

Machine Simulation using High Speed Machining (HSM) Inventor

Abdul Mutalib Abdul Majid*, Hashimi Lazim and Mohd Amirul Johari

Polytechnic Tuanku Syed Sirajuddin, Pauh Putra, 02600 Arau, Perlis, Malaysia.

ABSTRACT

In mould manufacturing, machining activities play a large part during the mould fabrication. The objective of this project is to produce G code and machining simulation for a bowl shaped insert mould. The design of this prototype and insert mould were made by using Computer Aided Design software of Autodesk Inventor Professional which is then simulated with the use of High Speed Machining Inventor software. The CAD software is used to create three parts namely prototype, core and cavity inserts. In order to generate the G code, a certain type of milling processes in the HSM Inventor software is used to machine the core and cavity insert. The simulation software will then generate toolpath that drives the selected machine tools to turn the design drawing into a physical part. Throughout these manufacturing processes, parameters such as stock size, tools type, cutting parameter and axes are important in order to avoid damage and failure in design.

INTRODUCTION

In mould manufacturing, machining activities play a large part during the mould fabrication [1, 2]. Current technology with the invention of Autodesk Inventor Professional is able to create design models by using geometrical parameters. These models typically appear on a computer monitor as a three-dimensional representation of a part or a system of parts, which can be readily altered by changing relevant parameters. The software enables designers to view objects under a wide variety of representations and to create a mould from the prototype.

With the use of High Speed Machining (HSM), time and cost can be lowered, improved machining efficiency, reduction in tooling variety, and minimum workpiece distortion. For example, in HSM Inventor software, it enables the mould part core and cavity to be tested by simulating real-world machining conditions. The simulation software will then generate toolpath that drives the selected machine tools to turn the stock into the core and cavity part. The software then encodes the geometrical data in G-codes and can be used to run the CNC machine that creates the designed core and cavity of a bowl. This project consists of the design and simulation of the machining process.

Among the measures and work done in preparing this project were :

- (i) Design prototype and insert mould ;
- (ii) Selection of machining process and parameters ;
- (iii) Machining simulation ; and
- (iv) Generating G-code.

The objectives of this research are as below:

- (i) To apply and design machined parts using HSM Inventor software;

*Corresponding Author: mutalibptss@gmail.com

- (ii) To create CNC machining operations using Inventor HSM software for milling and drilling; and
- (iii) To simulate toolpath and post process CNC codes for machines.

LITERATURE REVIEW

The use of CNC machines with High Speed Machining (HSM) has demonstrated many advantages to other rapid manufacturing techniques such as able to generate high quality surfaces, burr-free edges, and stress free components after machining [3]. It also minimizes the effect of heat on machined parts. Sometimes, in designing non-machinable components or the use of expensive tools and difficult operations, the use of CNC machines with High Speed Machining can be crucial. For example, in cases where the design must be modified several times, therefore resulting in increased machining lead times and cost. Therefore, great savings in machining times and costs can be achieved if designers can solve machining problems of the products at the design stage. This can only be achieved through the use of HSM Inventor.

Injection mould plays an important role in injection moulding process such as producing plastic product. In the manufacturing industry, there are different shapes and sizes of injection moulding products manufactured. Hence, many kind of mould designs are used to produce the products according to the user requirements. Moulds are then fabricated using standardized parts with different core and cavity inserts [4]. A mould is designed to safely absorb the forces of clamping, injection, and ejection. For obtaining the uniformity of product quality in continuous production cycles, the flow conditions of the plastic path had to be proportioned acceptably. The mould has to be able to absorb the heat from the plastic effectively while the solidification of the plastic product must be at controlled rate [4].

In this project, the type of mould used in this project is the two-plate mould. This is the most basic type of injection mould. The core and the cavity are inserted to the mould and the mould are mounted in either plate where the plates are fastened to the press platens. The ejector system is at the moving half of the mould. Injection mould must be designed well enough in order for the product that going to be manufactured meets the required specifications.

METHODOLOGY

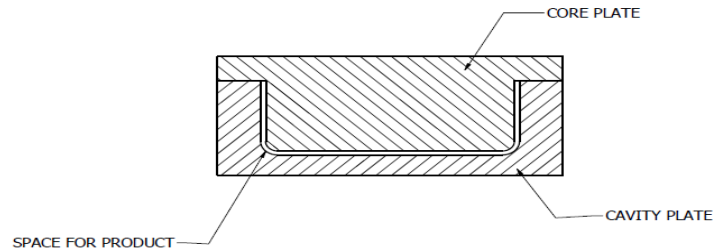
This project was completed accordingly to the process flow shown in Table 1.

Table 1 Stages of process flow

Stage	Process Flow
Stage 1	Product Design Brainstorming and Selection
	Design the prototype and dimension it. It is important to choose for right plane. Use XY plane for start a drawing. After finishing the drawing, find suitable mould base for the prototype.
	Sketch the shape of the core and cavity with dimension according to the mould base. If necessary change the prototype to suite the mould base.
Stage 2	The design is divided into three parts namely prototype, core and cavity as shown in Figure 1.
	Mould Design (Core and Cavity Parts)
	Using Autodesk Inventor, design the mould base according to standard mould base. From this standard mould base create the cavity part. The cavity part dimension is as

the outside dimension of the prototype. Then create core part by using the same mould base part and use the inside dimension of the prototype.

After complete the core and cavity parts, make an assembly for the core and cavity. Any defect can be seen from the assembly drawing. Make an adjustment if this happens.



Stage 3	<p>Stock Setup</p> <p>Setup the UCS coordinate at the top centre of the stock and make sure the z axis is pointing upwards. Then set the size of stock and if necessary set the offset according to the size of the core plate and cavity plate.</p> <p>The offset is only in XY direction and positive Z axis.</p>
Stage 4	<p>Machining Parameters for Cutting Core and Cavity Parts</p> <p>First set the type of machining to milling and used 4 types of cutting processes : (i) Adaptive with offset ; (ii) Facing ; (iii) Contour and (iv) Pocket.</p> <p>For each process set the tool type, geometry of cutting, height, passes and linking.</p>
Stage 5	<p>Simulation Process</p> <p>After complete the machining parameter, use simulation to see the real cutting process. Simulate each machining process and if any collision or inappropriate cutting happen, change the setting until suitable simulation is achieved. After all the machining processes are completed and the simulation as planning, send to post processes.</p>
Stage 6	<p>Generate G-Code</p> <p>The post processor is used to convert the CAM instruction to G and M code. Use the post configuration to HAS Automation and then give the program name and post. It will create all the G code for cavity and core inserts in NC format. The code can be used on CNC machining to run the actual machining.</p>

RESULTS AND DISCUSSION

The result of the simulation was carried out to enable the selection of suitable cutting processes to be performed either contour, facing, pocketing or adaptive. These processes sequence can be interchanged in order to obtain the ideal cut [5]. For every cutting processes, there can be divided to roughing and finishing. A roughing operation is used to remove large amounts of material rapidly and to produce a part geometry close to the desired shape. A finishing operation follows roughing and is used to achieve the final geometry and surface finish.

This project was completed according to the process flow as shown in Figure 1.

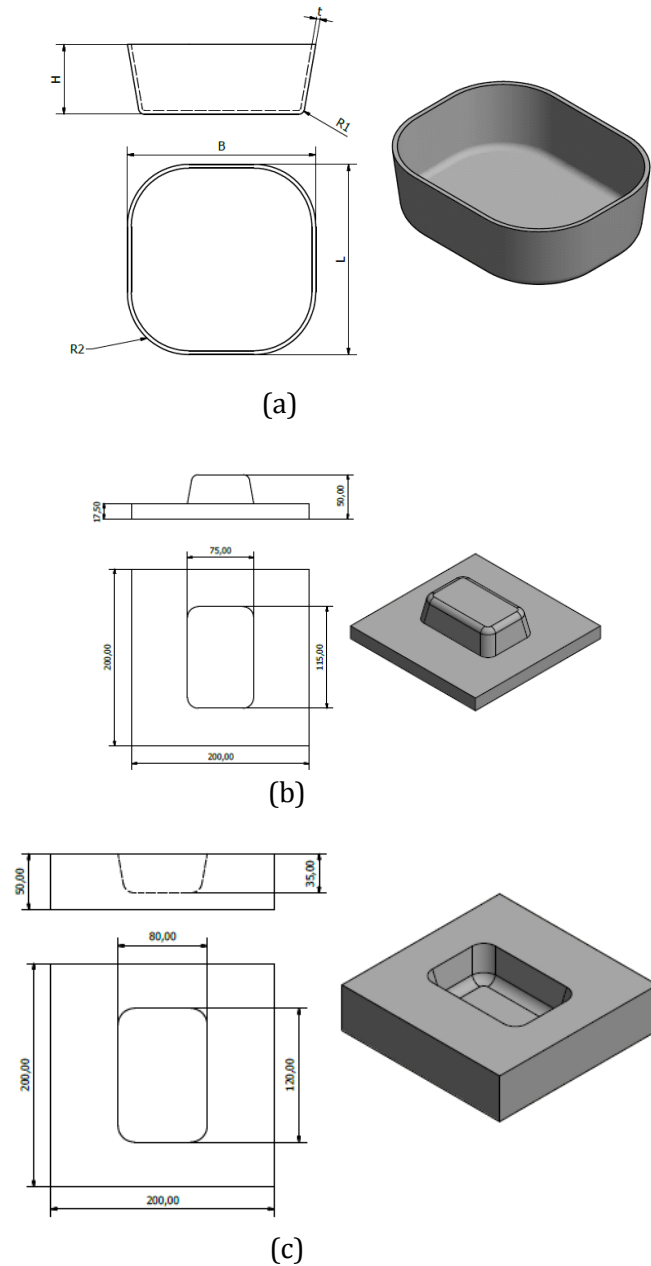
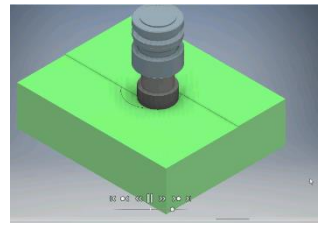
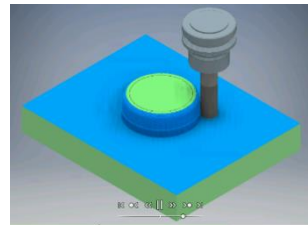


Figure 1. Design of a bowl shape (a) prototype (b) core and (c) cavity.

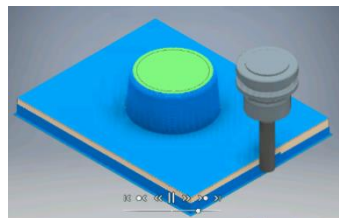
Figure 2 shows the simulation of cutting process using facing (finishing), adaptive (roughing) and contour (roughing). The advantage of part of simulations is one can trial and error in order to have good finishing. From the comparison side, the application of HSM Inventor can make the process easier other than using manual processes. Furthermore, it can save time, simple steps and easier to make any design. For the modified parts, we will know the right settings to apply on a prototype. For example, if the simulation is not at the right cutting part, then will need to change the tools and so on.



(a)



(b)



(c)

Figure 2. Types of Cutting Process (a) Facing, (b) Adaptive and (c) Contour.

CONCLUSION

The understanding of plastic product design concept, injection moulding machine operation and standard mould base are important in design the mould for the prototype. The knowledge of conventional machining such as selection of cutting tool will be a great advantage in running CNC simulation because of the variety in machine tool parameters such as shapes, sizes, speeds, and other dimensions. In this project, with Inventor HSM software, it helps to significantly improve the efficiency of machining processes and ultimately the quality of parts. For example, it is essential that the models for HSM be prepared to represent accurately the shape that will be milled. The tolerance of the mould dimension needs to be as precise as possible. The scope of this project was to study and verify the dimensions of the bowl for suitable simulation processes. This includes the understanding of all components in the mould and each of its function. Lastly, is to develop the cavity and core of the mould by using most suitable manufacturing process.

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