAD or CAPP interface problem, feature recognition is one of the most efficient technique. Feature recognition transforms a general CAD model into an application specific feature model. evaluated based on the objective functions. The objective of the CAPP problem is to obtain an optimal operation sequence that results in optimizing resources and minimizing production costs as well as processing time.[5]

1.5 BENEFITS OF CAPP:

The use of CAPP systems has the following potential advantages

- Process rationalization and standardization –CAPP leads to more logical and consistent process plans than when traditional process planning is used
- Increased productivity of process planners
- Reduced lead time to prepare process plans
- Improved legibility over manually written route sheets
- CAPP programs can be interfaced with other application programs, such as cost estimating, work standards, and others

1.6 RECENT TRENDS IN CAPP: -

In the global competitive market, various areas such as design process planning, manufacturing and inspection plays a vital role in reducing cost and lead time [14] **.**In the various areas, different kind of interference mechanism has been developed. A lot of difficulty arises while integrating the goal in CIM environment. A CAPP system, depending on the level of sophistication of its capability, may involve automating the interface between design and process planning as well as various process planning tasks.[6] Process Planning tasks such as process sselection, machine tool and cutting tools election, set-up planning, fixture selection, machining parameter selection and so on.

Hence, it is not only desirable but also inevitable to develop a single database technology to address these problems. The major challenges of and research areas are to make CAPP system affordable to the medium and small scale manufacturing industries. Hence a recent trend in CAPP systems includes;

1) Automated translation of the design dimensions.
2) Tolerances into manufacturing dimensions.
3) Tolerances considering process capabilities.
4) Dimensional chains.

1.7 APPROACHES TO PROCESS PLANNING:-

There are basically two approaches to process planning which are as follows :
(i) Manual experience-based process planning, and
(ii) Computer-aided process planning method.
Following difficulties are associated with annual experienced based process planning method:

- It is time consuming and over a period of time, plan developed are not consistent.
- Feasibility of process planning is dependent on many upstream factors (design and availability of machine tools).
- Downstream manufacturing activities such as scheduling and machine tool allocation are also influenced by such process plan [14]..

  Therefore, in order to generate a proper process plan, the process planner must have sufficient knowledge and experience. Hence, it is very difficult to develop the skill of the successful process planner and also a time consuming issue.

1.8 STEPS FOR DEVELOPMENT :-

The following are the activities for this exercise enumerated as steps:

1. Study the complete drawing of the Die and its elements including the material specifications and surface treatment, if any
2. Identify each element as per the bill-of-material (BOM) and assign a make or buy tag

3. While the materials with the `buy' tag could be procured from competent sources, the materials with the `make' tag should be listed out separately for including in the Process Engineering plan
4. Study the design intent of each element or part and assign appropriate tooling faces for resting, location, orientation and clamping
5. If additional fixtures or non-standard gauges are required, make a list of the same along with a Picture sheet for the operation
6. Allocate the appropriate machine/s for each element during its machining cycle
7. Specify the process of sub-assembly followed by the main assembly
8. Identify critical dimensions/ specs to be measured at each stage for ensuring functionality and smooth assembly
9. Discuss the inspection dimensions for the completed Die in conjunction with the Die Designer
10. Organize the trials and document the results for further improvement in the Die

1.9 CAPP SYSTEM FOR DIE DEVELOPMENT:-

This system was constructed on the basis of the know-how of industrial field engineers. By interviewing them, the production rules of the CAPP system are generated and developed. The cross-section of the product body, drawing coefficient, punch radius (Rp), and die radius (Rd) are considered as the main design parameters. The input data of the system is only the final product geometry of which modeling is performed on AutoCAD software along the major and minor axes of the product. The system is typically composed of recognition of shape, 3-D modeling to calculate the surface area, blank design and process planning modules. It means that we have to return first to rework the die construction by changing the critical die parameters (e.g. die radii, drawing gap, etc.). If it does not solve the problem, a new die design, or a new process planning is required. [2].The scope for this project work, although, is limited to generation of Process Plan aligning with its cross-functional departments.

III. INDENTATIONS AND EQUATIONS

Cutting speed (also called surface speed or simply speed) is the speed difference (relative velocity) between the cutting tool and the surface of the workpiece it is operating on. It is expressed in units of distance along the workpiece surface per unit of time, typically surface feet per minute (sfm) or meters perminute (m/min). Feed rate is the relative velocity at which the cutter is advanced along the workpiece; its vector is perpendicular to the vector of cutting speed. Feed rate units depend on the motion of the tool and workpiece; when the workpiece rotates (*e.g.*, in turning and boring), the units are almost always distance per spindle revolution (inches per revolution [in/rev or ipr] or millimeters per revolution [mm/rev]). When the workpiece does not rotate (*e.g.*, in milling), the units are typically distance per time (inches per minute [in/min or ipm] or millimeters per minute [mm/min]), although distance per revolution or per cutter tooth are also sometimes used.

Cutting Speeds For Various Materials Using A Plain High Speed Steel Cutter

Material Type	Meters Per Min (MPM)	Surface Feet Per Min (SFM)
Steel (Tough)	15–18	50–60
Mild Steel	30–38	100–125
Cast Iron (Medium)	18–24	60–80
Alloy Steels (1320–9262)	20-37	65–120
Carbon Steels (C1008-C1095)	21-40	70–130
Free Cutting Steels (B1111-B1113 & C1108-C1213)	35-69	115–225
Stainless Steels (300 & 400 Series)	23-40	75–130
Bronzes	24–45	80–150
Leaded Steel (Leadloy 12L14)	91	300
Aluminium	75–105	250–350
Brass	90-210	300-700 (Max. Spindle Speed)

Table No.1- Cutting Speeds For High Speed Steel

Approximate Material Cutting Speeds and Lathe Feed Per Revolution
Calculating RPM and Feed Rates

Sr. No.	Material	Ballpark CS with HSS Tool	Cutting Speed HSS Tool	Cutting Speed Carbide Tool	Feed/Rev HSS Tool Lathe	Feed/Rev Carbide Tool Lathe
1	SAE 1020-Low Carbon Steel	100	80-120	300-40	0.002-0.020	0.006-0.035
2	SAE 1050-Ligh	60	60-100	200	0.002-0.005	0.006-0.030

	Carbon Steel					
3	Stainless Steel Aluminum	100	100-120	240-300	0.002-0.005	0.003-0.006
4	Brass And Bronze	200	110-300	600-1000	0.003-0.025	0.008-0.040
5	Plastic	500	500	1000	0.005-0.50	0.005-0.05

Table No.2- Approximate Material Cutting Speeds and Lathe Feed Per Revolution Calculating RPM and Feed Rates

*Variation in Cutting-Speed & Feed-per-Revolution will exist with different alloys, procedures, tools & desired finishes. Feed-Per-Revolution is also affected by the size of the lathe-tool, as well as the depth of cut. The cutting speed and speed of plastics will vary greatly depending upon the type of plastic.

Table No.2 Approximate Material Cutting Speeds and Lathe Feed Per Revolution Calculating RPM and Feed Rates

Accuracy

However, for more accurate calculations, and at the expense of simplicity, this formula can be used:

$$RPM = \frac{Speed}{Circumference} = \frac{Speed}{\pi \times Diameter}.$$

$$= \frac{1000 \times 20 (mm/min)}{\pi \times 100 mm}$$

RPM = 200

*Variation in Cutting-Speed & Feed-per-Revolution will exist with different alloys, procedures, tools & desired finishes. Feed-Per-Revolution is also affected by the size of the lathe-tool, as well as the depth of cut. The cutting speed and speed of plastics will vary greatly depending upon the type of plastic.

Calculations:-

Feed Rate = fm (mm/min)
m = f × n
m = feed rate (mm/min) or MPM
f = feed (mm/rev)
n = rpm
the rate of tool travel through the work piece per unit of time, generally expressed in mm per revolution (turning)
f = 0.010 (mm/rev)
n = 200 rpm
m=0.010X200
m=2 (mm/min)

Drilling Speeds and Feeds :-

The speed of a drill is usually measured in terms of the rate at which the outside or periphery of the tool moves in relation to the work being drilled. The common term for this velocity is surface feet per minute", abbreviated as sfm. Every tool manufacturer has a recommended table of sfm values for their tools. General sfm guidelines are commonly found in resources such as the Machinery Handbook (see Table 1 in this document).

The peripheral and rotational velocities of the tool are related as shown in the following equation:

V = π * D * N (Eq. 1)

where ,
V is the recommended peripheral velocity for the tool being used
D is the diameter of the tool
N is the rotational velocity of the tool
Since the peripheral velocity is commonly expressed in units of feet/min and tool diameter is typically measured in units of inches, Equation 1 can be solved for the spindle or tool velocity, N in the following manner:

N [rpm] = 12 [in/ft] * V [sfm] / (π * D [in/rev]) (Eq. 2)

Equation 2 will provide a guideline as to the maximum speed when drilling standard materials. The optimum speed for a particular setup is affected by many factors, including the following:

• Composition, hardness & thermal conductivity (k) of material
• Depth of hole
• Efficiency of cutting fluid

- Type, condition and stiffness of drilling machine
- Stiffness of workpiece, fixture and tooling (shorter is better)
- Quality of holes desired
- Life of tool before regrind or replacement

Table 2 contains recommended feeds for various drill diameters. For each diameter range there is a corresponding feed range. Use the smaller values for stiffer/harder/stronger materials and the larger values for softer materials. To calculate the feed rate, use the following formula:

f = N * fr

where

f = feed rate [mm/min]

N = spindle speed [rpm]

fr = feed per revolution [mm/rev]

SR .No.	Material	Recommended Speed(Surface ft/min)
1	Aluminum And Its alloys	250
2	Bronze(High Tensile)	100
3	Cast Iron(Soft)	100
4	Cast Iron(Medium Hard)	80
5	Cast Iron(Hard chilled)	20
6	Hastelloy	20
7	Inconel	25
8	Magnesium and its alloys	300
9	Monel	25
10	High nickel steel	50
11	Mild Steel(.2-.3 C)	100
12	Steel (.4-.5C)	60
13	Tool Steel	40
14	Forgings	40
15	Steel alloys(300-400 Brinell)	30
16	Heated Steels 35-40Rockwell	
	35-40 Rockwell C	20
	40-45 Rockwell C	20
	45-50 Rockwell C	15
	50-55 Rockwell C	15
17	Stainless Steel free machining	40
18	Stainless work hardened	20
19	Titanium alloys	20

Table No.3-HSS speeds for common materials [13]

Sr.No.	Drill Diameter [in]	Recommended Feed,fr [in/rev]
1	under 1/8 "	up to 0.002
2	1/8" to 1/4"	0.002 to 0.004
3	1/4" to 1/2"	0.004 to 0.008
4	1/2" to 1"	0.008 to 0.012
5	1" and over	0.012 to 0.020

Table No.4 HSS feed [13]

Drilling **Uddeholm Corrax**

Drilling		Drill diameter (mm) 1 - 5	5 - 10	10 - 20	20 - 30	30 - 40
Uncoated HSS [1-2)]	Cutting speed, v_c (m/min)	13-15				
	Feed, f (mm/rev)	0,05-0,10	0,10-0,20	0,20-0,30	0,30-0,35	0,35-0,40
Coated HSS [1-2)]	Cutting speed, v_c (m/min)	13-15				
	Feed, f (mm/rev)	0,05-0,10	0,10-0,20	0,20-0,30	0,30-0,35	0,35-0,40
Indexable insert [3-4)]	Cutting speed, v_c (m/min)				180-200	
(cem. carbide inserts)	Feed, f (mm/rev)				0,03-0,08	0,08-0,12
Solid cemented carbide [5-7)]	Cutting speed, v_c (m/min)		100-130			
	Feed, f (mm/rev)		0,08-0,10	0,10-0,20	0,20-0,30	0,30-0,35
Brazed cemented carbide [5-7)]	Cutting speed, v_c (m/min)			50-70		
	Feed, f (mm/rev)			0,15-0,25	0,25-0,35	0,35-0,40

Table No.5- Cutting Parameters for HSS drill [13]

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Calculations:-

$V = \pi * D * N/1000$
$N = V * 1000/\pi * D$
$= 13000/\pi * 9$
N = 460(RPM)

Also,
f (mm/min) = N * fr (mm/rev)
= 460*0.10
f = 46(mm/min)

Surface Grinding:-

Grinding is a material removal process in which abrasive particles are contained in a bonded grinding wheel that operates at very high surface speeds. The grinding wheel is usually disk shaped and is precisely balanced for high roational speeds. Cutting conditions in grinding The geometry of grinding is shown in the figure:

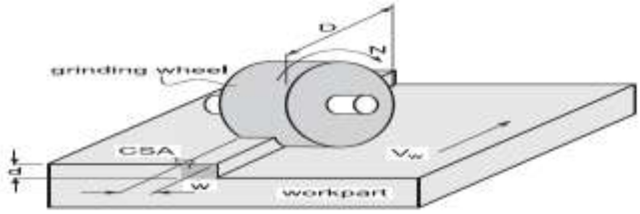

Fig.2 -The Geometry Of Surface Grinding Showing The Cutting Conditions

The geometry of surface grinding showing the cutting conditions.The cutting velocity V in grinding is very high. It is related to the rotational speed of the wheel by

$V = \pi DN$

where D is the wheel diameter, and N is the rotational speed of the grinding wheel.Depth of cut d is called infeed and is defined as the distance between the machined and work surfaces. As the operation proceeds, the grinding wheel is fed laterally across the work surface on each pass by the workpart. The distance at which the wheel is fed is z.

V. Figures and Tables

WITH THE INPUTS GATHERED DURING COLLECTION PHASE, THE ANALYSIS IS DOCUMENTED AS PER THE PROCESS SHEET BELOW.

PROCESS SHEET
Name of tool-Form /Deep Die
Name of the component -Die Block
Drawing No - ***AT0101***
Material - 20MnCr5 (Case-hardness HRC 58-62)
Qty - 1***no***

Op^n No.	Operation Name	Machine Name/ No.	Instrument/ Fixture/ Gauge	Description of operation	Estimated time for setting and machining
10	Milling Rough & Finishing	milling machine	Vernier Caliper - upto 200mm	Hold the blank in vice Clean out the face Finish Face (Name) to size(....+0.5)	8hrs.(Each for 6 faces)
20	Drilling Tapping	Radial Drilling machine	Drill bit(HSS or Carbide) Tap -size M8	Drill hole size ϕ6.8 thru's on P.C.D.Equispaced Tap to depth 15mm	Drilling -1 hr Tapping -1.5hr
30	Surface Grinding Top Face Bottom Face	Surface grinding m/c cylindrical grinding m/c	micrometer-50-100 micrometer-50-100	Rest face F,Grind G for clean finish Hold ϕ A and Finish B/C to Size Set speed for grinding = 2300 (rpm) Set depth of cut = 0.003 to 0.005 mm	1 hr 1.5 hr
40	Heat Treatment	Induction Furnace	Hardness Tester (HRC)	Pack carburize using carbon rich material at about 800°C Case Harden in the furnace at a temperature of 580 to 920°C Make identation using approprite steel ball (indenter) to confirm	4 hr 16 hr 0.5 hr
50	VMC Machining center	V.M.C.(BFW-60)	Bull-nose Cutter Size-10mm Side Face Cutter Size-6mm CMM/Robo-Arm	Run the machining program no - CAM021 Run The CMM Programe No-CMM021	3 hr 1hr

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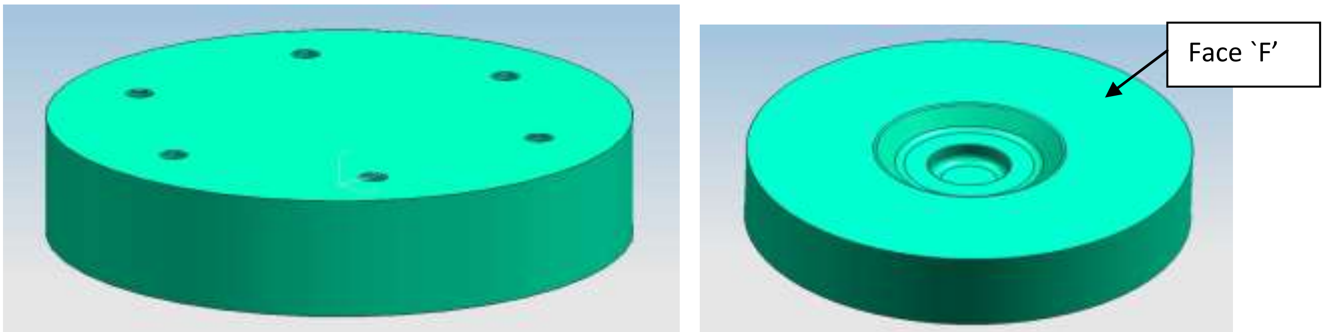
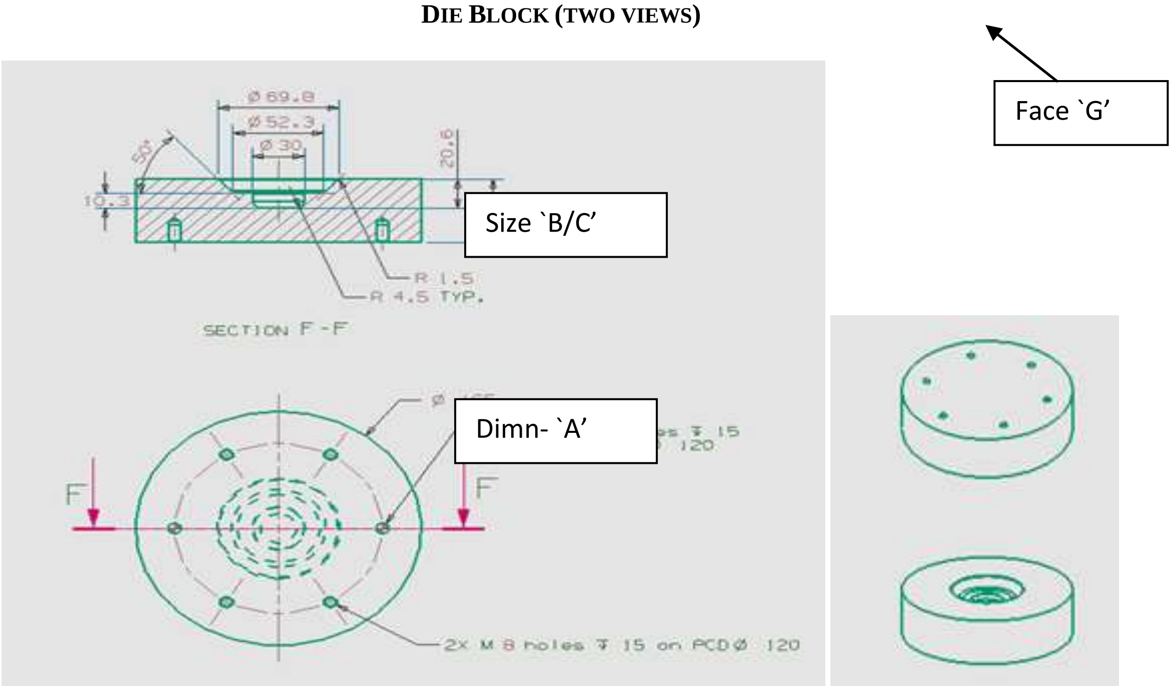
Table No.6 - Process sheet for Die Block

Table No 7- Process sheet for Punch

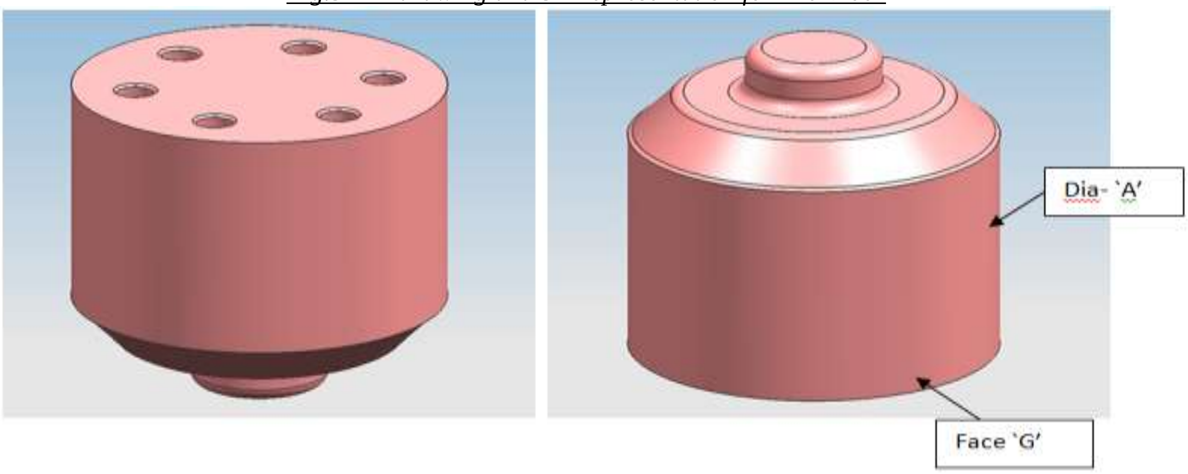


DIE BLOCK (TWO VIEWS)



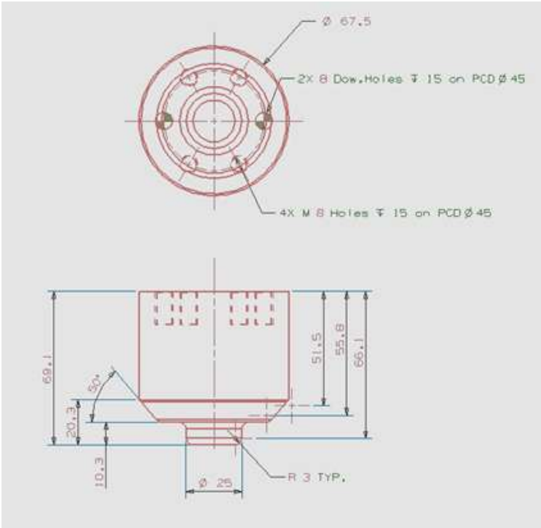
DIE BLOCK (2D DRAWING)

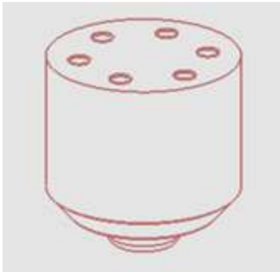
Fig.3- 2D drawing and 3D representation for Die Block



PUNCH (TWO VIEWS OF THE 3D MODEL)

Dimn- `D'





PUNCH (2D DRAWING)

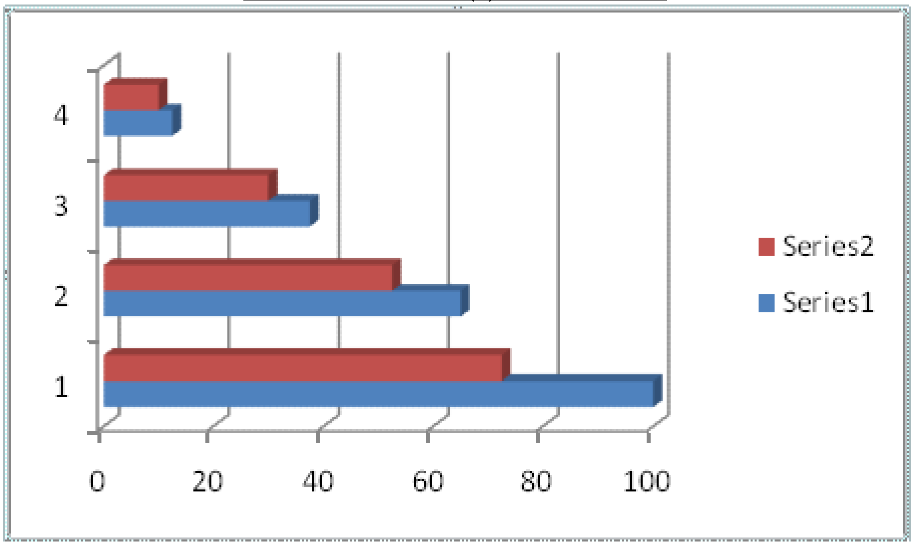
Fig.4- 2D drawing and 3D representation for Punch

Time required for release of the Die

Type of Die → / Type of Process to be used ↓	Type A	Type B	Type C	Type D
Current process (hrs)	80-120	50-80	25-50	Upto 25
(Average)	100	65	37.5	12.5
Proposed process (hrs)	60-95	40-65	20-40	Upto 20
(Average)	72.5	52.5	30	10

Time saved with the implementation of the new process = 23.25%

Table No 8: Results (1): % Time Saved



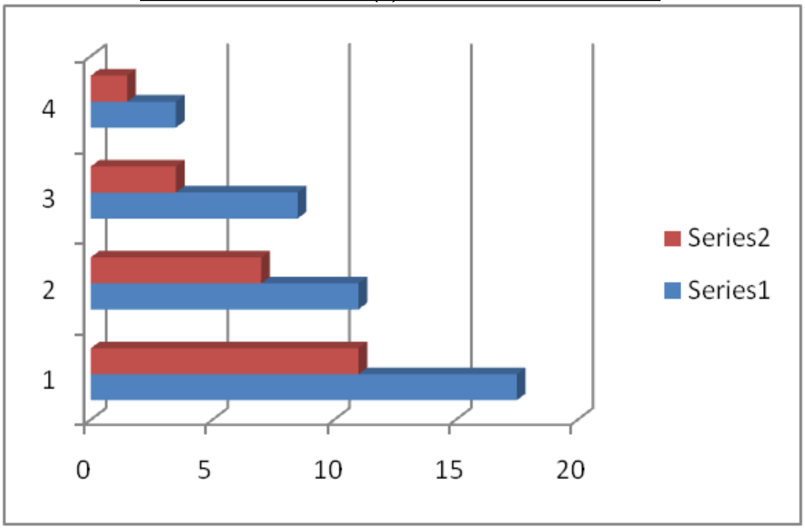
GraphNo.1- Graph of Comparison between CSM and FSM for average of Current process (hrs)Vs. Proposed process (hrs)

Number of Errors identified during development phase

Type of Die → / Type of Process to be used ↓	Type A	Type B	Type C	Type D
Current process (no. of errors)	15-20	10-12	7-10	2-5
(Average)	17.5	11	8.5	3.5
Proposed process (no. of errors)	10-12	6-8	3-4	1-2
(Average)	11	7	3.5	1.5

Percentage reduction in the number of errors = 43.21%

Table No. 9 - Results (2): % Reduction in Errors



Graph No. 2- Graph of Comparison between CSM and FSM for average of Current process Vs. Proposed process for `number of Errors' identified during development phase

V. Conclusion

The objective of this exercise was to administer the use of Process Plan for planning principles as a way to logically and sequentially plan process, to reduce time and errors and improve the process during developing a Die. This study carries evidence of genuine advantages of applying computer aided process plan in a small scale industry. By applying computer aided process planning tool in a die manufacturing industry, a current state map is developed. A future state value stream map is created by eliminating time and errors during developing die. The future state map shows marked improvement in the process planning.

A case study discussed outlines importance of Computer Aided Process Planning tool to achieve effectiveness by using efficiently the process planning. Strategy to shorten proposed process time required for release of the Die and Proposed process for number of Errors identified during development phase. The benefits realized through the pursuit of the Case Study are:-

1. The future state map shows marked improvement in the process and Time saved with the implementation of the new process = 23.25%.
2. Percentage reduction in the number of errors for the new process = 43.21%

For planning the implementation of the CAPP system, it is recommended that the Company should develop 5 to 10nos case studies. This can provide as an input to developing the 'Retrieval Method' which can be maintained for the first 100nos of Dies. Later, upon maturity, this system can be marked for transition to `Generative Method' or `Feature based Method' of Process Planning.

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REFERENCES

[1] Krishnan Ramaswami, *International Journal of, process planning for shape deposition manufacturing, January 1997*

[2] S.K. Gupta, D.A. Bourne, K.H. Kim, and S.S. Krishna, Rapid Manufacturing Laboratory, Robotics Institute, Carnegie Mellon University, Pittsburgh,. *International Journal of, Automated process planning for sheet metal bending operations, PA 1521.*

[3] Dr.Thomas R. KramerGuest Worker, National Bureau of Standards, & Research Associate, Catholic University*, International Journal of, process planning for a milling machine from a feature-based design*

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[5] By T.N. Wong, LecturerDepartment of Industrial & Manufacturing Systems EngineeringUniversity of Hong Kong, *International Journal of, development of a knowledge-based automated process planning system*

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[7] By Ramy F. Harik1, William J. E. Derigent2 and Gabriel Ris2, 1Lebanese American University, ramy.harik@lau.edu.lb,2Université Henri Poincaré - Nancy I, william.derigent@cran.uhp-nancy.fr,Computer-Aided Design & Applications, 5(6), 2008, 953-962953,Computer-Aided Design and Applications© 2008 CAD Solutions, LLC,http://www.cadanda.com, DOI**:** 10.3722/cadaps.2008.953-962, *International Journal of, computer aided process planning in aircraft manufacturing,DOI: 10.3722/cadaps.2008.953-9628*

[8] David J. Cooper Jr.Genworks International 5777 West Maple, Suite 130 West Bloom_eld, MI 48325.http://www.genworks.com david.cooper@genworks.com ,August 21, 1998 (updated August 13, 2002)*, International Journal of, understanding multi-state generative process planning, August 21, 1998(updated August 13, 2002*

[9] Dietmar Winkler Stefan Biffl Thomas Östreicher, Vienna University of Technology, Favoritenstrasse 9/188, 1040 Vienna, Austria,{dietmar.winkler, stefan.biffl, thomas.oestreicher}@qse.ifs.tuwien.ac.at, *test-driven automation: adopting test-first development to improve automation systems engineering processes.*

[10] Dhiman Johns, Thapar University, Patiala, *International Journal of Computer Aided Process Planning(CAPP)*

[11] V. Naranje, S. Kumar, American Journal of Intelligent Systems , *International Journal of,*A Knowledge Based System for Selection of Components of Deep Drawing Die, 2(2): 1-11, (2012)

[12] John Wiley and Sons, M. P. Groover, *International Journal of , Fundamentals of Modern Manufacturing* 2/e,2002

[13] http://www.zianet.com/ebear/metal/heattreat3.html

[14] http://www.ignou.ac.in/upload/Unit-9-CRC.pdf