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Development of CATIA Machining Process Template as a Varian CAPP for Mould Machining

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ABSTRACT

Mould manufacturing is a time consuming process and a large portion of the time is used for machining process involving process planning and execution on machine. Since there are similarities in machining process for various different moulds, the process planning can be automated by applying a process template that has been proven to be the best practice for mould machining, such as the best machining parameters and sequence. The automation of process planning, so called Computer Aided Process Planning (CAPP), in this research is integrated with Computer Aided Design (CAD) and Computer Aided Manufacturing (CAM) processes using CATIA V5 software. Due to the nature of mould machining that has similarities for different moulds, the CAPP developed using Variant type, where the best machining process is stored in the database and can be used as a process template for future machining process.

Keywords: CAD, CAM, CAPP, CATIA V5.

ABSTRAK

Pembuatan cetakan adalah proses yang memakan waktu dan sebagian besar waktu digunakan untuk proses pemesinan yang melibatkan perencanaan proses dan eksekusi pada mesin. Karena ada kesamaan dalam proses pemesinan untuk berbagai cetakan yang berbeda, perencanaan proses dapat diotomatisasi dengan menerapkan templat proses yang telah terbukti sebagai praktik terbaik untuk pemesinan cetakan, seperti parameter dan urutan pemesinan terbaik. Otomatisasi perencanaan proses, yang disebut *Computer Aided Process Planning* (CAPP), dalam penelitian ini terintegrasi dengan *Computer Aided Design* (CAD) dan *Computer Aided Manufacturing* (CAM) proses menggunakan perangkat lunak CATIA V5. Karena sifat pemesinan cetakan yang memiliki kesamaan untuk cetakan yang berbeda, CAPP dikembangkan menggunakan jenis Varian, di mana proses pemesinan terbaik disimpan dalam basis data dan dapat digunakan sebagai *template* proses untuk proses pemesinan masa depan.

Kata kunci: CAD, CAM, CAPP, CATIA V5.

1. Introduction

Mould and dies industry in Indonesia is growing up. According to Indonesian Mould and Dies Industry Association (IMDIA) as cited by Kompas (2018) in 2006 its member are 78 companies and in 2018 the number of companies joining IMDIA are 353 companies. The majority of mould and dies companies are supplying to automotive industry, where the growth in Indonesia market is significantly increased. Gaikindo (Indonesian Automotive Industry Association) released the information that in 2017 the production capacity of automotive companies in Indonesia was over 2.2 million units. Considering this increase in demands, mould and dies companies should also increase the capacity, either by adding production equipment or improve productivity.

In regard to this situation, the research was taken to increase mould manufacturing productivity by means of shorten manufacturing lead time. One of the method to shorten lead time is implementing machining process template to generate a process planning and CNC programming.

[1] http://imdia.or.id/indonesian/member/regular/index.html
[2]https://otomotif.kompas.com/read/2018/01/17/122310015/kapasitas-produksi-mobil-indonesia-tembus-22-juta-unit

2. Automation System

Automation is a work process or procedure without human assistance. Where this work is done by using an instruction program that is combined with a controller system (Groover, 2008). Automation is applied by using the program and is controlled by the control system and executed by the system controller with the aid of the actuator output. A process can be said to be automation because of the lack of human intervention.

The automation can be implemented in production facilities or production support systems. Automation in production facilities implemented into machines and production equipment. On the other hand, Groover (2008) define automation in the area of production support systems can be implemented into product design (Computer Aided Design), process planning, and production planning (Computer Aided Manufacturing).

2.1 Computer-Aided Design (CAD)

Computer Aided Design is a design activity that uses computers effectively to create or modify a design. The main task of CAD is to receive and compile interactive descriptions and provide graphical representations and geometric shapes that are created and generate data descriptions of a component that can be utilized in: parameter modification, technical drawing, and transformation processes into information for machining processes in CAM systems.

There are some reasons of using a CAD system to support the functions of design process:

1. Increase productivity in design
2. Improve the quality of design
3. Creating a manufacturing database

CAD is used to assist in the design, modification, analysis and optimization of designs. So that every program that embodies computer graphics and application programs that facilitate the design process engineering functions, is classified as CAD software.

Although CAD presents integrated computer use in a design process, the use of CAD does not change the design process requirements to: develop geometric details that require design (shape, dimension, tolerance, etc.), carry out the analysis required for the design, conduct design reviews and adjustments on the basis of functionality and economic characteristics, as well as communicating the design through an understandable technical drawing system.

2.2 Computer-Aided Manufacturing (CAM)

CAM is the effective use of computer technology in manufacturing planning and control processes. CAM applications are divided into two categories:

1. Manufacturing planning
2. Manufacturing Control

CAM application for manufacturing planning is where the computer is used indirectly to support the production function, this application category are:

- *Computer Aided Process Planning* (CAPP)
- *Computer-assisted NC Part Programming*
- *Computerized machinability data system*
- *Development of Work Standard*
- *Cost Estimating*
- *Production and Inventory Planning*
- *Computer Aided Line Balancing*

CAM application for manufacturing control is concerned with the development of computer systems for the function of manufacturing controls. And applications from this category are:

- *Process monitoring and control*
- *Quality control*
- *Shop floor control*
- *Inventory control*
- *Just-In-Time production system*

2.3 Computer-Aided Process Planning (CAPP)

Process planning is defined as a function in a series of manufacturing activities that define the production process and its parameters that are used to transform a material from its initial form into a shape that is in accordance with the desired design (Chang, 1990). Process planning is a link between design and production activities. The planned process must be optimal, where with production based on this process, the final part must be produced at the right time and with low production costs. All of these will lead to the need for computer-based systems that can carry out this process planning function or can be called Computer-Aided Process Planning.

Data input for CAPP can be a description of parts (both semi-finished and finished products) and production sizes. While the output of the CAPP is certainly a description of the process planning. According to Gawlik (2002), this description can be in the form of:

1. General information about: part names, part classes, portrayals of parts, and codes (notations or symbols)
2. Process structure including its elements (operation, set-up, position, cutting)
3. Information for each operation: operating name (string description), operating number (code, symbol), name of the production department, (code, symbol), workmanship (machining), name and type of work station (code, symbol), image part before and after machining operations, jig and fixture specifications, standard timing, to NC codes.
4. Information on each cutting technology: description of the cut numerically, the type of tool, and its characteristics (code, symbol), machining parameters, and machining time.

Figure 1 shows the framework of Computer-Aided Process Planning.

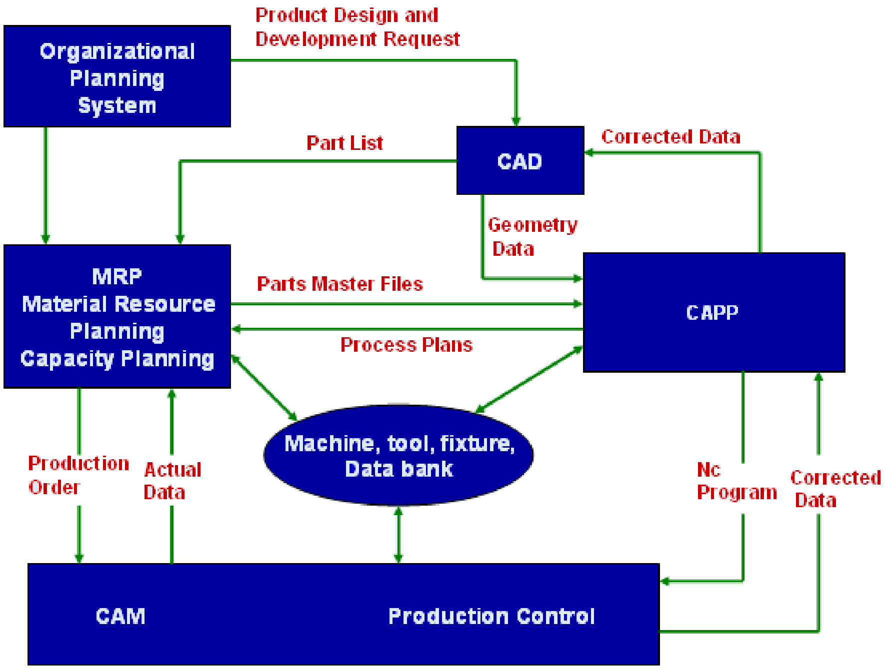


Figure 1. *Computer-Aided Process Planning* framework (Rao, 2018)

2.3.1 Computer-Aided Process Planning (CAPP) Method

Groover (2008) categorizes CAPP development methods into two main methods: Retrieval/Variant Method and Generative Method. The following is an explanation of the two methods.

2.3.1.1 Variant Method

The variant method is often compared to the manual method, where the process plan for new parts is arranged by identifying and searching for existing plans in the database for the same part (often called part master) grouped based on the concept of the technology group and making the necessary modifications to the part new.

One disadvantage of the variant method is the quality of the process plan is still very dependent on the process planner. The computer is only used as a tool to help with manual process planning activities. However, this method is still widely used, some of the reasons underlying them (Gawlik, 2002):

- Low hardware and software investments. Vendors for variant systems are more widely available than generative systems.
- Development time is relatively fast and does not require much energy. Installation is easier than generative systems.
- In some conditions, the variant system is more reliable to be applied to a real production environment, especially for medium and low-income companies.

There are advantages of using Variant CAPP approach as follows:

- Can solve problems from activities, which are complex processes and evaluations become more efficient.
- Use of standard procedures as a reference for the structure of manufacturing knowledge.
- Reducing costs for supporting devices and reducing time for the development of the planning process used.

2.3.1.2 Generative Method

Generative CAPP methods are generated through decision logic, formulations, searches, algorithms and geometric based data. Generally, the format of the CAPP system input can be divided into two categories: text input, where the user answers a number of questions (defined as interactive input); and graphic input, where the data part is taken through a CAD module (defined as interface input) (Gawlik, 2002).

According to Groover (2008), generative CAPP systems is another approach in process planning automation. The system does not retrieve and modify an existing process plan residing in a database, instead it generate the process plan based on logical procedures similar to the procedures a human planner would use. In a fully generative CAPP system, the process sequence is planned without human assistance and without a set of predefined standard plans.

Generative CAPP system is usually considered part of the field of expert systems, a branch of artificial intelligence. Process planning fits within the scope expert system as it is a computer program that capable of solving complex problems that is usually performed by an expert, a human with years of education and experience.

The advantages of the Generative CAPP approach are as follows:

- This method usually does not depend on the use of Group Technology (GT) codification from the process, but usually uses decision trees to categorize components into families.
- Maintenance and updating of the stored process plan is not necessary.
- Rules of process logic must be maintained with updates used and ready for use.

3. Methodology

The research focuses on development of Variant CAPP for mould machining using CATIA template and a small program developed in Visual Basic to generate Routing sheet. Figure 2 shows the flowchart of this development.

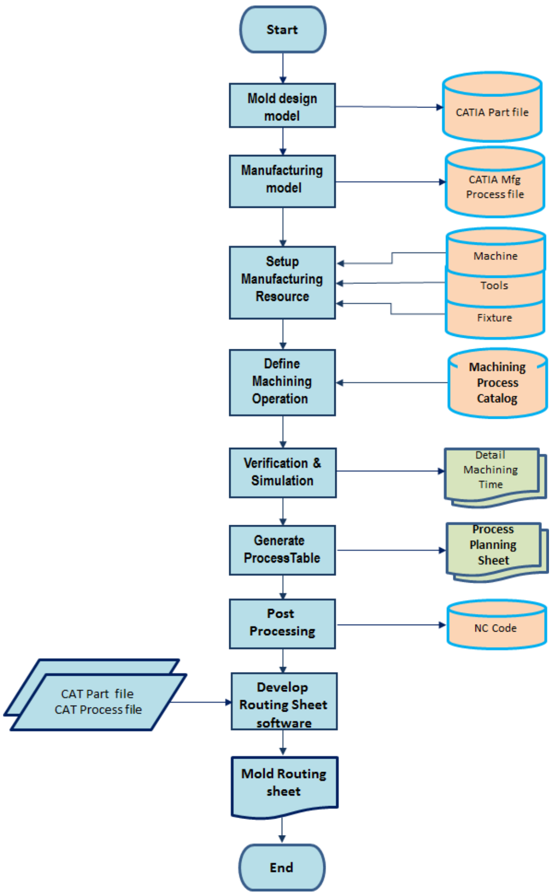


Figure 2. Flowchart of Variant CAPP for Mould Machining

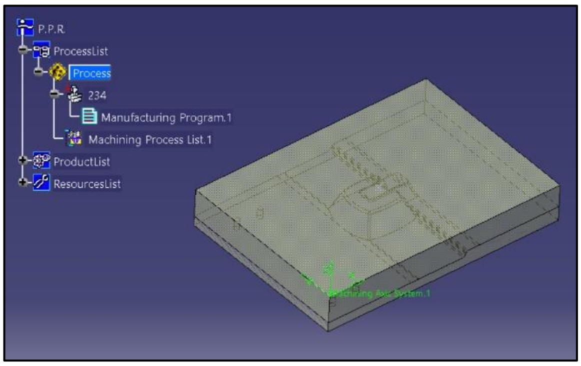
3.1 Development of Machining Process Catalogue

The procedure of creating the machining process catalogue is described as follows:

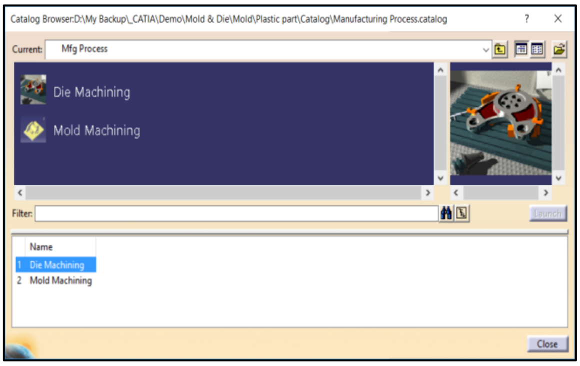
- Gathering the best machining operation sequence and parameters, including tools definition to manufacture the mold core plate or cavity plate, which have been verified in the shop floor.
- Create a machining process definition in CATIA, taking into account all the best sequences, parameters, and tool definition.
- Save the machining process definition in catalogue database

3.2 Definition of Machining Operation using Process Catalogue

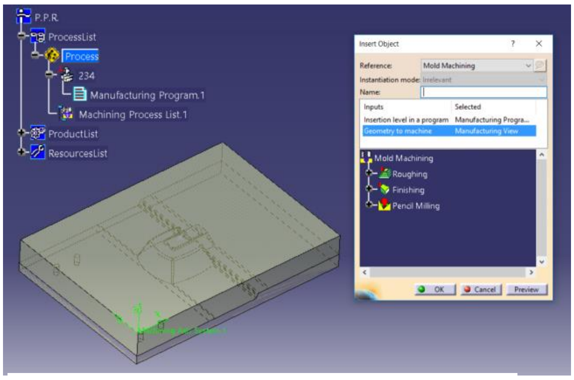
To define machining operation for a mould, user need to open machining process catalogue that has been developed previously. Figure 3 illustrates the process of defining machining operation using machining process catalogue.



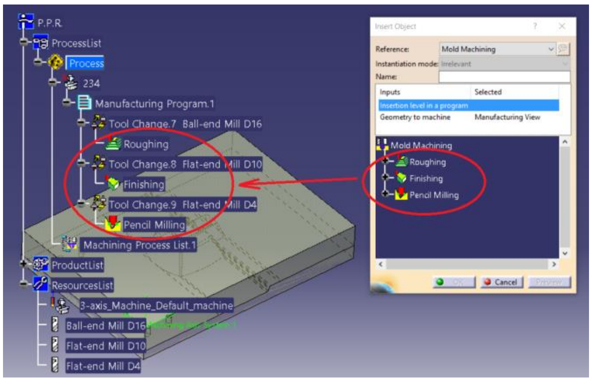
1. Prepare Part to be machined



2. Open machining process Catalog



3. The catalog contains operation needed to machine the mould



4. The machining process is then transferred to the new mould

Figure 3. Generating machining process using Variant CAPP for Mould Machining

3.3 Verification and Simulation

It is important to re-define the part to machine definition before running verification and simulation, as it is not defined in machining catalogue. The verification and simulation is needed to check whether the machining process has been conducted according to the required process to create the mould, and to get the calculated machining time for each machining operation. The machining process verification and simulation can be seen in Figure 4.

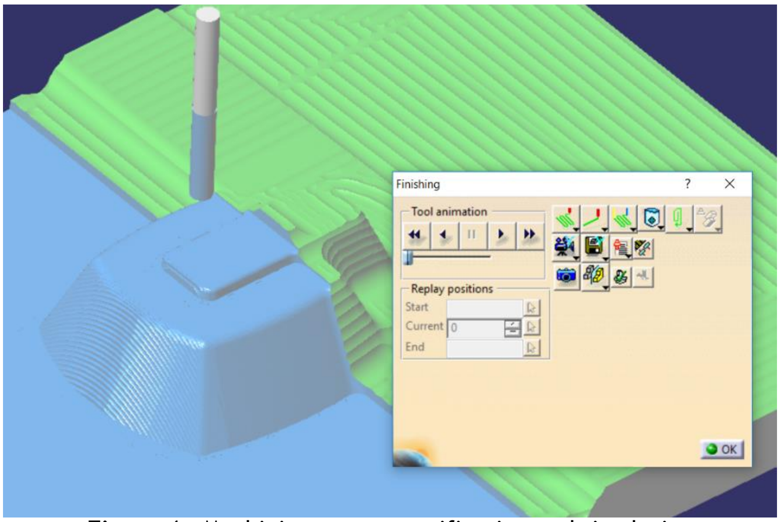
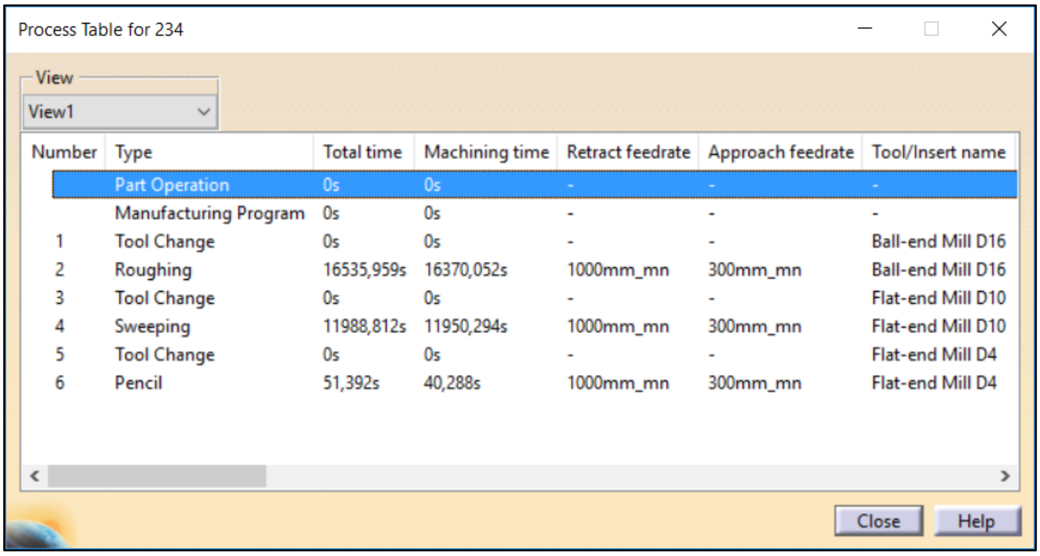


Figure 4. Machining process verification and simulation

A process table is then generated to be used as raw data for creating Route Sheet. Figure 5 shows the process table format which contains machine name, machining sequence, machining time, machining parameters, tool definition, and many other machining parameters.



Number	Type	Total time	Machining time	Retract feedrate	Approach feedrate	Tool/Insert name
	Part Operation	0s	0s	-	-	-
	Manufacturing Program	0s	0s	-	-	-
1	Tool Change	0s	0s	-	-	Ball-end Mill D16
2	Roughing	16535,959s	16370,052s	1000mm_mn	300mm_mn	Ball-end Mill D16
3	Tool Change	0s	0s	-	-	Flat-end Mill D10
4	Sweeping	11988,812s	11950,294s	1000mm_mn	300mm_mn	Flat-end Mill D10
5	Tool Change	0s	0s	-	-	Flat-end Mill D4
6	Pencil	51,392s	40,288s	1000mm_mn	300mm_mn	Flat-end Mill D4

Figure 5. Machining process table

3.4 Post Processing

Post processing is the process of generating the NC code (G-code and M-code) that is suitable for particular CNC machine controller. In post processing we have to carefully select the appropriate post processor for the said machine controller as every machine has its own CNC controller which is different from other machines.

3.5 Routing Sheet Program Development

The final result of this CAPP is a routing sheet developed using a program written in Visual Basic. Visual Basic is chosen because CATIA API (Application Programming Interface) is easily accessed using VB Script. The function of this program is selecting necessary machining process data from CATIA process table and presenting the data in the form of standard routing sheet. An example of routing sheet is shown in Figure 6.

A routing sheet basically contains information of part number, part description, materials, machine sequence, machining process sequence, tooling used in the process, and the time to accomplished each of the machining operation.

ROUTING SHEET			MECHANICAL SHOP PRESIDENT UNIVERSITY				
Part Number		12345	Generated by				
Part Name		Plastic Mould	Approved by				
Material		Mild Steel	Date, time		18/09/2018 18:48		
No.	Operation Name	Machine	Cutting Tool	Clamping Tool	Machining Time	Non Machining Time	Total Time
1	Roughing	3 Axis CNC Milling Fanuc 21i	Ball End Mill D16	Machine vise	4h 32' 50"	2' 45"	4h 35' 35"
2	Sweeping	3 Axis CNC Milling Fanuc 21i	Flat End Mill D10	Machine vise	3h 19' 10"	38'	3h 19' 48"
3	Pencil Milling	3 Axis CNC Milling Fanuc 21i	Flat End Mill D4	Machine vise	40"	11"	51"
4	Inspection						5'

Figure 6. Routing Sheet of a specific mould machining

4. Conclusion

Based on the discussion in this study, the following conclusions are obtained:

- A standard r**oute sheet generated from CAPP in this study co**ntain**s the needed information and produced from the mould** manufacturing process. The process plan is also formed automatically using the CATIA V5 program **developed in this study**, namely by using the **machining process catalogue and machining** process table. The process **plan** that **generated** after the simulation on CAT**IA V5 has a complete data that** can **be selected** according to the needs.
- The Route Sheet contains information related to mould being produced such as materials, process sequence, machines used, tools used, machine set-up time, and time of operation standards for the mold making process examined in this study.
- A further research would be needed to include an intelligent system that can select the machining process catalogue automatically by recognizing the machining features contained in the mould being processed. This will shorten the time to produce a process plan with the CAPP system.

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