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THE APPLICATIONAL APPROACH OF A COMPUTER AIDED PROCESS PLANNING AND ESTIMATION SYSTEM FOR A PRECISION CASTING UNIT-A CASE STUDY

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ABSTRACT

This paper describes the application of a computer aided interactive process planning and estimating system for use in a jobbing foundry. This system was developed by international technology corporation with collaboration of largest foundry of UK(Beloit walmsley Ltd along with University of Manchester institute of science &Technology (UMIST).This integrated system developed includes, The facility to estimate the weight of casting, core making and moulding materials from dimensions and shapes taken from drawing, to estimate using man-hours per tonne of casting produced, the manufacturing times in moulding, core making , dressing departments. The system has comprehensive feed-back loop for comparing the estimated weights and times against those actually achieved and the facility for automatically updating the current man-hours per tonne in moulding,core making and dressing departments. The system is menu driven and modular in format of which there are six .the use of the system is described by an example .To test the industrial applicability of the system, data from boundaries were used. The estimated weights and times were compared with data of actually achieved .This capp sheet is more consistent and complete than those which are produced manually. We are taking ideas from this model from various research papers and trying to create specially for the Investment casting unit.

Key words: *Computer aided process planning (CAPP), Investment casting, and Estimating system.*

1. Introduction

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.The term "Computer-Aided Production Planning" is used in different context on different parts of the production process; to some extent CAPP overlaps with the term "PIC" (Production and Inventory Control).Process planning translates design information into the process steps and instructions to efficiently and effectively

Manufacture products. As the design process is supported by many computer-aided tools, computer-aided process planning (CAPP) has evolved to simplify and improve process planning and achieve more effective use of manufacturing resources.[2].Process planning encompasses the activities and functions to prepare a detailed set of plans and instructions to produce a part. The planning begins with engineering drawings, specifications, parts or material lists and a forecast of demand. The results of the planning are: Process plans which typically provide more detailed, step-by-step work instructions including dimensions related to individual operations, machining parameters, set-up instructions, and quality assurance checkpoints. Fabrication and assembly drawings to support manufacture (as opposed to engineering drawings to define the part).Keneth Crow [3] stated that "Manual process planning is based on a manufacturing engineer's experience and knowledge of production facilities, equipment, their capabilities, processes, and tooling. Process planning is very time-consuming and the results vary based on the person doing the planning".According to Engelke [4], the need for CAPP is greater with an increased number of different types of parts being manufactured, and with a more complex manufacturing process. Computer-aided process planning initially evolved as a means to electronically store a process plan once it was created, retrieve it, modify it for a new part and print the plan. Other capabilities were table-driven cost and standard estimating systems, for sales

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representatives to create customer quotations and estimate delivery time.

2. Estimation System

Now In this estimation system as we explained in the abstract the input for the product to initially feed to the system as standard based on material /shape consideration and the time & man hr details are to be added. The process needs the various department like waxing, shelling, Dewaxing, Finishing department for that the various parameters like wax material details/coating details/ timing etc to be as input parameters. Now the system has all stored data for calculation of production investment casting planning with estimation (Table.1)

3. Cost Estimation Methodology

Casting cost estimation in an integrated product and process design environment (R. G. Chougule Research Scholar, Mechanical Engineering Department, IIT Bombay, India chougule@me.iitb.ac.in ,B. Ravi * Associate Professor, Mechanical Engineering Department, IIT Bombay, India has mentioned in his paper for the general casting ,The overall casting cost estimation methodology is user input for cost estimation includes only part solid model, casting material, quality attributes (maximum void size, surface finish, dimensional tolerance) and production requirements (production rate, order quantity, sample lead time and production lead time). The part model is used for automatic computation of geometric attributes such as casting volume and weight, minimum and maximum section thickness, cored hole size and shape complexity. All the above inputs in turn drive process design, which is completed by semi-automatic programs for casting process planning and methoding (feeding and gating design). Process planning deals with decisions related to methods, equipments, steps, time required, tooling type and process parameters (such as type of mould or core sand, sand composition, melting charge, pouring time, pouring height, cooling time and quality checks).

A case based reasoning approach, which involves searching for the process plan of the closest matching product manufactured earlier, has been employed for this purpose. Methoding involves design of feeding system (number, location, shape and size of feeders and feed aids) and gating system (location, shape and size of sprue, pouring basin, well, runners, ingates and filters). These are designed and modeled using a 3D methoding program.

The system module is flexible and expanded by adding new modules with specific functions .A foolproof system is impossible but an attempt has been made to designing and developing the system. Module 1: Weight Estimation: All materials density and shape of Plane figures with their geometrical formulas are loaded their by the system will look the shape and calculate based on material.T1-Table of Mensuration,T2 -Table of density of materials Module 2:Time & cost estimation : In this Man-Hour rate for the operations based on machine capacity and skill of the labour.By adding allowances the labour cost data are loaded. T3-Machine details of capacityT4-Skill Rank of LabourCost Calculation data requirement summarization:Determination of overhead & various cost components Factory Cost =Prime cost +Factory expencesPrime cost =Direct labour cost +Direct material cost+Direct expences Manufacturing cost =factory cost +Administrative expencesTotal cost = Manufacturing cost +selling expences + Distribution expenses Selling Price = Total cost + Profit Market Price = Selling Price + Discount Determination of formulas were loaded in the module to estimate the time & cost of details. Module 3: Module 3: technical and part information: This module help the secondary requirements data's to estimate the primary calculations like core making material data, gating design details, etc.In this paper of reference was shown that the casting weight and time for manufacturing with material cost were given for sample to calculate estimation of all details for the general casting process but the same came be implemented for the investment casting by considering carious uncontrollable parameters like Temperature for Drying room Humidity for the coati data accurately.(Fig 2)

4. Data Interpolation

The data of all tables will be interpolated with the module and final process sheet will be prepared based on the investment casting process as shown above.

5. Software

The software like AUTO CAST for the designing the process automatically by giving as input of the drawing in 3D form and by interlinking with wedICE – (web-based intelligent collaborative engg) software developed at IIT-Bombay R.B.chougule & B.Ravi Associate Prof) for the casting design architechture. By continuing this concept we can have an idea to create the full process sheet with cost estimation for the investment casting only. Additionally we can include the control of various parameters like

Table1: System (CAPP) for Investment casting

INPUT	SOFTWARE	OUTPUT
Manufactruing Data base Modules of the system Shape code /Drawing of component		Process Planning sheet Man Hour /Machine hour required Weight of the component Cost of manufacturing
Wax Department Std -Time for Wax pattern /Die Assembly/ Injection of wax with man hour details for each Die numbers	**Computer Aided Process Planning (CAPP) System**	Estimation Cost of Above data + Overhead cost(Selling expenses like packing etc +Tooling cost or process cost& Administrative cost)
Coating Dept Man hr/Time for Stucco coating/slurry Dipping Drying /temp Maintenance Dewaxing- Auto clave	**Estimating data**	Allowances consideration For both Material/Man Hr COST
Casting Knock out the slurry Fettling of casting Maching/	**Costing Calculation**	Labour cost Material cost Over head cost

temp, humidity control, RH factor of coating liquid, which are uncontrollable factors. These factors are to controlled by using Design of Experiments or optimization technique to get zero % of rejection

6. Final Route Sheet

contains Technical data like Die details to inspection schedule date form, Pattern& shelling controllable parameters like Pressure, temp, time and weight details along design of casting elements like gate/fillets etc.Finally Melting temp, chemistry of composition of Computerized cost estimating and process planning for manufacturing using Auto cast & Web ICE we create this route sheet along this we also try to add the quality control technique of the controlling standard parameters data by optimizing the process

7. Actual Interpolation of CAPP & Our Project

The following figures and table shows the input and output of the system sample based on the model the approach of application can be possible to our model of quality control in Investment casting unit. Table: 1 Estimation of Casting wt & Cost Details through the Drawings (Fig 1) The casting drawing has to be given as input then the CAPP system read it then it will display as given

Table 2: Process of Investment Casting

Nature of Work	Department
Production Planning Control /DIE Manufacturing	shell baking Pouring in shell
Wax Pattern Injection –Up to 20 Bar Wax Pattern Assembly-Room tem-20^0-22^0c	Raw Material/Molten Metal(1500^0)
Nature of Work	Department
Shelling Making RH55+-5%,Drying Dewaxing- Auto Clave Tem 150^0-200^0 Plate Fixing, Handle fixing Chemical, Water washing, Dipping Pre-wet,Pre-coat &Stucco coating	Knock out Cleaning, Runner Cutting, Grinding welding/Fettling Department Quality Department

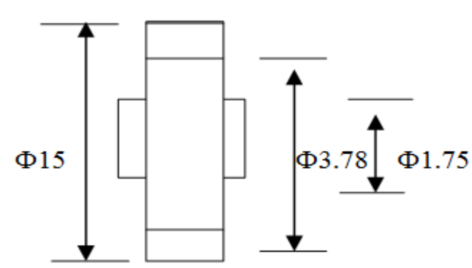


Fig. 1 casting Component of Gear blank from Jobbing Foundry

Table 3: Reference Journal Table Data

Casting Wt :16.00 Kgs Core wt : 8.78Kgs Mould wt :171.72Kgs Mould Box size: 24”x24”x12”	No of catsing/Box:1 No of core/Casting:5 Mould / Metal : 11.82 Estimation Box yield :90%	Work centre:	Manufacturing Time
		Moulding : 47.50 Man-Hrs/tone	45.82 Mins
		Core making :24.12 Man-Hours	12.71 Mins
		Dressing:6.90 Man-Hrs	6.65 Mins
Manufactruing Cost			
Moulding :	6 Rs/Hr	Casting	125 Rs/tone
Core making :	4.59Rs/Hr	Core Making	150Rs/tone
Dressing:	3.50Rs/Hr	Moulding	80 rs/tonne

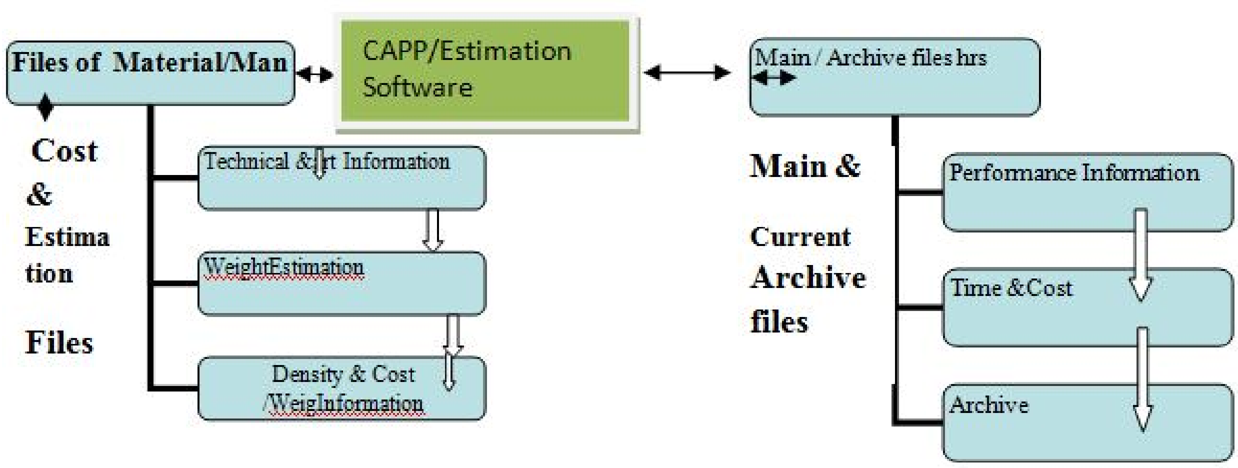


Fig. 2 The Module Flow Diagram with Table Integration

7.1 Integration of Statistical Tools

Mathematical statisticians Dr.Shewatt created this tool to control the variable &Attributes .Usng this charts we can get the data of output based on input which collected from old record of manufacturing .and find the reasons for rejection like Die Vs Temp,Die Vs Time, Time VS % RH, Inspection Vs Rejection etc. The tools for the quality control are :1.Frequency distribution, 2.Control chats, 3.Sampling Technique. The parameter considered in this calculations statistical tools are the chance & Assignable variables are the input . Also the Table . 3 Data from the Publications of Elsevier – CAPP system in Jobbing foundry by Dr. ABullah- 1982. attributes for variable s the control charts like X & R – Charts are used and for attribute P- & C charts are used. Generally the Variables like Dimensions, Hardness, Temperature, Time, Wt etc. But for Attribute by Visual inspection make like crack in the pressure gauge defect in the weld etc.

8. Sample Datas from the Casting Unit

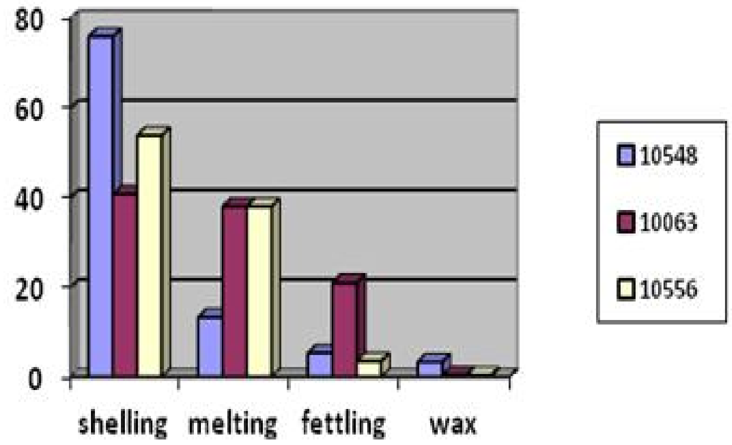
The project data were collected from the Precision casting unit at SIPCOT .The control charts programme to be added in the software and it will display the controls chart by calculating the input what we are giving as collected from the foundry unit. The list of datas are summarized in the table:2 given below. Also actual data from the unit followed this table:4&5Graph:1 y axis -% of Die Number & Rejection areas. Table:4&5 Summarized table of data to be collected in the Foundry unit. By filtering the critical dies based on no of times repeated & No of rejection to identify the major problem area using ABC (Always better control)catagories.Class A: Very serious, Class B:Serious,ClassC:Moderately Serious. % of Total rejection of Critical dies = Total Rejection/Total Cast x 100 From this maximum no of repeated dies are selected as critical dies for analysis. Based on this the list of dies for above 200Kgs rejection /300Kgs rejection like that table will be listed & Graph also be plotted. Table:4

Table 4: Coding system

Engg Problem	**Melting problem:**	**Wax Problem:**
E1- Shrinkage & wrong ,E2- Non fill, E3- Out of dimension **Shelling Problem:** S1- Shell crack, S2-Ceramic inclusion, S3-Extra metal, S4- Bulge:: W1-Pattern damage,	M1- cold run, M2-cold shunt, M3-slag, M4-Off composition, M5-shrinkage, M6-pitting, M7-short pour **Fettling Problem:** F1- excess cutting/ Grinding, F2-Damaged in handling,	1.Shell leak 2.Ceramic inclusion 3.Extra Metal, 4.Bulge, 5.Cold shut, 6.Slay inclusion, 7.Off-Composition, 8.Gassy Metal 9.Fettling,

8.1 Coding system of defects

No of datas are collected but some of samples are given in the table 5.No of coating with time and humidity data are tabulated for this shelling department using that ,control charts are prepared to find the average & Range of datas..Thus the final control charts are listed between. Die number Vs Temp (tapping & pouring), Vs Coating & Drying time, Date Vs Relative Humidity Like this based on this charts we can able to predict the various department defects .That can focused more to eliminate. These focus areas of defects are listed along the Final Route Sheet with regular datas.To prepare the route sheet the wax material data also to be feed as input in the software. Wax Materials :Petroleum Waxes ,Paraffin waxes, Natural waxes &Resins, Mineral waxes, Plastic waxes,& Also the Controlling Parameters in Shelling Department: Viscosity of slurry, Bath temp, Thermal Expansion, Permeability, to be feed.



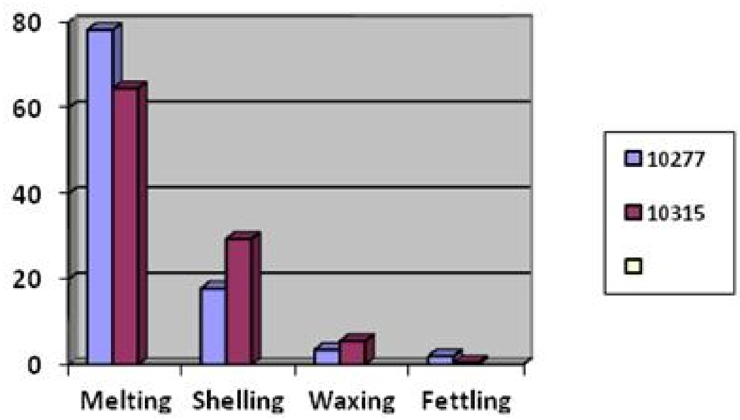


Fig. 3 Graph for % Rejection based on Die Numbers 1 &2

Table 5: Die No&, No of Components produced, Total wt (kgs) & Rejected datas

Die No	No : Comp produced proproduced	Total wt(Kgs)	Data for the Financial one year No of components Rejected												TOTAL
			APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	
10020	4800	1728	-	37	-	146	146	86	39	-	-	-	-	63	517
10021	1440	552	-	-	-		114	38	76	-	-	-	16	60	304
10042	2072	321	69	-	-	54	54	-	-	46	-		98	-	321
10063	2213	815													815
10131	3080	982													982
10447	718	231	-	-173	-	-	-	29	-	29	-	-	-		231
10527	4060	1565	116				195	398		328	54		126	224	
10547	3672	774	62	-	59	91	-	-	177	82		86	34	177	774

Table 6: Sample Datas from the Casting unit (4 &5 sample)

Die No	10020	No of Defect	10021	No of Defect	10547	No of Defect
Pour (Kgs)	4800		1440		3672	
Reject(kgs	517		304		774	
%	10.7		21.11		21.7	
wax	W_1-102	102	W-22	22	W2-35 W3-66 W5-65	166
Melting	$M_1$23, M_2.99 M372	203	M1-5, M2-46 M3-23, M4-3	77	M1-9, M2-20 .M3-69 M4-90	188
Fettling	F_1-4	107	F2-1 F1-1	2	F1-1, F2-14, F3-10	
Shelling	S_1-3. S2-21 S_3.7	97	S1-101, S2-60, S3-15	176	S1-98, S2-120 S3-150	368
Miscellane ous	O_1-7	18	O3-5 O5-22	27	O1-5 O2-22	27

Fig. 4 Final Sample Route Sheet

LOT NO	QTY	TEST BAR	X-RAY	TEST	DIE No

Min PCS Required	sign	Date	Progress	DIE ok by Engr	Released for sample	Patts Made	Assy.Made	Shell Made	Gate Cutting &&Given to Given	H/T Done	Fet Done	Finishing	Inspection & PAssed
	Tech Rep												

PATTERN Wax Used Top Pressure Bottom Pressure Dwell Time Sec	ASSEMBLY		SHELLING RH Temp Time for Drying Stucco Coating Slurry Used
	Diagonal (or) Max Span	Wax Details	
No of Cavity Patt Wt with gate With out gate	Autoclave TemP Handling Method		Dewaxing Time: Heat Treatment: Fettling Method

Table 7: Rejection Analysis Control Charts

Wax dept	Shelling	Drying	Autoclave	Fettling
Remedy instruction for the defects based on previous data	Coating chemical Composition ratio, No of Coating Huminidity Temp	Temp Wet bulp & Dry bulp Temp Time	Temp & Time Pressure	Method of tools use

Based on Rejection analysis control chats we can find the problem or reason for the rejection and further we can avoid the same problem n ot to be rejected.

9. Conclusion

This system developed which is integrative in operation for both ferrous & Non ferrous castings and for metric units and imperial units also offer reduction in time of calculation & estimation, comprehensive, consistent.

i. Feedback loop for comparing with manual palnning, Automatic update facility of datas.
ii. Provision to build standardized methods for casting description.
iii. This system used in training new planning engineers to experiment without the risk if making expensive m
iv. We can get Cost estimation and process sheet & we can find no of components going to accepted and rejected for future controlling to maintain the quality .for the investment casting unit

9.1 Requirements To Get The Outputs

i. Input for the table should be standard.
ii. Software like AUTOCAST/Web ICE are to be loaded in the system for integration.
iii. Uncontrollable Parameters like temp, humidity, RH are to be optimized.
iv. The model flow diagram of the system along with rejection data analysis of old production can be available.
v. 5. Programme knowledge is required to frame of integration or to learn to do this project.

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