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Review of 3D Printing VS Injection Molding VS CNC Machining Processes: Simulation and Fabrication

Annamalai Pandian
Faculty
Department of Mechanical Engineering
Saginaw Valley State University
University Center, Michigan, USA
apandian@svsu.edu

Abstract

In this paper, a suitable prototype model part was developed. A CAD model and drawing was developed using SolidWorks program for the review of the three manufacturing processes: such as, (1) 3D Printing- AM (additive), (2) Injection Molding- IM (formative), and (3) Computerized Numerical Control (CNC) Machining (substrative) manufacturing processes. All three manufacturing processes were simulated using SolidWorks program. The CAD model AM part file was simulated using stereolithography (STL) file, and the AM part was sliced using CatalystEX software. The IM process was simulated using SolidWorks Plastics flow simulation tool and the CNC machining process was simulated using SolidWorks CAM program. The actual prototype model parts were fabricated using three different machine tools for the study using IM, AM, and CNC machining fabrication processes. The same part design and the same polymer thermoplastic material is used for all three manufacturing processes. The protype type model part processes study results and the recommendations are provided.

Keywords
Additive Manufacturing, Injection Molding, CNC machining, CAM, Plastics flow Simulation.

1. Introduction

Additive manufacturing (AM) also known as 3D Printing is becoming a disruptive technology to compete with traditional subtractive processes like machining. AM is used extensively in dental, medical, aerospace, fashion design, food processing, fashion, and prototype tooling, and in manufacturing industries The global 3D printing market size was estimated at USD 20.67 billion in 2023 and is projected to be worth around USD 98.31 billion by 2032 with a notable CAGR of 18.92% during the forecast period 2023 to 2032. Effortless in development of tailored products, reduction in manufacturing cost and process downtime, manufacturing of the functional parts makes this technology a viable solution to the traditional machining process. The demands of quick turnaround time, faster delivery and cheaper cost make AM technology very attractive. It is predicted that the AM technology may replace traditional manufacturing methods in the near future. AM processed part is being fabricated layer by layer using various polymers. Whereas the Injection molded part was fabricated using specifically designed molding dies. The global plastic injection molding market is valued at $175.02B in 2021 and expected to reach $266.1B by 2030 poised to grow at a compound annual growth rate (CAGR) of 4.8% from 2021 to 2030. The global CNC milling machines market size was valued at USD 79 billion in 2023 and is anticipated to reach around USD 113 billion by 2033, growing at a CAGR of 3.64% from 2024 to 2033. The CNC milling machines market growth is driven by rise in industrialization, and increased production of automobiles according to the Precedence research report (www.precedenceresearch.com).

1.1 Objective

This paper aims to provide a comprehensive review of the three manufacturing processes: namely, 3D Printing, Injection Molding and CNC machining. The study part is designed, and engineering drawing is developed. The actual parts with the same design and same material are used to fabricate parts for the study. Also, the Injection Molding Die design was designed and developed assembly drawing and manufacturing part drawings using the SolidWorks program. All parts and mold tooling are fabricated using university laboratory equipment. All three manufacturing processes are simulated using Stereolithography (STL) file for 3D printing, Plastics flow simulation for Injection Molding process, and CAM simulations for CNC machining using the SolidWorks program. All processes use the same part design, and the same Acrylonitrile butadiene styrene (ABS) material for this review. All three manufacturing techniques are used to fabricate parts. The review results and recommendations are presented.

There are so many manufacturing processes available to produce plastic components. Which process is the best process to use depends on Volume/Budget, Lead time, Material/Finishes, and Design considerations, Process flexibility. This paper compares three different processes- Additive Manufacturing (additive), Injection Molding (formative), and CNC machining (Subtractive) that are often contenders for similar products namely plastic components applications (Bruml, 2024).

2. Literature Review

The recent developments in 3D printing also known as "Additive Manufacturing" or AM have revolutionized the modern manufacturing process and the engineering design process. Emerging use of 3D printing technology is prevalent in automotive, manufacturing, aerospace, pharmaceutical industry and healthcare, fashion, retail, and sports. The authors reviewed the recent trends and challenges in 3D printing technology. The technological advancements in extrusion materials, design and processes, equipment's capability have brought down the cost of manufacturing. Also reviewed the latest developments in 3D printing material types, manufacturing techniques, equipment types, and the development of standards for selecting material, quality control, and 3D printing machinery (Pandian and Belavek, 2016). (Schmitt et.all, 2021) presented a literature review of publications from the last 20 years. The research landscape is organized into four areas: machine and process, material, digital process chain and methodology. The paper summarizes the developments in each of these areas and concludes by presenting current and discussing future research topics. Current developments in the area of AM processes, such as multi-material printing, open up new opportunities, including digital materials and functionally grade products, resulting in new trends, e.g. 4D printing.

In the last few decades, massive efforts have been added to investigate liquid-state additive manufacturing (AM) processes, such as laser and electron beam-based AM, in the context of their technicality, commercial viability, and research progress. However, the challenges associated with localized melting, processing complexity, defects, high amount of equipment, and operation cost have sparked an interest in the possibility of alternative solid-state AM methods. Therefore, it is vital to consolidate the major solid-state AM processes and their advancements in a lucid manner. (Kumar and Kar, 2021) provide a short review of the major solid-state mechanical deformation-based AM processes, such as ultrasonic-assisted, friction stir-deposited, and cold-sprayed AM, in the context of their research advancements, challenges, and capabilities. It has been observed that solid-state AM processes can effectively suppress the various shortcomings encountered with liquid-state AM techniques. Among the different solid-state AM methods, the additive friction stir AM techniques are outstanding, with isotropic microstructures and mechanical properties almost similar to the base metals (Yu et.all, 2022) used Case Based Reasoning (CBR) technology to obtain the feasible process parameters for injection molding. The typical case showed that compared with the traditional characterization methods based on manually extracting features, such as maximum flow length and average wall thickness, the proposed method can better characterize the slight differences the molding features and has a higher retrieval accuracy. This work paved the way for the adoption of pressure profile at the injection location as a representative feature in CBR-based intelligence setting of process parameters.

Injection molding is an efficient manufacturing process for mass-producing parts with complicated geometry, consistent quality, and attractive appearance. With the increasing dependency of consumers' decisions on the aesthetic and design attraction of the products, improvement of surface quality has been one of the main areas for research and development of injection molding technologies. (Gim and Turng, 2022) presented a comprehensive overview of injection molding for high surface quality based on the optical aspect of surface quality and defects. It classifies the recent research and development into four sections, namely, measurement, influencing factors and causes, prediction, and control of surface quality and defects. Based on those reviewed studies, this paper proposes further research and development topics for high surface quality injection-molded products.

Aminabadi et.all, (2022) presented a novel in-line AI fully automated closed-loop process quality control for the injection molding process. The automation was implemented over the OPC UA network platform in compliance with Industry 4.0 framework for the injection molding process. A novel in-line dimensional measurement system was used to measure the as-molded dimensions of the parts. Therefore, three quality features of the molded parts (weight, dimensional properties, and surface quality) were measured in an in-line and as-molded manner. The surface quality was controlled to achieve a surface quality value higher than 0.6 (where 1 is the best surface quality). The linear dimension (the average of three measured linear dimension lines) was controlled for the goal of 120 mm with a tolerance of +/-0.025 mm. The quality features were predicted through the AI models and applied to make the control decision in comparison with the in-line measurements. (Khosravani et.all, 2022) focused on (a) simulation and generative design for optimization of manufacturing, (b) additive manufacturing, and (c) virtual reality. In this research, after a short overview of the knowledge-driven process of injection molding, the proposed knowledge-based system is presented. Then, explained the use of the mentioned technologies in the injection molding production line. The current work indicates that a production process can be significantly changed and revolutionized by intelligent solutions and smart devices. For instance, utilizing 3D printing in fabrication of injection molding clamps leads to 95% and 85% reductions in cost and time, respectively. Further research and experiments can improve and enrich the existing affordable and proper solutions resulting from the proposed knowledge-based system. (Finkeldey et.all, 2020) addresses that the knowledge obtained by both, simulation and technologically based approaches, is only valid for the analyzed process configurations. In contrast, models based on machine learning (ML) approaches can provide forecasts for previously unseen data and can be evaluated quickly. This paper a novel ML-based methodology to predict quality characteristics of an injection molding process for different process parameter values using an intelligent combination of simulation data and measurements is presented.

Soori and Asmael, (2022) applied optimization process to the machining operations in order to provide continual improvement in accuracy and quality of produced parts. The effects of machining parameters in milling operations, such as spindle speed, depth of cut and feed rate are investigated in order to minimize the surface roughness as well as the time of machining process. The effective machining parameters, such as depth of cut, feed rate and spindle speed in turning operations are investigated to minimize the surface roughness as well as the time of machining process. Also, machining parameters, such as peak current, gap voltage, duty cycle and pulse on time in Electro Discharge Machining (EDM) operations optimized in order to obtain the optimized material removal rate, tool wear, and surface roughness in part production process. To improve material removal rate, surface roughness, and spark gap in part production process using the wire EDM operations, machining parameters, such as spark on time, spark off time, input current are studied and optimized. To calculate optimized machining parameters, authors used different optimization methods, such as Taguchi method, fuzzy logic algorithm, artificial intelligence, genetic algorithm, artificial neural networks, artificial bee colony algorithm, ant colony optimization and harmony search algorithm. The authors concluded that time and cost of accurate production can be reduced to increase productivity in part production process using machining operations.

Conditions for machining operations were traditionally selected based on geometry and surface finish requirements. There are a few methods to optimize the machining process, such as minimizing unit production time or cost or maximizing profit. In this research (Lee et.all, 2020) focused on maximizing the profit of computer numerical control (CNC) milling operations by optimizing machining parameters. Cutting speeds and feed are considered as the main process variables to maximize the profit of CNC milling operations as they have the greatest effect on machining operation. In this research, the Nelder–Mead simplex method was used to maximize the profit of CNC milling processes by optimizing machining parameters. The Nelder–Mead simplex method was used to calculate best, worst, and second-worst value based on an initial guess. The possible range of machining parameters was limited by several constraints. The Nelder–Mead simplex method yielded a profit of 3.45 ($/min) when applied to a commonly used case study model.

3. Model- Part Design Parameters

SolidWorks software program is used to design and develop a study part named as “Cover” and an engineering drawing was created per ANSI standard. The actual parts are fabricated using the same type of material (ABS) for all three processes. The part model named as “Cover” design and drawing is shown in Figure 1. The model part has a

2.125 in. diameter and shallow depth of 0.469 in, with 0.125 in wall thickness. The part also has 6 holes with Ø 0.281 in. on 1.500 in. pitch circle diameter. A protruded solid square section 0.500 in. with height 0.375 in. on top. The chosen model material is a thermoplastic polymer material Acrylonitrile butadiene styrene (ABS) is selected for all manufacturing processes. The material density = 0.037 in^3; ABS _Mass = 0.115 pounds; Volume = 3.109 in^3 ; Surface area = 24.957 in^2 .

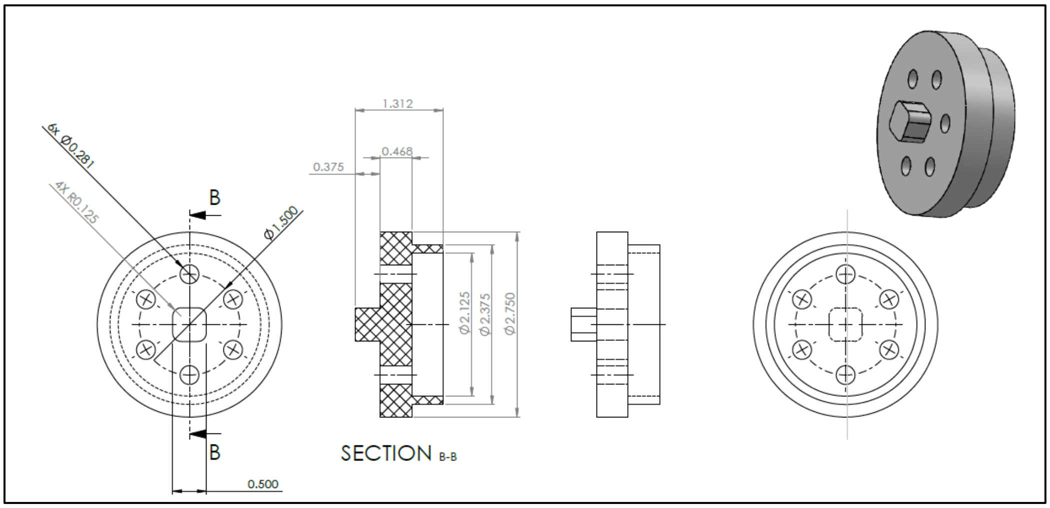

Figure 1. Part (Cover) Model and drawing

4. AM Process

AM process is an additive manufacturing process. Process of printing (adding) one thin layer at a time to build the part as shown in Figure 2. AM process involves **Geometric modeling**- the creation of a solid model of the component on a Computer Aided Design (CAD) system to define its enclosed volume. In the **Tessellation of the geometric model** step, the CAD model is converted into a format that approximates its surfaces by triangles, with their vertices arranged to distinguish the object's interior from its exterior. The common tessellation format used in rapid prototyping is STL, which has become the de facto standard input format for nearly all RP systems. In the final step, the model is **Sliced** into layers. The model in STL file format is then sliced into closely spaced parallel horizontal layers. These layers are subsequently used by the Rapid Prototype (RP) system to construct the physical model (Figure 2)

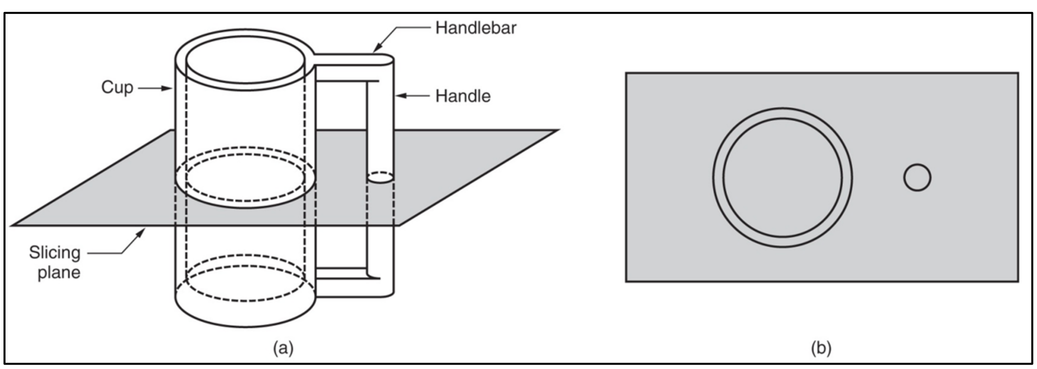

Figure 2. Conversion of a (a) solid model of an object into (b) layers (only one layer is shown) (Groover, 2020)

4.1 Build Time Calculation

The part (Figure 1) is divided into a square solid section, shell section and round solid section with 6 holes. Fused-deposition modeling uses a second extruder if the support material is of a different type than the part material (e.g., lower-melting-point wax to support a plastic part). In this case, the time taken by the secondary work head must be added if the extruder heads operate sequentially. CAD modeling and 3D printer setup time is not considered in the cycle time calculation.

$$T_i = \frac{A_i}{vD} + \frac{A_{si}}{vD} + T_r \qquad \text{(Eq. 1)}$$

where A_i = area of layer i
A_{si} = support area in layer i
v = velocity of moving spot
D = diameter of moving spot (assumed circular)
T_r = repositioning time between layers

Total build calculation time = 5.252 + 2.542 = 7.794 hrs.

4.2 Fabrication Technique and Model Parameters

The moving spot technique is used for layer-formation using laser spot moving across a layer of photo-curable liquid polymer. The Material extrusion (FDM) process is used to build the model. A long filament of wax or thermoplastic polymer is extruded onto the existing part surface from a work head to complete each new layer. The work head is controlled in x-y plane during each layer and then moves up by a distance equal to one layer in the z-direction. Extrudate is solidified and cold welded to the cooler part surface in about 0.1 second. Part is fabricated layer-by-layer from the base up. The model material ABS-M30 is selected due to its greater tensile, impact and flexural strength than standard ABS to fabricate the model. Support is required to build the model from the ground up. P400-SR Soluble Support Material Cartridge / Dimension Elite / SST 1200es is used to provide the support. The height of the part (*z*-direction) = 1.312 in. and divided into each layer thickness = 0.007875 in. and laser spot diameter = 0.001 in. The beam velocity across the surface of the photopolymer = 31.50 in/s. Cycle time is computed to build the part, with 20 s for each layer for repositioning and recoating.

4.3 Printer Specifications

STRATASYS, INC. Dimension BST 1200es / SST 1200es printer is used to fabricate the part using material extrusion additive process. The Printer build volume is 10 in. x 10 in. x 12 in. with layer resolution Low = 0.013 in. and High = 0.010 in. The Support Cleaning System (SCA-1200) size:16 in. x 19 in. x 26.5 in. is used to dissolve (clean) the support material. The part orientation and the model slicing window is shown in Figure 3. The STL file part model is shown in Figure 4. The fabricated actual part is shown in Figure 5.

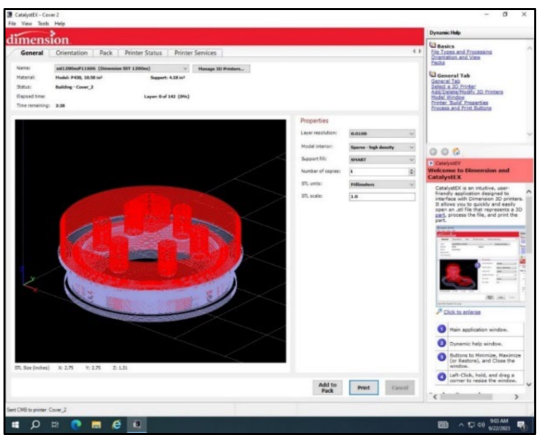

Figure 3. CatalystEX Model slicing window.

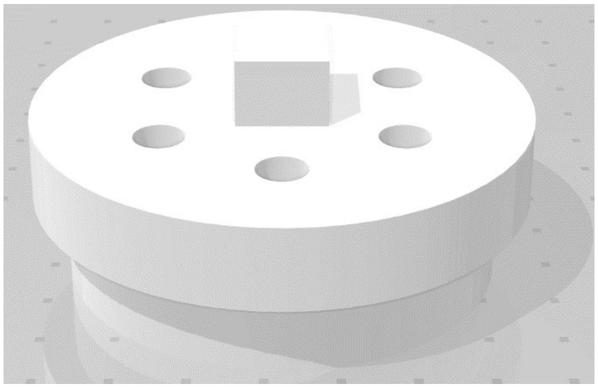

Figure 4. Simulated STL part file.

Figure 5. AM fabricated part.

5. Injection Molding Process

Injection molding process is a formative manufacturing process. The injection molding has simple four steps: Melt material, inject molten material into a mold, let the molten material cool to a solid state, and remove the molded component from the mold die. Polymer is heated to a highly plastic state and forced to flow under high pressure into a mold cavity where it solidifies, after solidification the molded part is then removed from the cavity.

5.1 Model Plastic flow Simulation

For the IM simulation process study, the part process plastic flow parameters were developed and analyzed using Solid Works plastic flow simulation program. Various injection points were created and used for the plastic flow to study the various flow parameters. The plastic flow part simulation is shown in Figure 6.

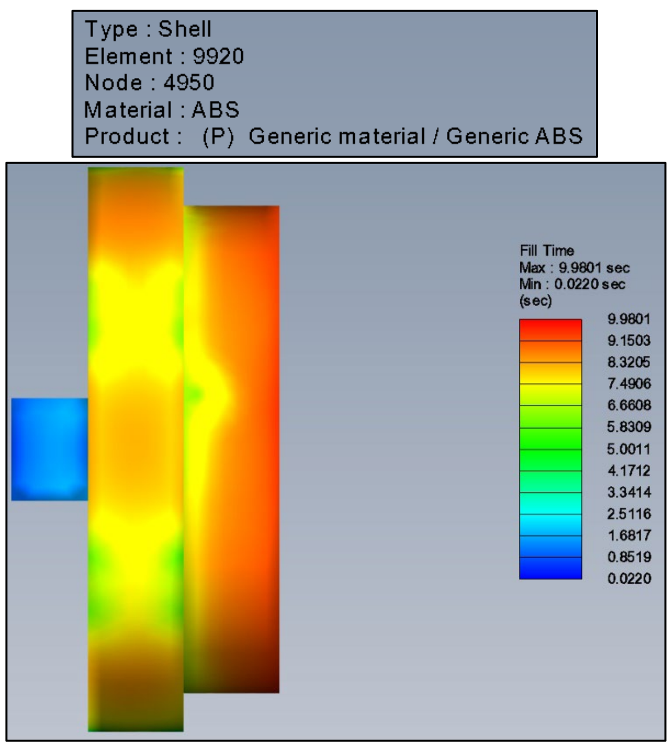

Figure 6. Plastic flow part simulation

5.2 Molding Die Design

For the IM process study, injection molding die design was developed and modeled in Solid Works using add-on Mold making option. The actual molding upper and lower dies were fabricated with draft and runners. The mold die design assembly drawing is shown in Figure 7. The fabricated upper and lower die with locating pins and ejector is shown in Figure 8. It is very important to provide a generous draft whenever necessary to remove the molded part from the mold dies. A hole was provided on the upper die for the injection port. Also, it is critical to apply mold release compound before using the dies in production.

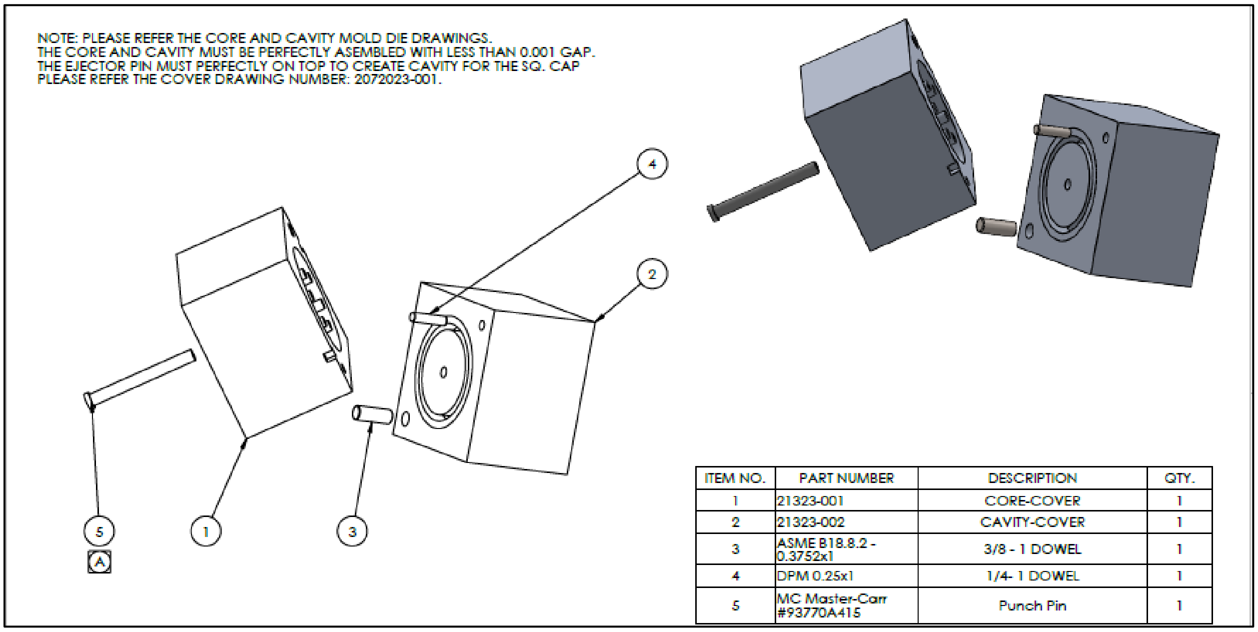

Figure 7. Molding Die assembly with ejector.

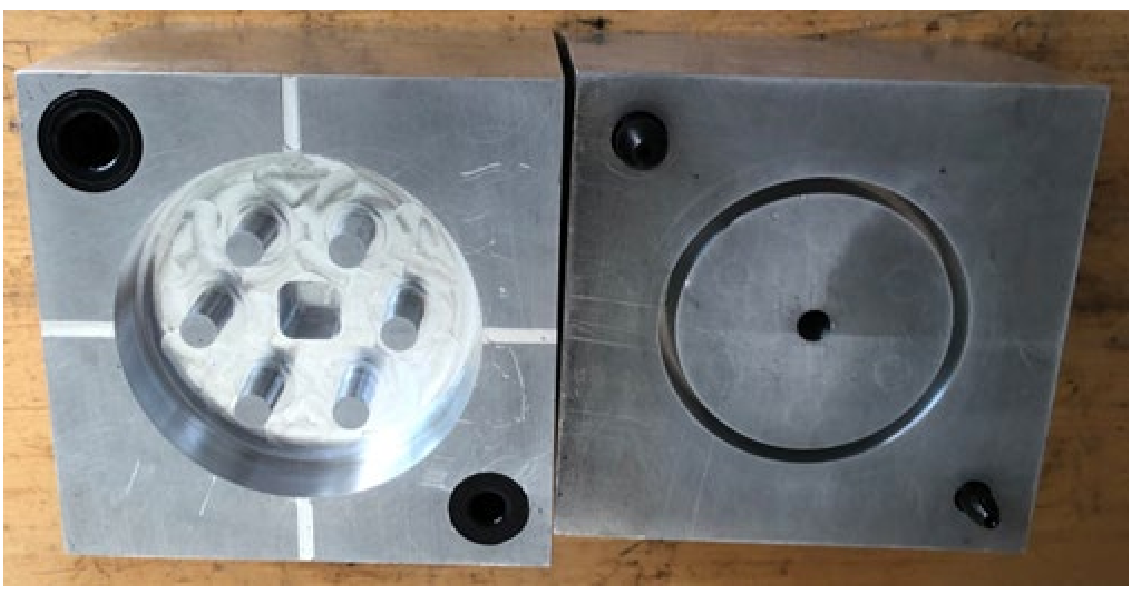

Figure 8. Fabricated mold upper and lower die.

5.3Build Parameters and Machine Specifications

Key Process steps are Mold design, Material preparation, Injection, Cooling and Ejection. The mold upper and lower die were mounted on to the press and dies were clamped with 9 ton force. A hole was provided on the upper die for the material injection port. The mold dies are heated up to 450^{0}F, plastic pellets are poured into the heating barrel and then it is injected into the die cavity at very high pressure. The part was removed after mold dies and the molded part was cooled down to room temperature. The ABS material pellets were poured into the heating barrel. The barrel, nozzle, and mold temperatures were set at 475^{0}F, 500^{0}F and 180^{0}F respectively. At the temperature attained the set values, the liquidous material was injected to the mold cavity at 5000 psi pressing pilot valve. The molded part was removed after 10 minutes cooling time from the molding die.

The injection molding machine consists of four main parts: Injection unit, clamping unit, control, and base. The molding upper and lower dies were placed on the bed. The MORGAN Industries Inc. Model G-55T Machine was used to fabricate the part. Machine Specifications: 3 cu. in. (2 oz.) max. single shot 20-ton max. clamping force (toggle).13,500 psi max. injection pressure, 8"x11"x7.5" mold area, 0-800^{0}F (430^{0}C). Accessories: Heated bed, injection speed control, anti-drool nozzle. Design Limitations: 6 in^2 max shot (total volume), 4-20 in^2 parting line cross section dependent on material choice. The flow rate is 2.5 in^2 : 115 in^2 of cross section. The actual injection molded part is shown in Figure 9.

Figure 9. Injection Molded part.

6. CNC Machining Process

The CNC machining is a substrative manufacturing process that use computerized controls and machine tools specifically, cutting tools to remove layers of material from a workpiece to produce a finished shape of the part per design. The CNC machining process involves designing the CAD model, converting the CAD file to a CNC program, preparing the CNC machine, and executing the machine operation. Computer Aided Manufacturing (CAM) produces G and M codes for the tool path movement and various CNC machine functions. CNC Milling process is utilized to manufacture the prototype part with the same type of material. The part (Figure 1) requires at least two setups- first, the part was machined per 2.75-in diameter dimension with a pocket leaving 0.125-in wall thickness. Secondly, six holes with 0.281 diameter dimensions were drilled. Finaly, the 0.281 square head with 0.375 height was machined.

6.1 CAM Simulation

Computer Aided Design (CAD) software such as SolidWorks program is used to draft and produce 2D vector or 3D solid part and surface rendering, and produce technical drawings and documentations associated with the part.
CAM add-on program in SolidWorks is used to extract the technical information from the CAD model and generate machine program necessary to run the CNC machine and create tool path to produce the part per part design.

The CAM simulation steps are: Define machine, define coordinate system, define stock size, setup the part, extract machinable features, generate tool path, simulate tool path for visual verification, save cutter location file data for future use, post process to translate tool path and operation information into G-code for a specific machine tool controller.

Machining operation simulation: 4-axis milling cycle time simulation is performed. The M -code and G- codes were developed to perform the operation simulation. The part CAM simulation is shown in Figure 10.

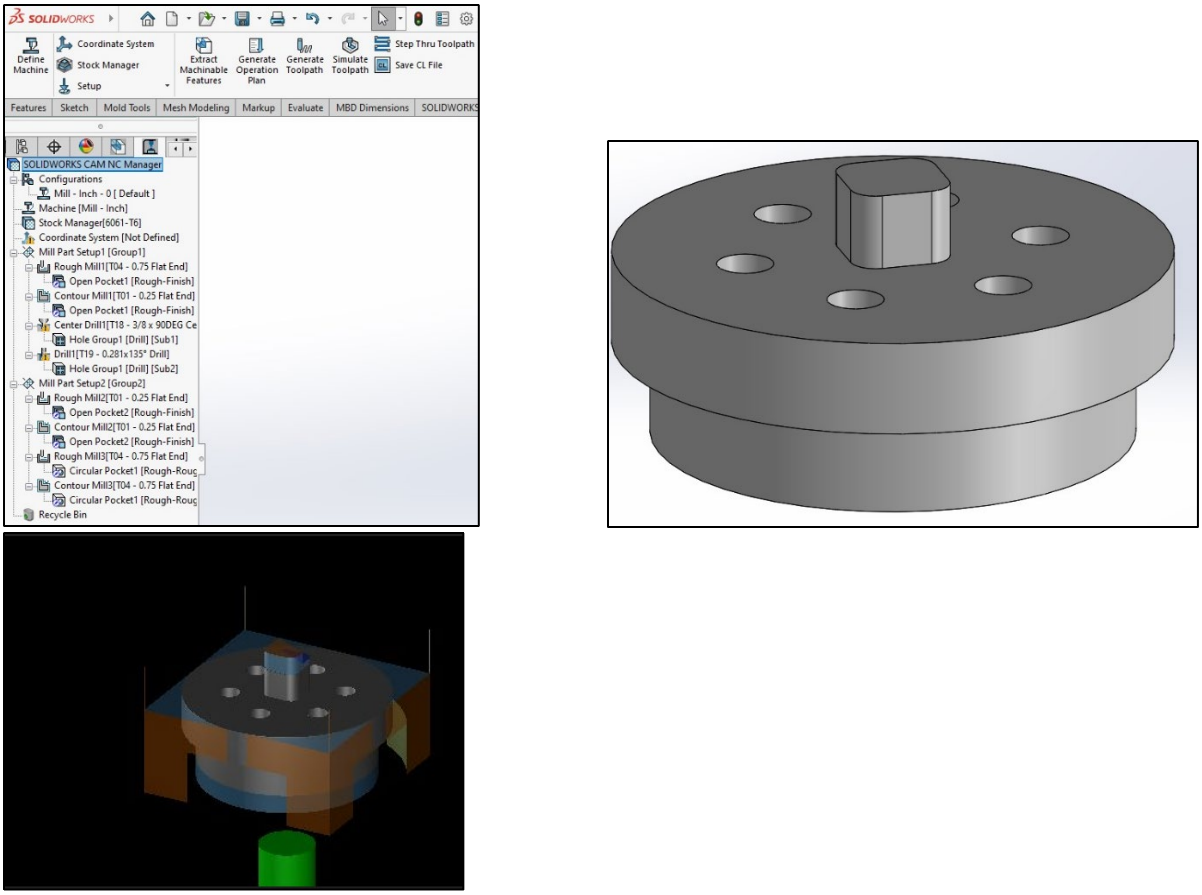

Figure 10. CAM- Machine setup, Part setup and Simulation of tool path

6.2 CNC Machining Tool path and Programming codes

CNC Tool path programming codes are shown in Figure 11. The operation number is one (**O**0001), the sequence of steps coded as N1, N2 etc., M-code is the machine control language for machining, and it is used with G-code to switch on and off various machine functions. The M-code dictates the machine for miscellaneous commands such as spindle start and stop etc. The tool path co-ordinates are denoted as X,Y,Z. The CAM simulation time is shown in Figure 12.

```
O0001
N1 (CNMG 431 80DEG SQR HOLDER)
N2 T0101
N3 B90.
N4 G00 G96 S702 M03

N5 ( Face Rough1 )
N6 G54 G00 Z.0071 M08
N7 X2.9641
N8 G01 X2.75 Z-.1 F.008
N9 X-.0314
N10 X-.0455 Z-.0929
N11 G00 Z.0071
N12 X2.7641
N13 Z-.1689
N14 G01 X2.75 Z-.176
N15 X-.0314
N16 X-.0455 Z-.1689
N17 G00 Z-.0689
N18 X2.7641
N19 Z-.2449
N20 G01 X2.75 Z-.252
N21 X-.0314
N22 X-.0455 Z-.2449
N23 G00 Z-.1449
N24 X2.7641
N25 Z-.3209
N26 G01 X2.75 Z-.328
N27 X-.0314
N28 X-.0455 Z-.3209
N29 G00 Z-.2209
N30 X2.7641
N31 Z-.4209
N32 G01 X2.75 Z-.428
N33 X-.0314
N34 X-.0455 Z-.4209
N35 G00 Z.0843
N36 X20. Z5. M09
N37 M01

N38 (DNMG 431 55DEG SQR HOLDER)
N39 T0303
N40 B90.
N41 G00 G96 S702 M03

N42 ( Face Finish1 )
N43 G54 G00 Z-.3309 M08
N44 X2.9327
N45 G01 X2.7186 Z-.438 F.008
N46 X-.0314
N47 X-.0455 Z-.4309
N48 G00 X20. Z5. M09
N49 M01
N50 (CNMG 431 80DEG SQR HOLDER)
N51 T0101
N52 B90.
N53 G00 G96 S702 M03

N54 ( Turn Rough1 )
N55 G54 G00 Z-.3309 M08
N56 X2.7641
N57 G01 X2.55 Z-.438 F.008
N58 Z-.872
N59 X2.75
N60 X2.7641 Z-.8649
N61 G00 X2.9641
N62 Z-.4309
N63 X2.4591
N64 G01 X2.445 Z-.438
N65 Z-.872
N66 X2.55
```

Figure 11. CNC Tool path programming codes

Milling part Setup 1	Milling part Setup 2
Rough Mill1 = 2.343 min	Rough Mill2 = 1.809 min
Contour Mill1 = 0.202 min	Contour Mill2 = 0.451 min
Center Drill1 = 0.342 min	Rough Mill3 = 1.333 min
Drill1 = 0.614 min.	Contour Mill2 = 0.614 min
= 3.501 min.	= 4.207 min.

Total time = 7.708 min.

Figure 12. CAM simulated time

The CNC machining process is used to fabricate the part. The same part design and the same Acrylonitrile butadiene styrene (ABS) material is used for CNC machining. The HAAS Mini-Mill machine is used to fabricate the prototype part for the CNC machining process. The HAAS milling machine has a spindle speed of 8000 rpm, with 10 hp power. The machine table has 16" x 14" x 15" travels. The CNC machined part is shown in Figure 13.

Figure 13. Fabricated CNC part

7. Results and Recommendations

This paper provided a comprehensive review of the three manufacturing processes: namely, Additive manufacturing, Injection Molding and CNC machining. All three manufacturing process times were simulated, and also actual parts were fabricated for comparison. All three manufacturing process parameters, both simulated time and actual fabrication times are summarized in Table 1 for the prototype part. The prototype parts were fabricated using the SVSU laboratory equipment to review the processes. Please note that this study is based on “one piece” proto-type part. The mass produced per piece part cycle time will be much less. Choosing the right manufacturing process is crucial to the product’s success. Depending on a multitude of factors, the “correct” manufacturing process technology will change accordingly.

Table 1. Prototype part Manufacturing Process parameters

Prototype Part Manufacturing Process Parameters							
Process	**Software**	**Company**	**Machine tool**	**Simulation time**	**Design, Tooling and Machine Setup time**	**Process time**	***Fabrication time**
Additive Manufacturing	SolidWorks CatalistEX	Stratasys Inc.	Dimension 1200 3D printer	**Calculated time = 7.794 hrs.**	CAD, 3D printer setup, and cleaning: 1 hrs.	6.0 hrs.	**7.5 hrs.**
Injection Molding	SolidWorks Plastic flow simulation	Morgan Industries Inc.	Morgan 20 Ton Molding Press	**Plastic flow fill time = 9.96 Sec.**	Mold tooling-CAD/CAM, machine setup, and bench work: 6 hrs. Mold- machining time: 2 hrs., 15 min.	15 min.	**8.6 hrs.**
CNC Machining	SolidWorks CAM simulation	Haas Automation Inc.	4-Axis CNC Milling Machine	**CAM simulated time = 7.708 min.**	CAD/CAM Part-machine setup time: 3 hr. 30 min.	10 min and 20 sec.	**3.67 hrs.**
*** Please note:** The prototype 'one piece' part is very expensive compared to mass produced parts. Injection molded part per piece will be much cheaper than other processes for large quantity. CNC machnined part per piece cost will be much cheaper than AM processed part for medium quantity. AM process part per piece cost is much cheaper compared to other processes for very small quantity.							

Volume and Budget play a significant role in selecting the right manufacturing process. For example, 3D Printing has very little start-up cost due to no tooling or programming required. Printing time plays an essential role in the unit cost for 3D printed parts. The Injection molding process is preferred for high volume production because of the low unit cost. But the start-up cost may be higher due to Mold tooling. CNC machining may require a small start-up cost to cover CAD/CAM development. Machining time will determine the unit cost per piece. Complex geometry parts will take more cycle time increasing the unit cost. One must choose the "right" manufacturing process based on volume and budget. Lead time also may play a role in selecting the right manufacturing process. 3D printed parts may take 2-7 business days compared to CNC machining may take 10-25 business and Injection Molded parts may take 20-30 business days. Material and Surface finish may also play a role in selecting the right manufacturing process. The design complexity of the part also will play a role in selecting the right manufacturing process.

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Biography

Annamalai Pandian is a Full Professor in the Department of Mechanical Engineering at Saginaw Valley State University, Michigan, USA, and Program Director for B.S. in Engineering Technology Management degree program. He earned his B.Eng. and M. Eng. Degree in Mech. Eng. from University of Madras, Chennai, India, and M.S. Degree in Mech. Eng. from Louisiana State University, Baton Rouge, LA, USA and D. Eng., Doctoral degree in Manufacturing Systems from Lawrence Technological University, Southfield, MI, USA. He has a wealth of knowledge and experience in automotive tooling design and manufacturing engineering and processes, having worked for Chrysler Corporation for more than a decade. Over 15 years, he has taught mechanical and manufacturing engineering courses at University of Wisconsin-Stout and at SVSU. He published about two dozen research papers. His research interests include Robotics Applications, 3D Printing, Simulation, Injection Molding, CAD/CAM, Plastic flow simulation, and FEA. He is a member of ASQ, ASEE, and IEOM. He is also a member of the editorial advisory board for the International Journal of Quality and Reliability Management. Journal paper reviewer for many International Journals.