UNIVERSITI TEKNOLOGI MALAYSIA

MANUFACTURING PROCESSES

Hand Coffee Grinder

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1.0 Introduction

AMA (Advanced Manufacturing Association) is a company focused on manufacturing and creating electronic and mechanical devices for everyday use as household consumer items. This internal company project report is focused on analyzing a new coffee grinder set to be released to the consumer market. The scope of the study pertains to evaluating and studying the processes, equipment, materials and techniques required to manufacture the item. Furthermore, a discussion on the current competitors in the consumer market and finally the type of manufacturing system that suits the product, with an estimate on the production quantity and consumer model price.

1.1 Product Background/Importance

As previously mentioned, the product chosen for consumer release, is a handheld, lightweight and robust mechanical coffee grinder. Caffeine is a popular choice of beverage, with almost every household drinking some form of caffeine or caffeine derived products every day. This daily habit has evolved from a lunch-time drink, to a global phenomenon, with caffeine enthusiasts around the globe trying their best to elevate the taste and experience of the beverage through various means. One such technique is to freshly ground the coffee beans instead of using pre-ground instant powder to brew the coffee.

However, coffee grinding is not a rudimentary process and cannot be performed using normal food processors or blenders in the kitchen, due to the lack of fine blades producing inconsistency in grain size, hence negatively impacting the taste of the brew.

Instead, it is usually done with industry grade, fine grinding machines that ensure the consistency of the grounds to regulate the rate of caffeine absorption in the water when brewing coffee. Unfortunately, for many caffeine enthusiasts, such equipment is neither affordable nor easy to use. To provide enthusiasts and consumers around the globe with an easy and economical solution to the problem, the company plans to manufacture a handheld coffee grinder manufactured from various materials and metal alloys to ensure its lightweight and long lasting build quality.

1.2 Method of Production

While discussing the manufacturing processes involved in the production process, it must be considered that due to the simple shape and size of the product, aside from the methods discussed in this case study, there are various others available to obtain a similar end product. Hence, the methods of production are not finalized, and instead rely heavily on the budget and preferences of the manufacturer.

1.2.1 Component/Parts list:

1. Turning Shaft
2. Cylindrical Body
3. Spring Guard
4. Conical Burr
5. Dial Slot Board
6. Dial
7. Cylindrical Base/ Container

Part Name	**Method of Production**
Turning Shaft	CNC Machining
Cylindrical Body	Metal Die Casting
Spring Guard	Coiling and Machining
Conical Burr	CNC Machining

Dial Slot Board	Metal Die Casting
Dial	Metal Die Casting
Cylindrical Base	Metal Die Casting

Table 1. Manufacturing Process

As tabulated above, the manufacturing method of production for each major part is listed. Observing table 1, a trend in the methods of production can be spotted. This is largely attributed to the simplistic shape of the component and overall end product. Hence, a simple process such as metal die casting can be used to obtain the component. In contrast, for parts with CNC Machining as a method of production, slightly complex patterns and precise tolerances are required to ensure the end products function.

To elaborate further on the processes listed, a brief explanation of the process and steps required to each end component will be discussed.

1.2.2 Metal Die Casting:

For components manufactured using metal die casting, the process can refer to Gravity or Pressure Die Casting. Both processes are similar in nature and output an identical end product, however, pressure die casting requires additional equipment as compared to gravity die casting, resulting in higher tool cost. For our purposes, the intended casting process is selected as Gravity Die Casting.

Gravity Die Casting

The general casting process is a permanent mold casting process in which molten material is poured into preheated metallic or graphite molds without any external pressure involved. The steps of the process can be classified as below.

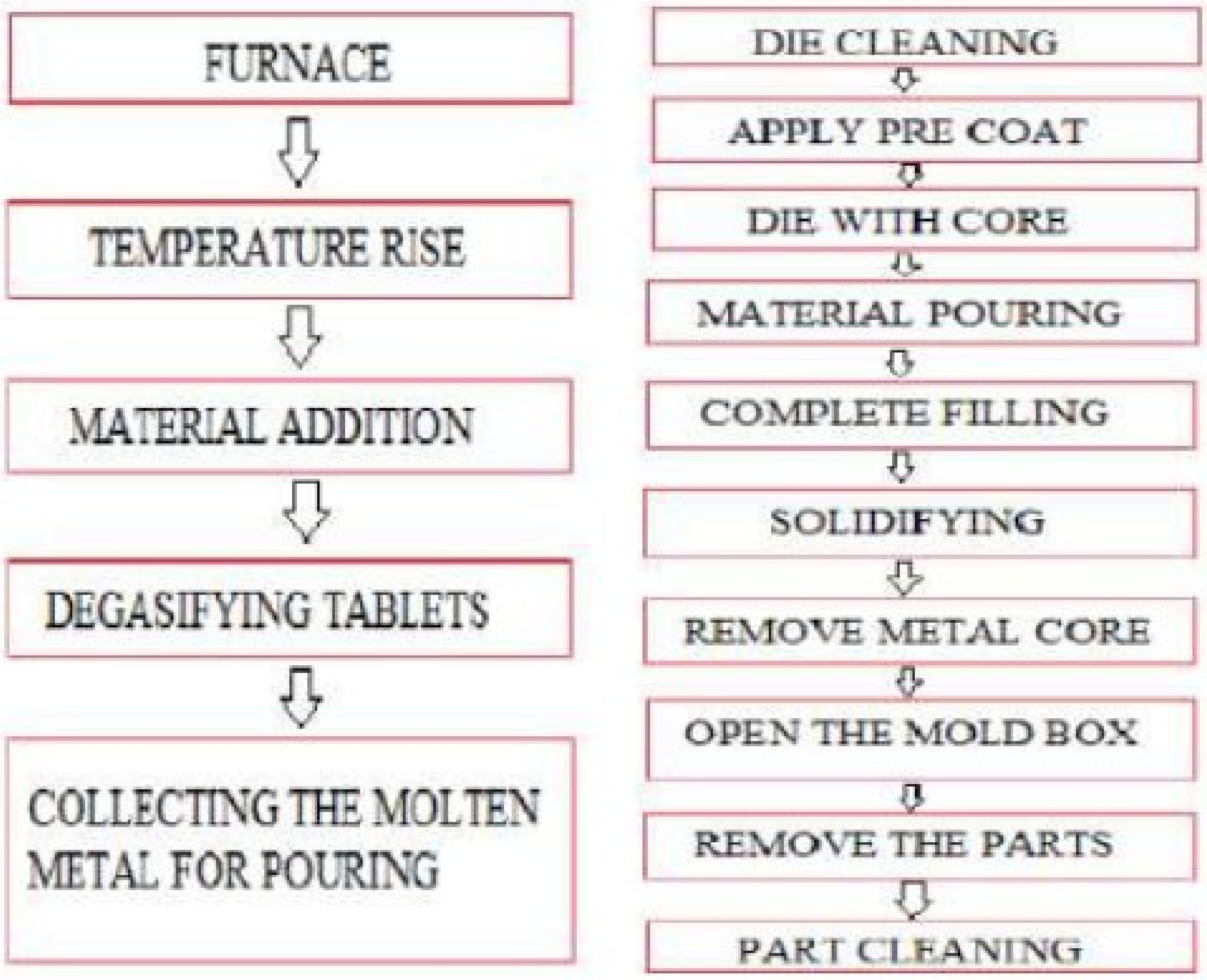


Fig 1. Production Process for Gravity Die Casting [2].

Despite being considered a simple process as compared to other variations of the casting method. Gravity Die Casting has several advantages:

- Excellent Surface Finish
- Excellent Dimensional Tolerances
- Reusable/Permanent Mold
- High Production Rates Possible
- Very Low Tooling costs compared to Pressure Die Casting
- Rapid cooling of mold provides better mechanical properties
- Non-turbulent filling/ Slow pouring ensures minimal porosity in part produced

To elaborate, as the process utilizes a permanent metal/graphite mold instead of a temporary mold, the mechanical properties are significantly better due to better thermal conduction properties of the metal die. Furthermore, due to the refined surface of the mold the resulting surface of the casting is also improved. Lastly, as mold is reusable and process is linear, very high production rates are possible to increase efficiency of production, resulting in larger quantities of product which can easily satisfy consumer demand.

However, the casting process does have its own inherent drawbacks that might hinder production:

- Not entirely ideal for complex shapes due to difficulty in removing casting without chemical additives
- Metallic or graphite molds are very expensive compared to sand molds
- Not cost-effective at low production rates
- Surface finishing process required as rapid cooling makes the surface hard and rigid.
- Impractical for large castings

The above section summarizes the processes involved in the production. A detailed overview of the casting and finishing process along with the equipment and tools involved will be discussed throughout the report.

1.2.3 CNC Machining:

Components manufactured with CNC (Computer Numerical Control) machining undergo a thorough process involving various machines and techniques. A pre-written program dictates the movement of machinery and tools. In practice, the software is used to control a plethora of tools ranging from grinders, mills and lathes.

The CNC machining process begins as early as the product's conception, the design steps for this cycle are listed below.

1. CAD/CAM Model Design: Engineers or craftsmen will render a 3d-model of the desired component.
2. 3D-Model Conversion to CNC program: The model is then converted into a step of instructions for the CNC-Machine to follow.
3. CNC-Machine Setup: The Machine is set up with the tools required for the job.
4. Operation Execution: Operator initiates the program and executes the code.

Although a complicated process that requires expensive equipment and a skilled operator/technician in order to program the required instructions, a CNC machine holds numerous advantages in terms of production.

- Very low waste product generated
- Fast and efficient production with little to no error
- Enhanced worker safety
- Lower energy consumption
- Wide range of material selection

Analyzing and discussing the advantages listed above, a CNC machine performs precise and efficient operations. Hence, the material required conforms to the end product's size. Limiting the material waste produced, also resulting in lower product cost.

Furthermore, CNC machines separate humans from risk-inducing procedures such as grinding or cutting, improving worker safety but not compromising on the quality of the end product.

Nonetheless, similar to all manufacturing procedures, there are inherent disadvantages and factors that might negatively impact the process.

- Skilled technician/ Operator required

- Maintenance /Repair is very costly
- Initial setup cost is high

As previously mentioned, a CNC machine runs on a program or code written specifically for the machine to maneuver complex tools and other machinery to process material. However, the software for the machine requires a skilled operator that possesses the skill to effectively operate the machine. Furthermore, like all machines, a CNC machine is not impervious to fatigue or wear and tear. A regular maintenance needs to be performed to ensure the machine is operating within the standard limits. The costly maintenance and repair set a huge barrier for most businesses to adopt this manufacturing technique into their repertoire.

Further along the report, this production technique is discussed in detail along with the tools and equipment used.

1.3 Manufacturing System & Function

In addition to the manufacturing processes used, it is essential to identify the manufacturing system in place. A manufacturing system can affect production rates and product prices. As previously mentioned the main function of the product is to allow consumers to grind coffee beans. A quick and efficient process made easy through the conical burrs used in the design. Analyzing the design further, the outer-body of the product is only a cylinder with no complicated features.

Hence, considering the availability and the materials utilized in the product, as well as its primary function. The most suited manufacturing system would either be Batch or Mass production.

However, to choose between the two, it ultimately boils down to manufacturer's preference and consumer demand. Comparing Batch and Mass production systems, the largest difference is evidently the production rate as well as the production cost.

Mass production systems are best suited for extremely large quantities of product, furthermore, the design of the product must remain consistent and rigid to enable automation. This results in extremely low labor cost, low product cost but high equipment cost.
In contrast, Batch Production systems are best suited for medium to small quantities. Slight variation in each batch is possible, giving the product more "personality" and "character". Results in slightly higher labor cost, lower equipment cost and higher product cost.

In conclusion, an assumption can be made on the manufacturing system considering all factors. Simplistic product shape, rigid design and medium quantities lean towards Batch Production. As the target audience is coffee enthusiasts, larger quantities may not suit the niche market. Furthermore, by incorporating the Batch Production System, each coffee grinder can be given a different color palette to provide more decorative options to the consumer.

1.3.1 Quantity of Production

As mentioned while assuming the manufacturing system, the production quantity hinges on a few factors:

- Target Audience
- Market Share
- Product Cost
- Material Availability

Taking the function of the product into account, as well as its target audience, the production quantity could be within the thousands. The manufacturer could choose to produce hundreds per batch, and go on to sell according to demand. As the demand depends entirely on consumer trends, the quantity of production is variable. But as the demand increases, more batches can be produced, increasing the quantity.

To conclude, the quantity of production is not set, but variable depending on demand set by consumers. As the demand increases, the manufacturer can choose to increase the amount of batches produced, hence selling more product without incurring massive costs in warehouse storage.

1.3.1 Cost Estimate

Accounting for all materials, processes and market demand, according to recent market competitors, the product would approximately cost RM 172- RM285 per piece. The variation in price can be attributed to design choices of the consumer, opting for colors or materials that are harder to process as compared to the standard variant.

2.0 Detailed Specification

2.1 Materials Selection

This section of the report aims to discuss the materials utilized in each component of the final product. Referring to the component list as tabulated earlier in table 1. An appropriate material choice for each component considering its function can be made.

Part Name	Material
Turning Shaft	Stainless Steel
Cylindrical Body	Aluminum Alloy
Spring Guard	Aluminum Alloy
Conical Burr	Stainless Steel
Dial Slot Board	Stainless Steel
Dial	Stainless Steel
Cylindrical Base	Aluminum Alloy

Table2. Material Selection

As listed above, each material is selected per component after consideration of that component's use, functionality and importance to the product or mechanism.

Hence, considering the outer body, to make the product portable and lightweight, a strong but low density alloy such as aluminum can be used. The alloy is easy to process and to source, but provides great quality and weight to the product as compared to a silicon outer body. The aluminum alloy also ensures protection from corrosion with its oxide layer, allowing it to be kept for long term use.

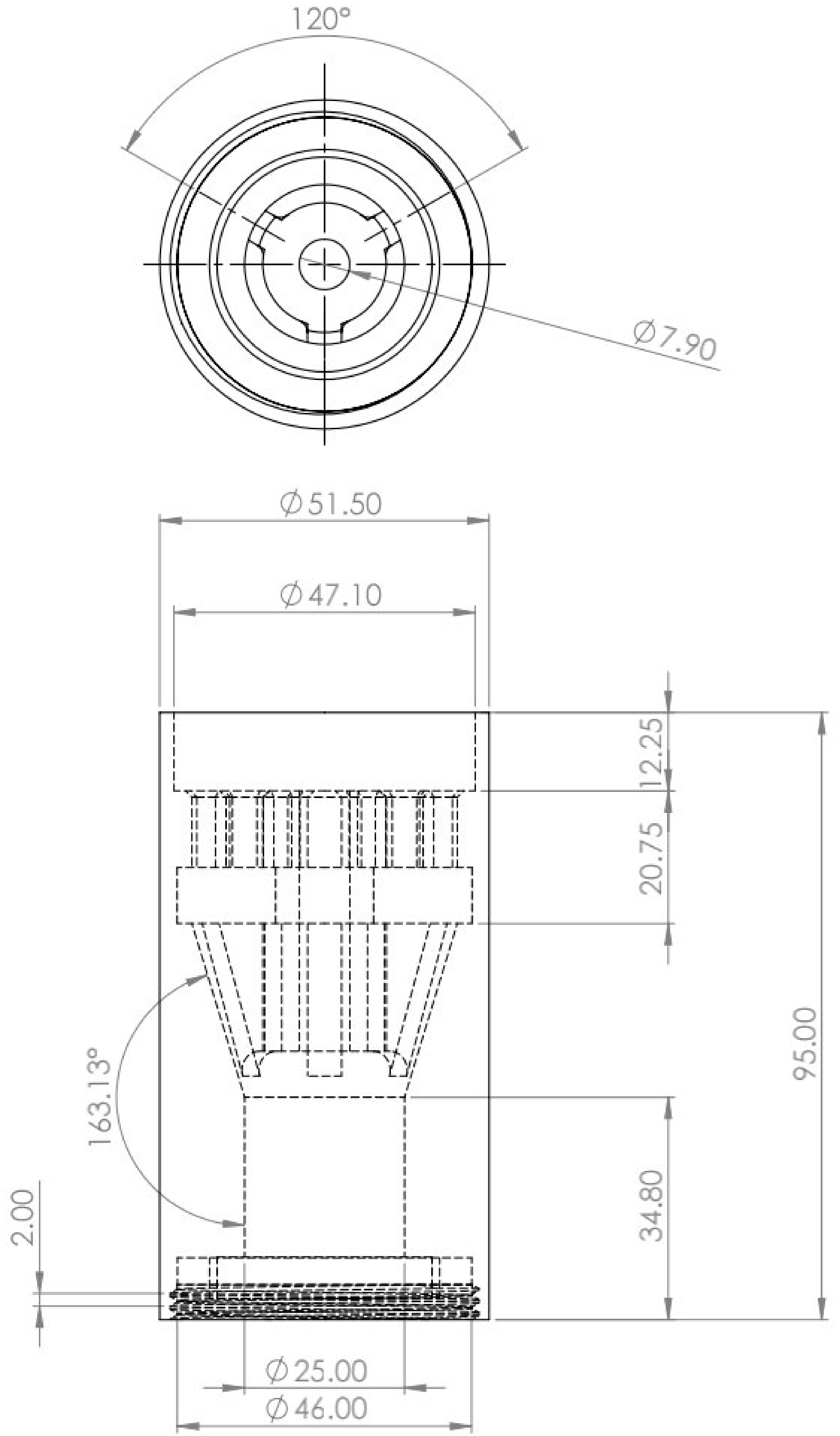
On another note, all other parts of the mechanism are manufactured from stainless steel. This is partly done to increase its durability and ensure long term usage, but also due to the material properties of stainless steel that has high wear resistance, high hardness and toughness. These traits allow the conical burr and the dials to maintain their shape, allowing the grinder to function with the same consistency. If a lower toughness material was used, the conical burrs and dials would wear out with use, impacting the consistency of the product. Furthermore, like aluminum, stainless steel has very high corrosion resistance and can safely work in high moisture environments without risking material corrosion or rust.

2.2 Surface Details

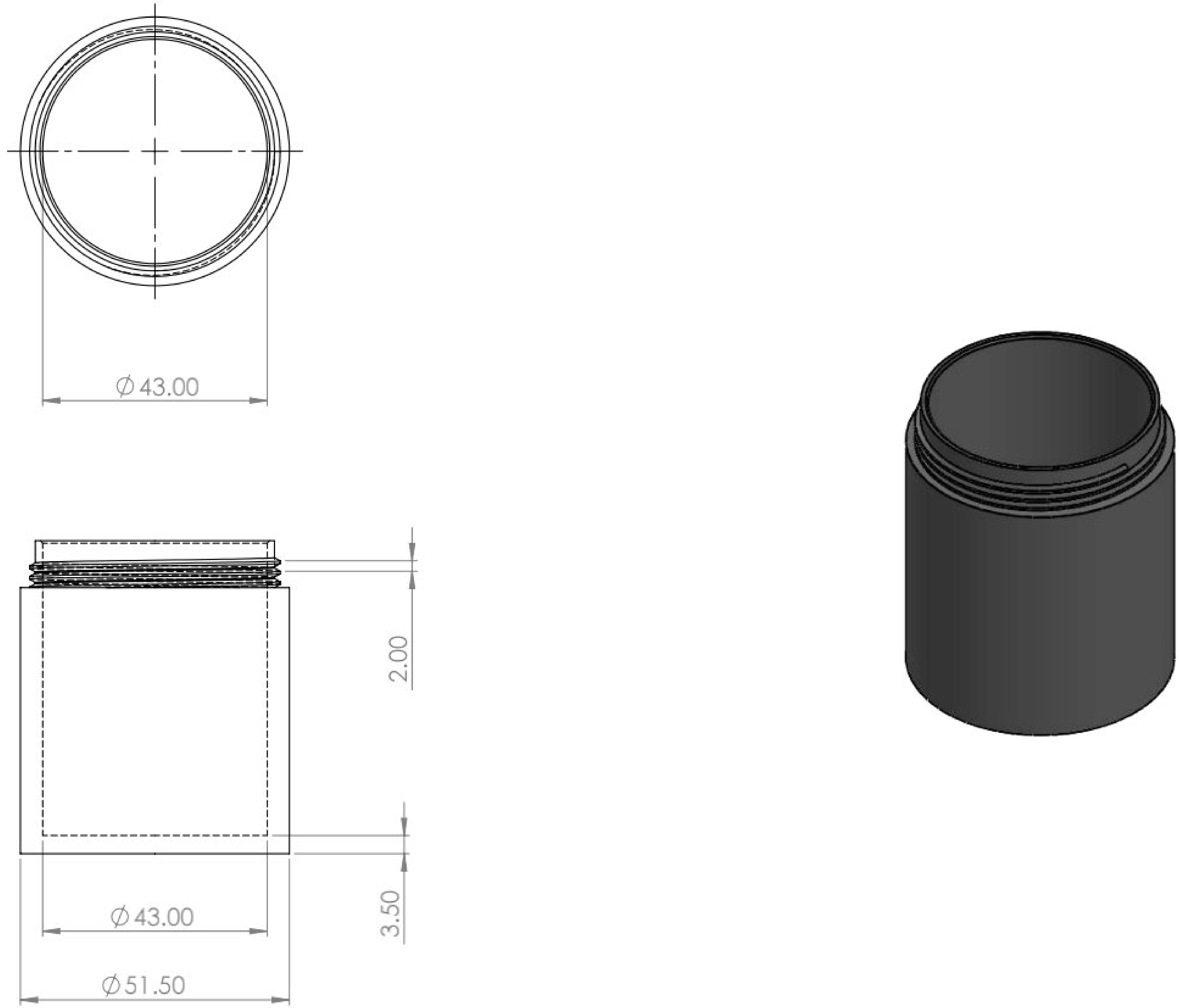
This subsection of the report entirely focuses on defining the surface characteristics of the product, largely for machining and finishing purposes to ensure the quality of the product remains as intended.

Firstly, the outer body aluminum alloy requires a consistent and smooth finish, which can be achieved through grinding and polishing. Secondly, parts requiring close or intimate assembly should have a polished finish, ensuring friction does not impede movement of the mechanism. Lastly the base of the body should have a grooved or rougher exterior which allows consumers to grip it better and ensure easy use while hand grinding. All these subtle characteristics play a huge role in the product's intended use and any disregard for these characteristics can impact product performance. Hence, these characteristics are usually defined and dimensioned in the GD & T system. This system is discussed and analyzed further along the report, supplemented with GD&T notations in technical drawings for the components.

TECHNICAL DRAWINGS OF COMPONENT AND ASSEMBLY



UNIVERSITI TEKNOLOGI MALAYSIA SCHOOL OF MECHANICAL ENGINEERING	TITLE: Coffee Grinder Body	COURSE: SEMM 2713 SECTION: 40	DATE: 04-JUL-2023 SCALE: 1:1



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SCHOOL OF MECHANICAL ENGINEERING

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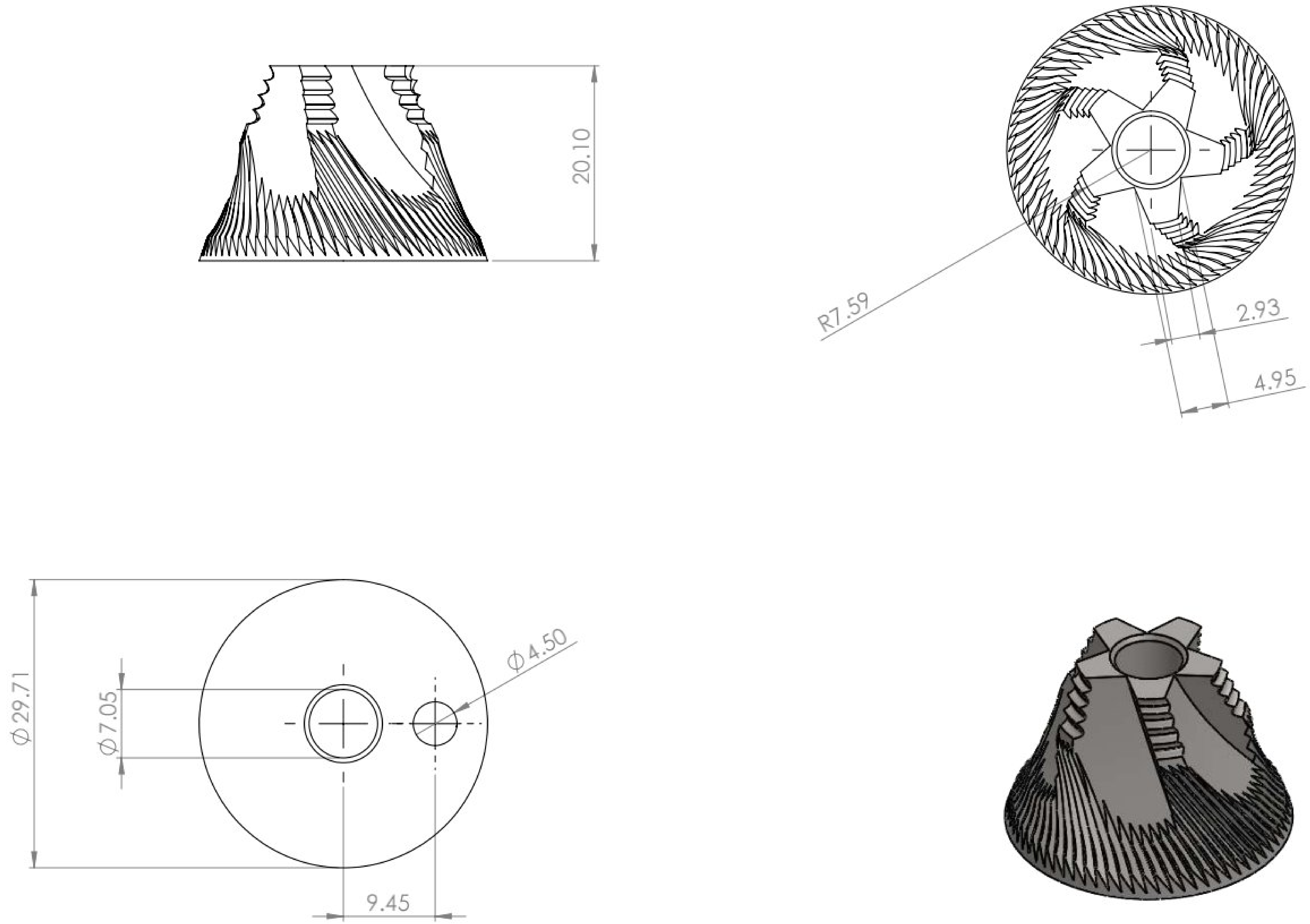

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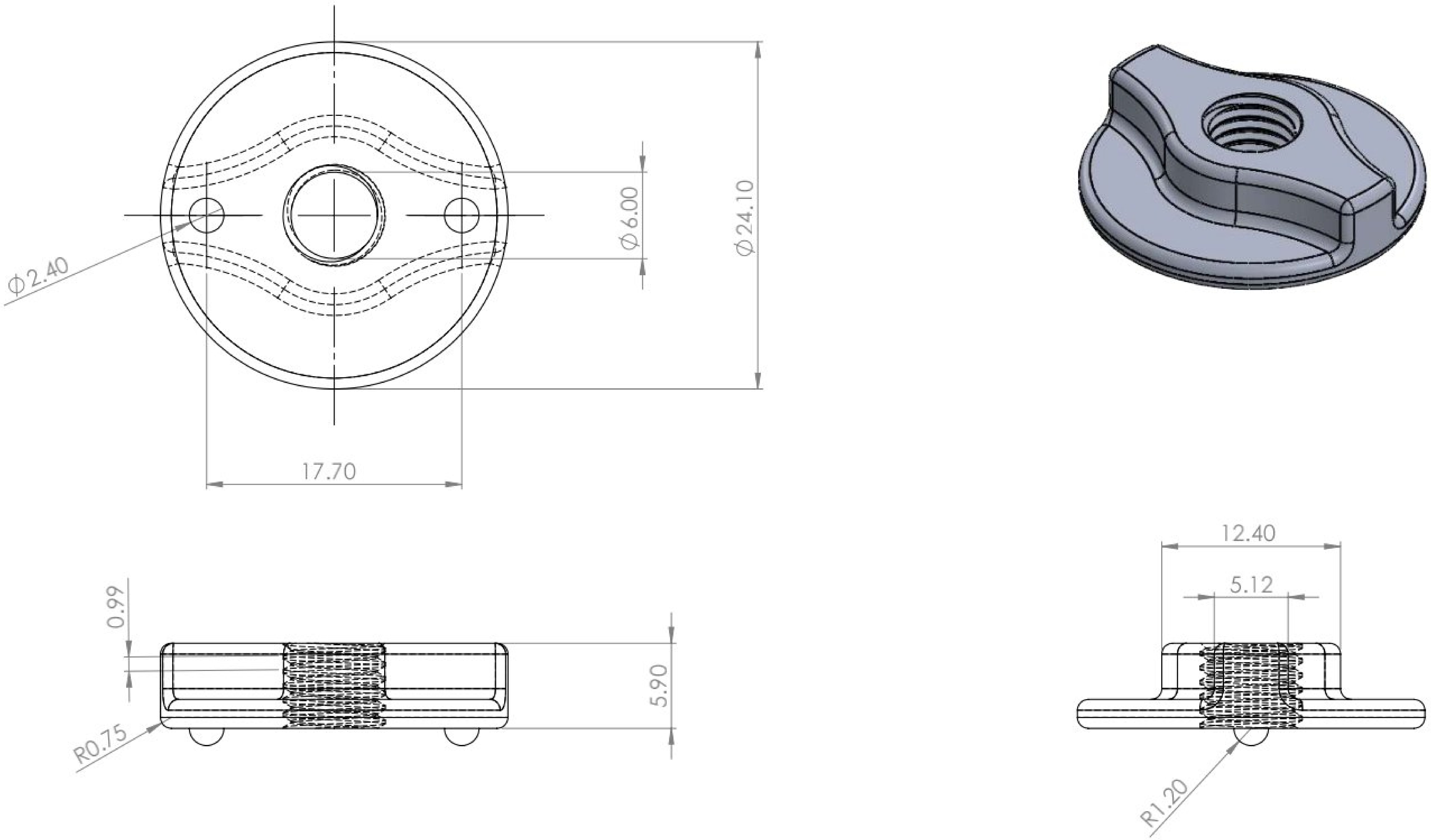
SCHOOL OF MECHANICAL ENGINEERING

TITLE: Conical Burr

COURSE: SEMM 2713
SECTION: 40

DATE: 04-JUL-2023
SCALE: 2:1



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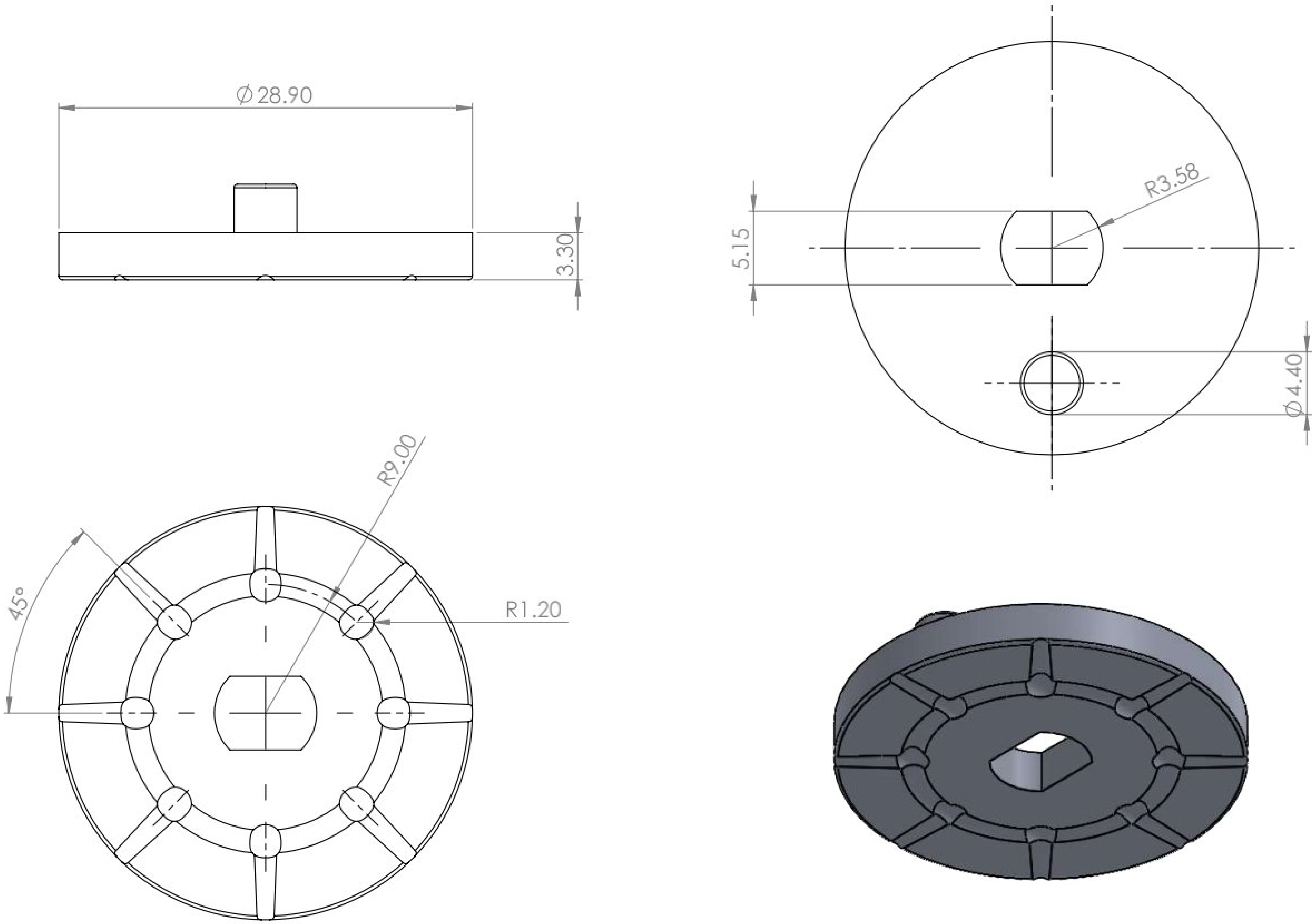
TITLE: Dial	COURSE: SEMM 2713		DATE: 04-JUL-2023
	SECTION: 40		SCALE: 3:1



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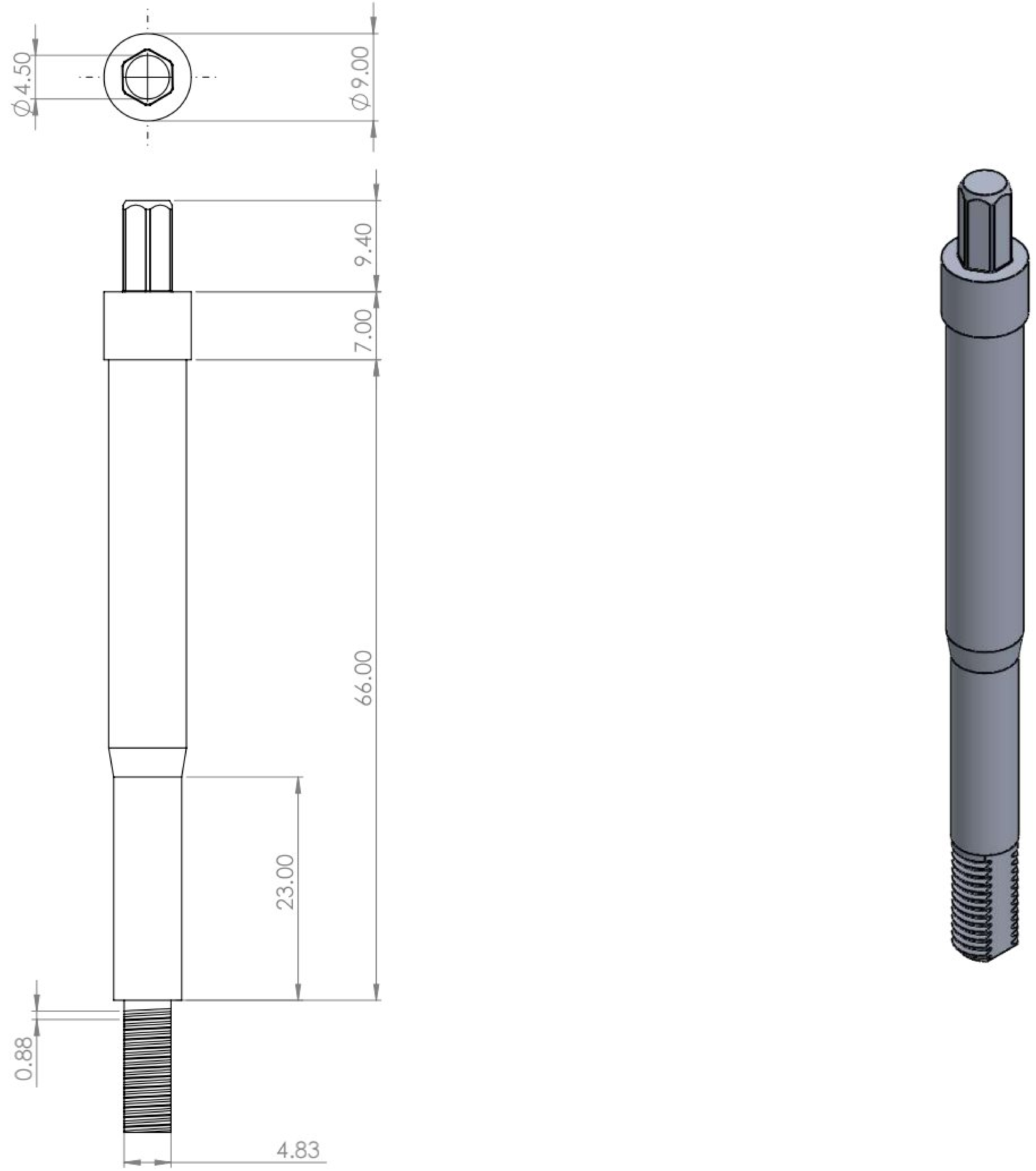
TITLE: Dial Slot Board	COURSE: SEMM 2713		DATE: 04-JUL-2023
	SECTION: 40		SCALE: 3:1



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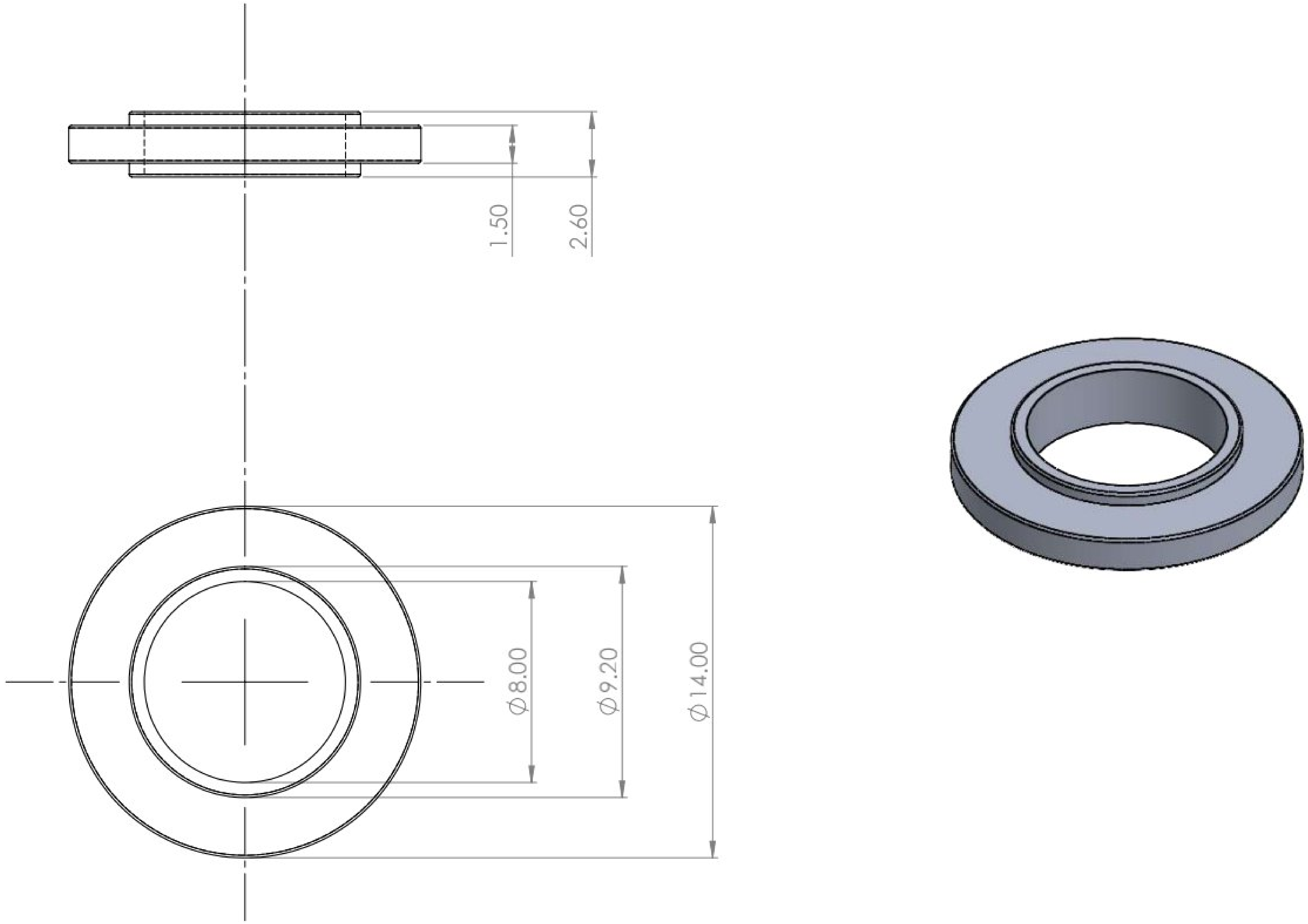
TITLE:	Turning Shaft	COURSE:	SEMM 2713	DATE:	04-JUL-2023
		SECTION:	40	SCALE:	2:1



UNIVERSITI TEKNOLOGI MALAYSIA SCHOOL OF MECHANICAL ENGINEERING	TITLE:	Spring Gaurd	COURSE:	SEMM 2713	DATE:	04-JUL-2023
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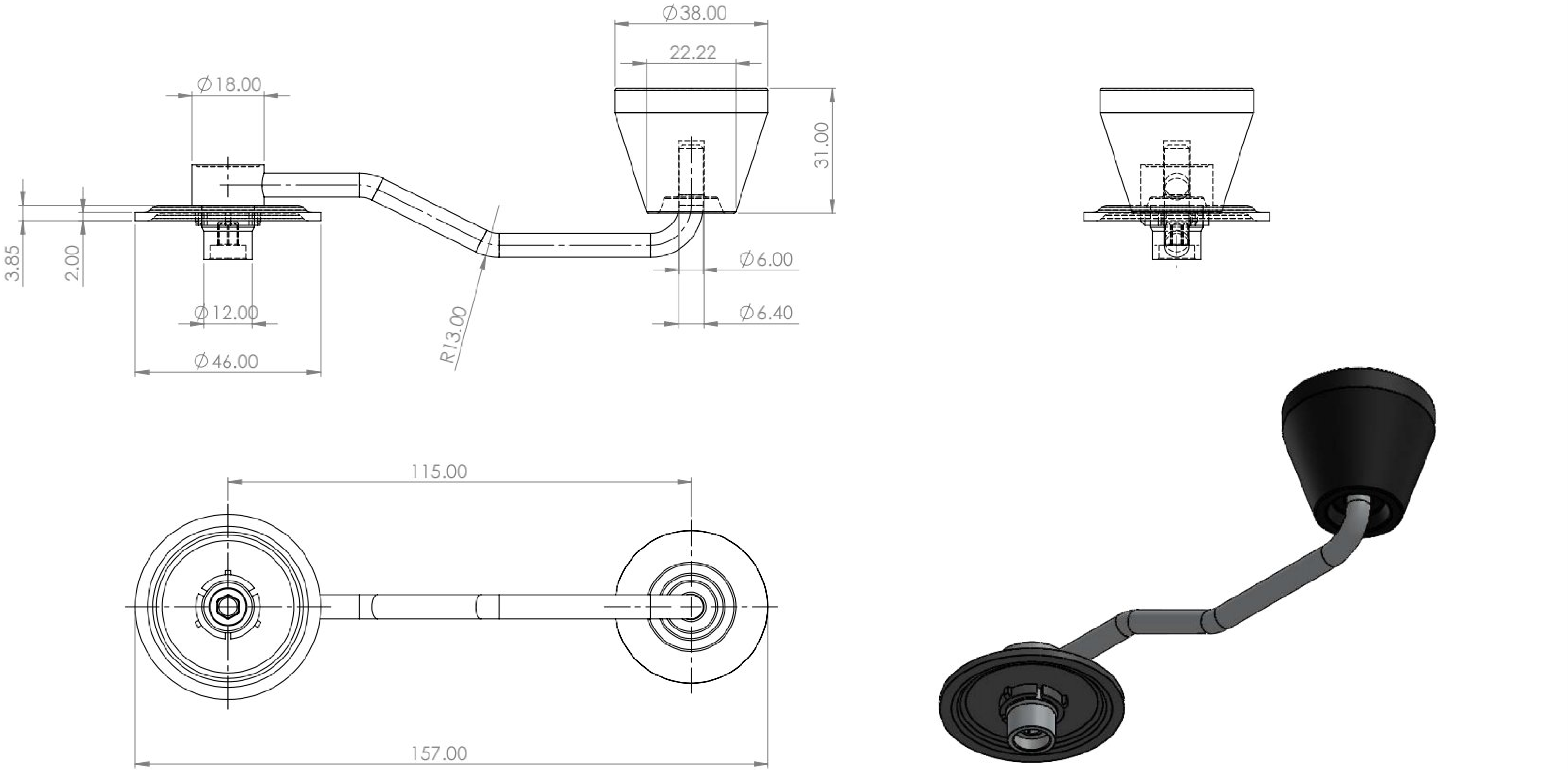

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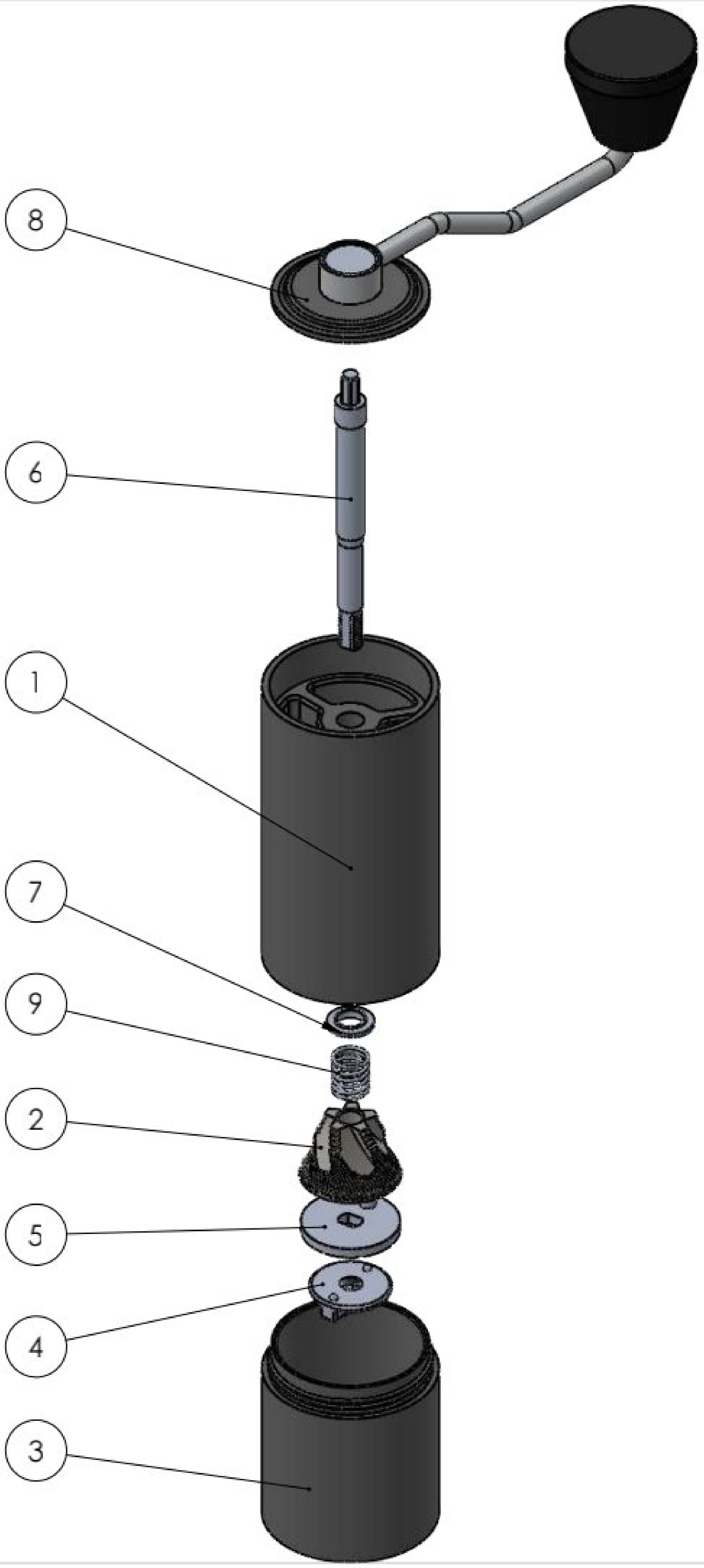

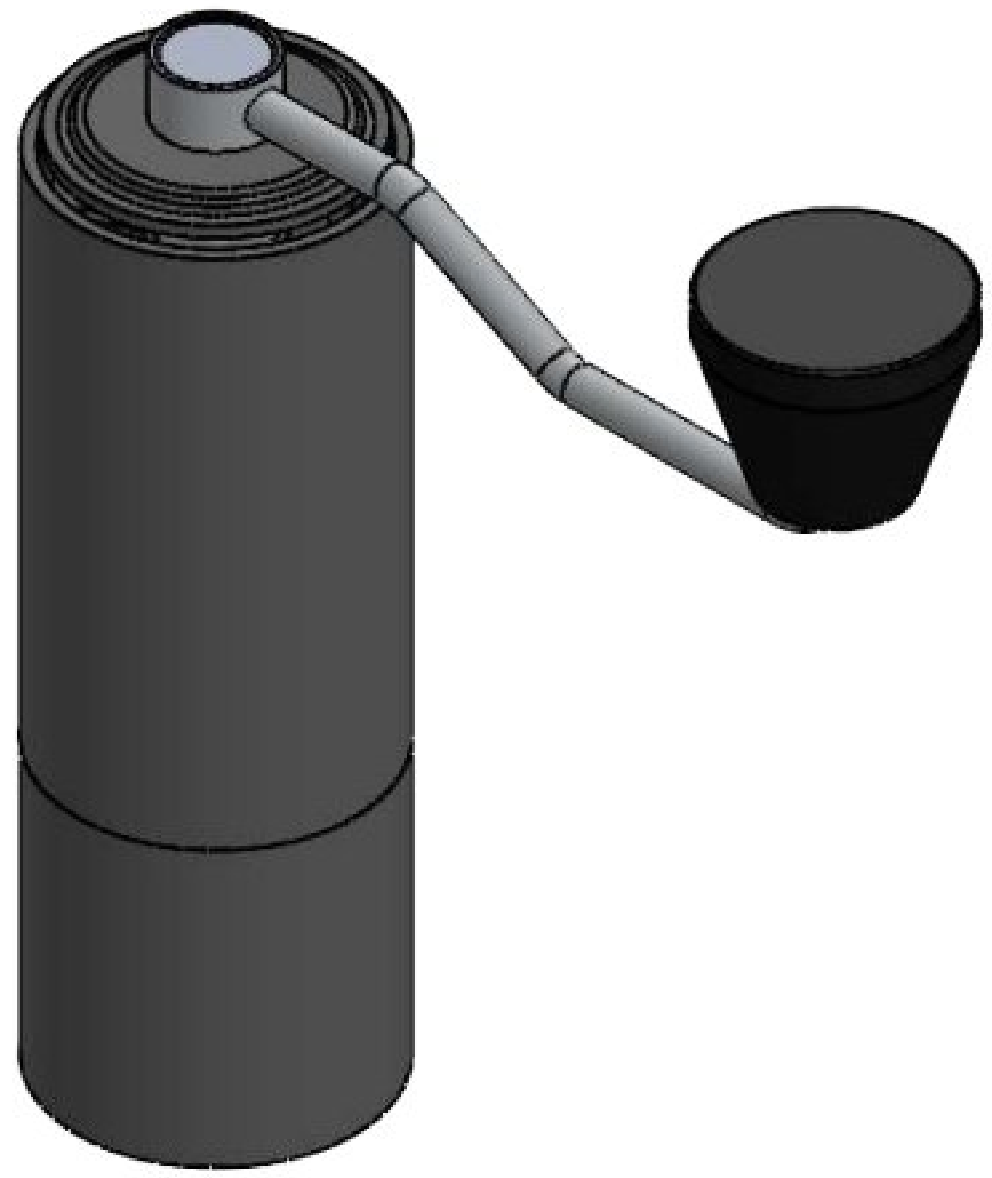

No.	Description	Quantity
1	Coffee Grinder Cylindrical Body	1
2	Conical Burr	1
3	Cylindrical Container	1
4	Dial	1
5	Dial Slot Board	1
6	Turning Shaft	1
7	Spring Gaurd	1
8	Lid and Handle Lever	1
9	Spring	1

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SCHOOL OF MECHANICAL ENGINEERING

TITLE: Coffee Grinder Exploded View

COURSE: SEMM 2713
SECTION: 40

DATE: 04-JUL-2023
SCALE: 1:1.8 / 1:1.5

3.0 Stages of the Process

A product comes a long way from raw material via various processes. These processes strongly depend on the type of material used, the available budget to manufacture the product, and lastly, the tolerance required to make the product.

In this section the manufacturing of each part will be discussed featuring 3 different processes that can be used to achieve the same final product. The reason why some processes are chosen over others will be discussed before revealing the final chosen process for every stage. Finally, a flow chart will be utilized to better visualize the manufacturing processes involved in the production of each part.

3.1 Cylindrical Body & Container

The cylindrical body of the coffee grinder is the main component that houses the entire product. It is fully made up of aluminum, which ensures durability and longevity during years of use.

This part was modeled as a single part for the sake of simplicity, when in reality, it is made up of two parts that are assembled and screwed together.

The cylindrical body of the grinder is expected to have a grip texture in order to aid the user and prevent slipping while rotating the handle lever. The grip texture must look aesthetically pleasing while achieving its function. A good, premium feeling surface finish is also desired in order to reflect the higher price of the grinder compared to other cheaper alternatives.

Figure 2: Aesthetic Grip Pattern on Cylindrical body.

3.1.1 Process Selection

<u>Sand Casting</u>

This casting process is the most basic and common type of casting. This is due to the fact that it can be used for a plethora of casting applications; and the cylindrical body & container are surely compatible.

The following will outline the casting process in steps:

1. Two flasks with alignment pin holes are set on a flat surface, the bottom one flipped upside down.
2. Using cope and drag patterns to eliminate the steps of creating the pouring basin, riser and gate; since they are already incorporated. This will reduce the margin and probability of errors.
3. The pattern is split in half and the appropriate part is aligned inside the flask boundaries.

Figure 3: Placing the pattern while leaving proper space from the flask wall.

4. It is then dusted with powder to ease the pattern extraction process and prevent sticking.
5. Sand is then poured into the flask and packed tightly to ensure the sand has taken the print of the pattern.
6. The sand mold is then flipped and the pattern is removed, leaving the desired print on the sand. Venting holes are poked in the sand.
7. The core is placed in the core print before the two sand mold halves are rejoined and aligned with the pins
8. Metal is melted then poured into the pouring basin that was created by the cope and drag pattern; until the excess molten metal appears from the riser hole.
9. Wait for the metal to solidify and cool completely before extracting the cast from the mold and removing the core, usually destroying it in the process.

Centrifugal casting

This process involves the use of centrifugal forces to ensure the molten metal has taken the shape of the rotating mold; as what is apparently deduced from the naming. This method of casting is most suitable for cylindrical objects; which is the reason it is one of the processes eligible to cast the cylindrical body and container. The use of this process results in a uniform, dynamically balanced and distributed cast. It is also capable of producing perfectly cylindrical casts, hence being suitable for manufacturing of products with very tight tolerances.

The following describes the steps of centrifugal casting:

1. A cylindrical casting mold is set up on two rollers that are connected to a motor. The rollers control the speed in which the cylindrical casting mold rotates with.

Figure 4: Molten metal being poured into the rotating cylindrical casting molds

2. While the cylindrical casting mold is rotating, the metal is melted and poured from the ladle to the pouring basin that leads to the opening in the rotating mold. The amount of molten metal that is poured is previously calculated to achieve the desired thickness of the cylindrical cast; in this case the cylindrical body and container of the coffee grinder.
3. The cylindrical mold is kept spinning at appropriate speeds, until the red hot molten metal solidifies inside.

4. The metal cast is then extracted after carefully opening the mold.

Gravity Die casting

As discussed in chapter 2, this process results in very desirable properties in the cast product. Good surface finishing and mechanical properties are required to achieve great reliability and durability of the final product.

Gravity Die casting is a process where molten metal is poured into a metal mold from the top; allowing gravity to make sure all the crevices of the mold are filled. The metal mold is made up of two parts that are held tightly together while the molten metal is being poured, and then separated to easily extract the metal cast product.

1. The open mold is cleaned and the core is placed in the core print inside the mold to prevent metal from filling that area.
2. A permanent metal mold is held tightly closed by hydraulic presses, and molten metal is poured into the pouring spout until excess metal is seen to overflow to the surface.
3. The metal is left to cool down; which is accelerated by the conductive properties of the metal mold
4. The two parts of the metal mold are separated, leaving the metal cast to be easily extracted and cleaned for further processing.

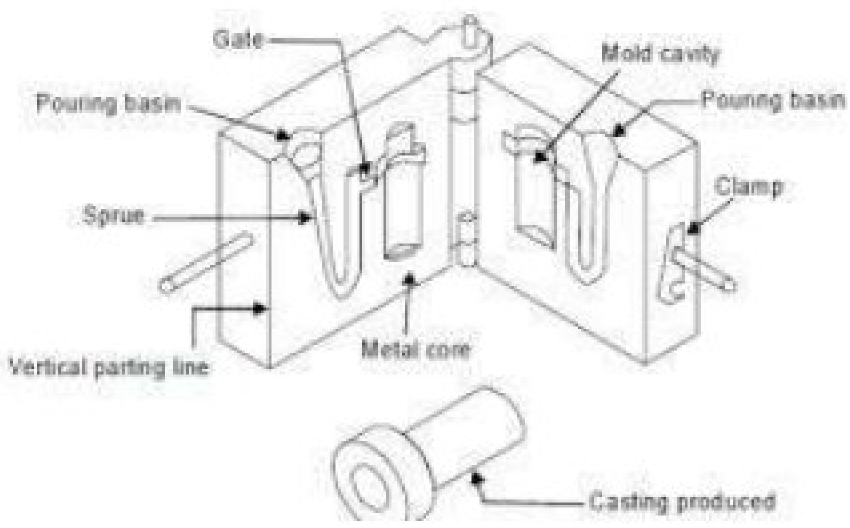


Figure 5: Gravity Die casting

Investment casting

This process is well known for its ability to produce highly complicated castings; as long as an appropriate orientation can be achieved to effectively discard the resin pattern.

This process involves the making of resin patterns that are then coated with slurring and stucco ceramic powder in order to make a temporary or disposable mold. The resin pattern ensures a good surface finish.

The complicated inner part of the cylindrical body model can be easily produced using investment casting, hence the viability of this process; despite the high cost of the process. In addition, this process requires long lead times and is often less suitable for mass produced products such as this manual handheld coffee grinder.

Nevertheless, the following describes the steps involved in investment casting.

1. Resin or plastic patterns are produced and joined into a tree-like structure that is strategically oriented to allow the resin to be discarded later without any of it remaining when flipped upside down.
2. The structure is then dipped into slurry mix, and then into stucco mix.
3. The previous step is repeated as needed.
4. After the coating solidifies, the mold is put in a furnace while upside down in order to melt the resin or plastic mold and simultaneously create an excellent surface finish layer inside.
5. The mold is then ready to be used. The ceramic, now solidified, mold is heated before the molten metal is poured into it to avoid cracking.
6. The metal is left to cool down in air slowly before the ceramic mold is destroyed to extract the metal casting tree-like structure.

7. Individual castings are broken off the structure and cleaned for further processing.

3.1.2 Selected Process

The selected process is gravity die casting, due its very good surface finishing properties, mechanical properties, high production rate coupled with low cost and great ability to produce low tolerance parts.

Sand casting, despite being a viable option, is found to produce undesirable features that will increase the steps of production and thus hinder the production rate and quality. The surface finishing of the final product is quite poor and not up to standard of the design quality of the grinder body; thus the castings will be required to undergo further finishing works. The castings produced by sand casting often have large tolerances; thus hindering the quality of the final product and risking issues with assembly.

Centrifugal Casting has proven to meet many of the requirements. It produces castings with good surface finishing, great tolerancing and material distribution. However, this process, despite ticking all the boxes, is not suitable for mass production due to its low production rate. The time taken for the cylindrical cast molds to be spun, then cooled and opened to extract metal casting hinders the production time. In addition, the cylindrical body has many non cylindrical features that are not suitable for centrifugal casting; therefore only the cylindrical container/base can be manufactured using this process. It is often undesirable to have two different production processes for similar looking parts; as it decreases the uniformity and increases the cost of production.

While the afore-mentioned processes were found to be lacking in terms of lacking the desired final product characteristics or having lower production rate; investment casting can solve the production rate problem due its large batch size (tree-structure can contain many castings connected together). This makes investment casting a promising solution, however, the cost constraint was found to be a limiting factor; since patterns and molds are all disposable; along with many process steps that will require higher quality control.

3.1.3 Overall Process flow

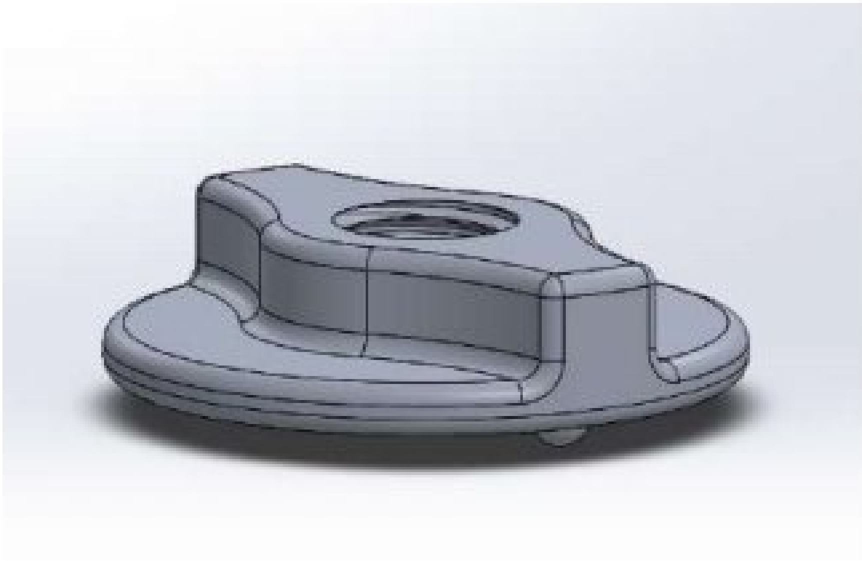
1. Designing of pattern model and patenting it if required
2. Material Selection and Sourcing; in this case Aluminum alloy 3003
3. Process Selection and Equipment Purchase and Set-up
4. Production processes execution
    a. Gravity Die casting
    b. Cleaning and preparation for coating
    c. Painting of the parts
5. Testing, Quality Control and Error troubleshooting
6. Assembling

3.2 Dial & Dial Slot Board

The function of the dial is to adjust the coarseness of grinding by rotating it along the steps that are indented on the dial slot board. Dial slot board piece is inserted and then held in by the dial; which has a screw pattern that fits with the one on the turning shaft. The more the dial piece is turned clockwise, the closer the conical burr is to the wall inside of the cylindrical body. Hence, the smaller the space that the beans have to pass through which results in a finer grind. This piece is tensioned by the spring which pushes on the conical burr that is on top of the dial slot board.

Since the dial is expected to be touched by the user, a good surface finish and look is desired. The same applies to the dial slot board to ensure the smooth gliding of the hemispheres of the dial (as shown in the technical drawing).

Good wear resistance is also crucial in the production of the dial and dial slot board pieces as they will be gliding across each other while in use.



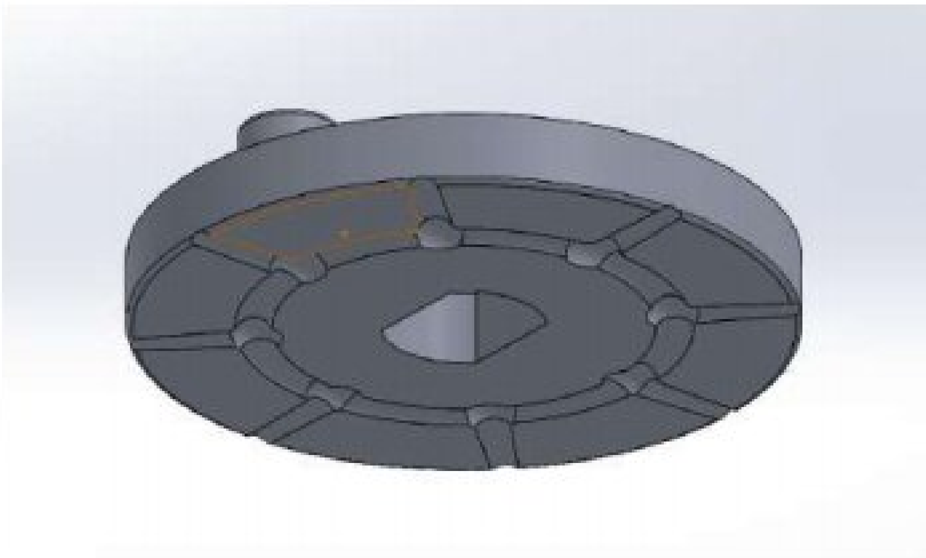


Figure 6. Dial and Dial slot board models

3.2.1 Process Selection

Closed Die Forging

This metal forming process starts from a general, predetermined shape of metal, in this case a metal cylindrical puck, where it is heated and pressed or hammered into the desired shape. The forging process grants plenty of desirable properties to the final piece. For instance, forging is well known to produce results with high wear resistance, strength and durability. All while being economical.

Since the material selected for the Dial and Dial slot board is stainless steel; forging process further proves to be a viable option as it has moderate forgeability.

The production rate of forging fairly aligns with the required quantity of production; being a mass produced product.

The cost of production is very low only after the machines and equipment have been purchased; which are considered very expensive investments.

The following describes the steps involved in the forging of the Dial and Dial slot board pieces:

1. Cylindrical metal puck is heated to the appropriate temperature for stainless steel forging.
2. The hot metal is placed on the bottom die, then the top die is clamped onto the hot metal.
3. The hammer strikes a couple of times the upper die; causing it to deform the hot metal into the shape of the dies.
4. The top die is then opened; which starts the cooling process of the forged piece.
5. Then the ejector pin that is in the bottom die is pushed to eject the forged piece.
6. The piece is then trimmed by a trimming machine.

Figure 7: Closed die forging after step 4.

This process involves significant waste of material due to necessary trimming after forging. In addition, the trimming process may hinder the production rate of the process and result in parting lines.

Sand Casting

This process has been described in section 3.1.1 to be suitable for a wide variety of applications; which extends to the casting of the stainless steel dial and dial slot board. Despite the good tolerance accuracy of closed die forging being a welcome benefit; it is not strictly required as these parts will still function as intended with a slightly larger tolerance zone.

Using sand casting, however, does result in a worse surface finish compared to closed die forging or any permanent mold casting method.

Pressure Die Casting

This casting process lies in the same category as gravity die casting, which was discussed in section 3.1.1. This process shares the same characteristics and properties of the resulting metal casts. Good surface finishing, good mechanical properties and tolerancing accuracy are three of the advantages of using pressure or die casting.

The following describes the processes involved in pressure die casting:

1. Permanent metal mold is set-up (cores are placed if required), and the cylindrical chamber is set ready by making sure the ram is placed before the opening.
2. Molten metal is poured from a ladle into the cylindrical chamber and then closed.
3. The ram is released, pushing the molten metal into the metal mold. Thus forcing it to fill the impression of the mold.
4. The metal is left to cool down before the metal die is opened and then cast metal is extracted by pushing the ejector pin, similar to Closed die forging.

3.2.2 Selected Process

The most practical and feasible process was found to be gravity die casting too. Despite forging resulting in the very desirable properties such as good wear resistance; the initial high cost of equipment increases the risk of the project, making it less appealing to the board of directors.

Pressure casting was also found to be almost similar to gravity die casting. Since the process selected for the previous part (cylindrical body and container) was gravity die casting, the cost of purchasing equipment specifically for the casting of the dial and dial slot board is not practical and only drives the cost of production upwards. It is more efficient to use the same process of production if possible; and hence the selected process for these parts.

Sand casting was automatically eliminated as the bad surface finishing renders the process too cumbersome.

3.2.3 Overall Process

1. Designing of pattern model and patenting it if required
2. Material Selection and Sourcing; in this case Stainless Steel
3. Process Selection and Equipment Purchase and Set-up

   Metal dies are made with consideration to shrinkage, machining and distortion allowances.

4. Production processes execution
   a. Gravity Die casting
   b. Cleaning
   c. Finishing and Polishing of the parts
5. Thread making by rolling

6. Testing, Quality Control and Error troubleshooting
7. Assembling

3.3 Turning Shaft & Handle Lever Rod

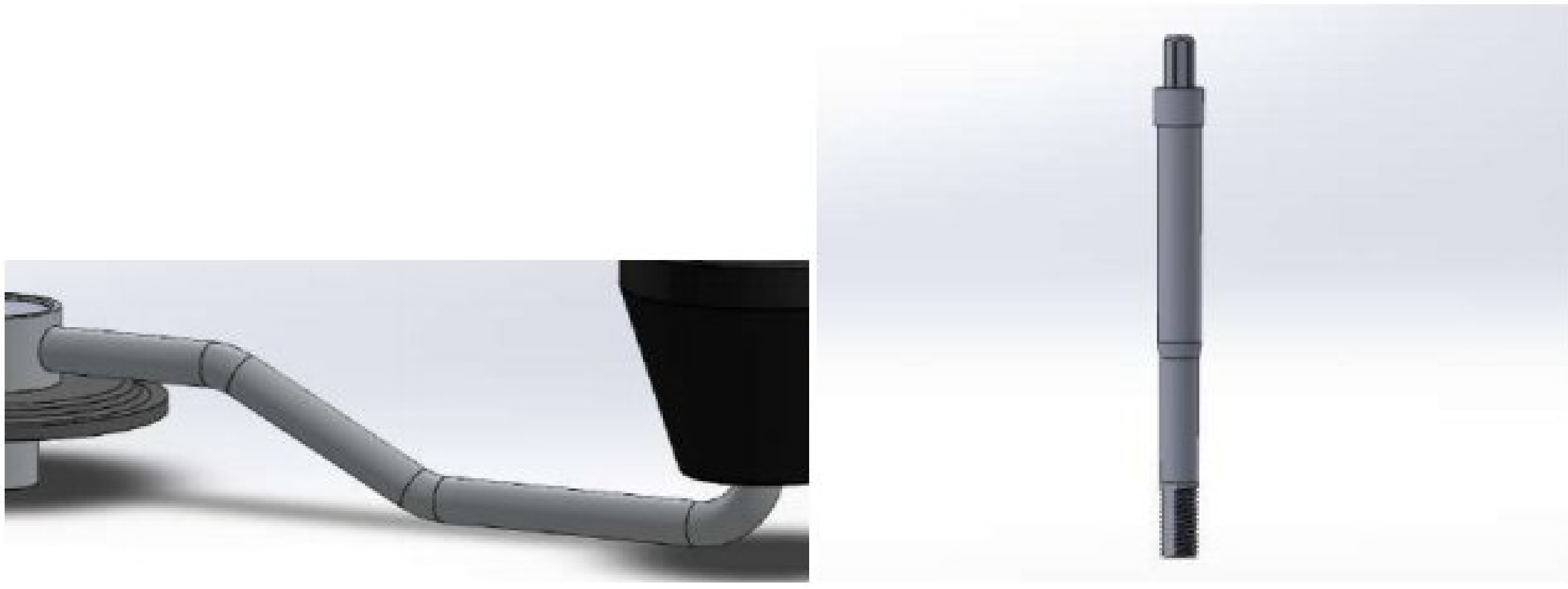


Figure 8. Turning shaft & handle lever rod models.

3.3.1 Process selection

Cold Extrusion & Rolling

This process is one whereby metal is extruded from a metal billet. The room temperature metal is forced through a die; which produces a cylinder of uniform cross section. A plethora of benefits can be obtained by using cold extrusion as compared to hot extrusion. For instance, higher strength, close tolerances, improved surface finish and high production rates are all very desirable benefits of manufacturing the shaft and the lever rod.

For the turning shaft, since the extrusion is done using one die; the final extruded part has one diameter. To achieve the required shape of the turning shaft as shown in the technical drawings, cold rolling can be undergone on the extruded cylinder.

1. Stainless Steel billet is put behind the ram and the die is secured in place in the machine.

2. The ram starts forcing the metal billet through the die; forming a cylindrical rod.
3. The rod is cut to size as required.
4. The produced rod is then fed between two rollers that carry the profile of the turning shaft
5. The final product is collected into a tray and inspected to ensure correct dimensions.

CNC Machining

This process is one that removes materials to achieve the desired product. A standard metal piece is secured into the CNC (Computer Numerical Control) machine and spun at high speed while a drilling tool removes material as it comes in contact with the metal piece. This process is often automated by a program that is written according to the desired tolerance specifications and dimensions of the desired CAD model.

The following describes the CNC machining process:

1. CAD model dimensions and tolerance specifications are translated into CNC software and code is written
2. Programming code is installed into CNC machine
3. Standard (cylindrical) part is secured into the designated area.
4. The CNC machine is started, the part starts rotating and the drilling piece moves as programmed by the code.
5. Special lubricating and cooling fluid is pumped into the part while it is being machined.
6. After the machining process is over, the part is removed from the securing slot and inspected for errors and quality issues.

Centrifugal casting

This process, as aforementioned in section 3.1.1, is used for cylindrical parts; which is why it is considered as a possible alternative process. However it is not as practical due to lower production rates compared to the above-mentioned processes. The steps of centrifugal casting are described previously, please refer to section 3.1.1.

3.3.2 Selected Process

There were several nominated processes for the production of these parts. The turning shaft is considered one of the main pieces that the reliability and quality of the product relies on. Ensuring that it was manufactured with high quality and precision according to the given tolerances is crucial.

Using cold extrusion and rolling is one of the eligible alternative processes. The piece produced displays a wide range of very desirable properties such as good tolerancing and strength. High mechanical strength is needed to ensure neither the shaft nor the handle rod is bent or twisted under unexpected stress.

Centrifugal casting, despite presenting to be a feasible option, was found to lack the production rate required for a mass produced product.

The selected process for the manufacturing of the turning shaft and handle lever rod was chosen to be CNC Machining. The high precision and tolerance promised by CNC machining cannot be ignored. This method was also preferred as the equipment and machine for it was already planned to be purchased for another part - the conical burr. Using the machine for both parts is sure to cut the production cost and reduce the set up time.

3.3.3 Overall Process

1. Designing of CAD model and patenting it if required
2. Material Selection and Standard metal rod sourcing; in this case Stainless Steel
3. Process Selection and Equipment Purchase and Set-up

   Program is written according to the CAD model with consideration to all the defect and error eliminating practices and conventions, such as pumping of coolant while machining.

4. Production processes execution
   a. Standard (cylindrical) part is secured into the designated area.
   b. The CNC machine is started, the part starts rotating and the machining piece moves as programmed by the code.
   c. Special lubricating and cooling fluid is pumped into the part while it is being machined.
   d. After the machining process is over, the part is removed from the securing slot and inspected for errors and quality issues.
5. Thread making by rolling
6. Part finishing and polishing
7. Testing, Quality Control and Error troubleshooting
8. Assembling

3.4 Conical Burr

This part is the most crucial part of the entire grinder. In fact, it is one of the main selling points of the coffee grinder. The consistency of the ground coffee is largely affected by this part; hence very low tolerancing is allowed in the manufacturing of the conical burr. The process selected to produce this part must ensure high wear resistance to ensure the burr remains sharp for the longest time possible.

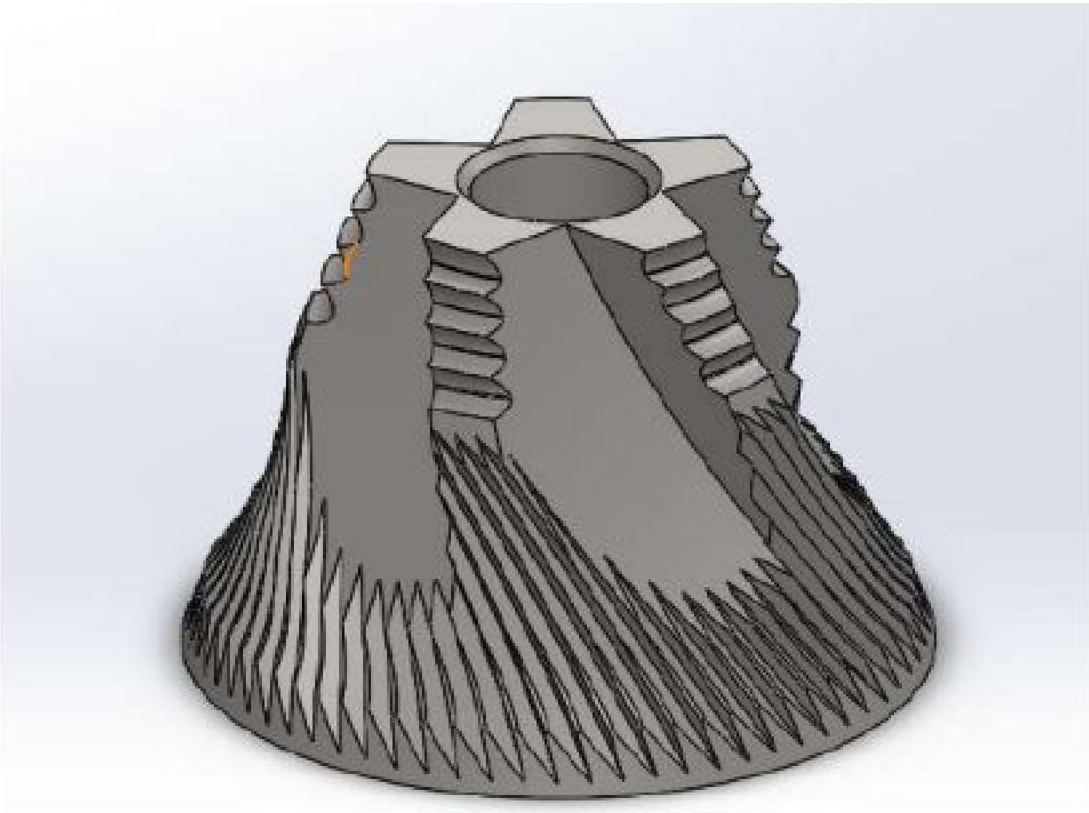


Figure 9. S2C™ Conical Burr model.

3.4.1 Process Selection

<u>*CNC Machining*</u>

The conical burr is one of, if not the most complex part in the entire assembly of this handheld manual coffee grinder. The blades on the burr are angled in a unique way that was developed by the designing team to guarantee a consistent and accurate grind reliably every time for as long as the grinder is maintained properly.

Producing these angled burr blades must ensure their sharpness too. Afterall, the blades are what cuts the coffee bean; and having dull blades will shatter them instead. Crushing the beans is not desirable as it produces fine dust and large chunks that greatly impact and hinders the quality and consistency of the ground coffee; resulting in a bitter or sour coffee. CNC machining with multiple axes of approach was found to be very suitable for the achievement of a sharp and precise burr.

Conical metal pieces can be purchased easily and input into the pre-programmed CNC machine. The simplicity of production surely increases the rate; hence meeting the expected mass production quantities.

The process steps were described and listed in section 3.3.1 of this chapter.

Investment casting

Investment casting is of the high-quality casting processes that outputs products of excellent tolerancing and surface finish. An example of the uses of investment casting are prosthetic hip replacements; which require great precision and production quality - two of the most sought after properties in the production of the conical burr.

This casting process is also known for its ability to cast complex shapes. The conical burr is considered a very simple shape compared to typical castings produced using this process.

The two main disadvantages of this process is production cost, which is driven high by the disposable resin patterns and ceramic casting molds, and lead time. Products produced using investment casting require up to a week of leed time. This is not factoring in the cost and time required to set-up the production equipment and process flow for this type of casting.

Closed Die forging

Similar to CNC machining, closed die forging uses a standard metal piece, in this case a metal cone, as a starting point. Which not only reduces the cost of production, but also ensures casting quality depends only on the sourcing of the raw metal cones; thus reducing one quality aspect that needs to be checked. The most compelling aspect of closed die forging is the wear resistance of its produced pieces; which is one of the important properties required for the conical burr to stay sharp for a longer span of time.

This process, however, does result in high amounts of waste material. Although this issue can be resolved by simply recycling the scrap material from the trimming process, it is often not preferred as it only increases the processes of production.

The process of production using closed die forging was discussed in section 3.2.1 of this chapter, please refer to it for the list of steps of this production process.

3.4.2 Selected Process

The selected process for the manufacturing of the conical burr was chosen to be CNC machining. Simply for its desirable high precision and tolerancing capabilities, along with its automated, quick production process which result in high production rate. Being automated has the added benefit of reducing labor costs once the CNC machine has been programmed. The process is also flexible as it only requires the program written for the CNC machine to be edited in order to adjust for any amendments required after the quality inspection process.

3.4.3 Overall Process

1. Designing of CAD model and patenting it if required
2. Material Selection and Standard metal cone sourcing; in this case Stainless Steel
3. Process Selection and Equipment Purchase and Set-up

   Program is written according to the CAD model with consideration to all the defect and error eliminating practices and conventions, such as pumping of coolant while machining.
4. Production processes execution
   a. Standard (cylindrical) part is secured into the designated area.
   b. When the CNC machine is started, the machining piece moves as programmed by the code along six axes to achieve the required burr blade pattern.
   c. The CNC machining piece is then replaced with a drilling piece, which is used to make a hole according to the required dimensions and tight tolerances.
   d. Special lubricating and cooling fluid is pumped into the part while it is being machined.
   e. After the machining process is over, the part is removed from the securing slot and inspected for errors and quality issues.
5. Part finishing
6. Testing, Quality Control and Error troubleshooting
7. Assembling

4.0 Engineering Application of GD&T in Technical Drawing

4.1 Importance of GD&T of Product Designs in Manufacturing

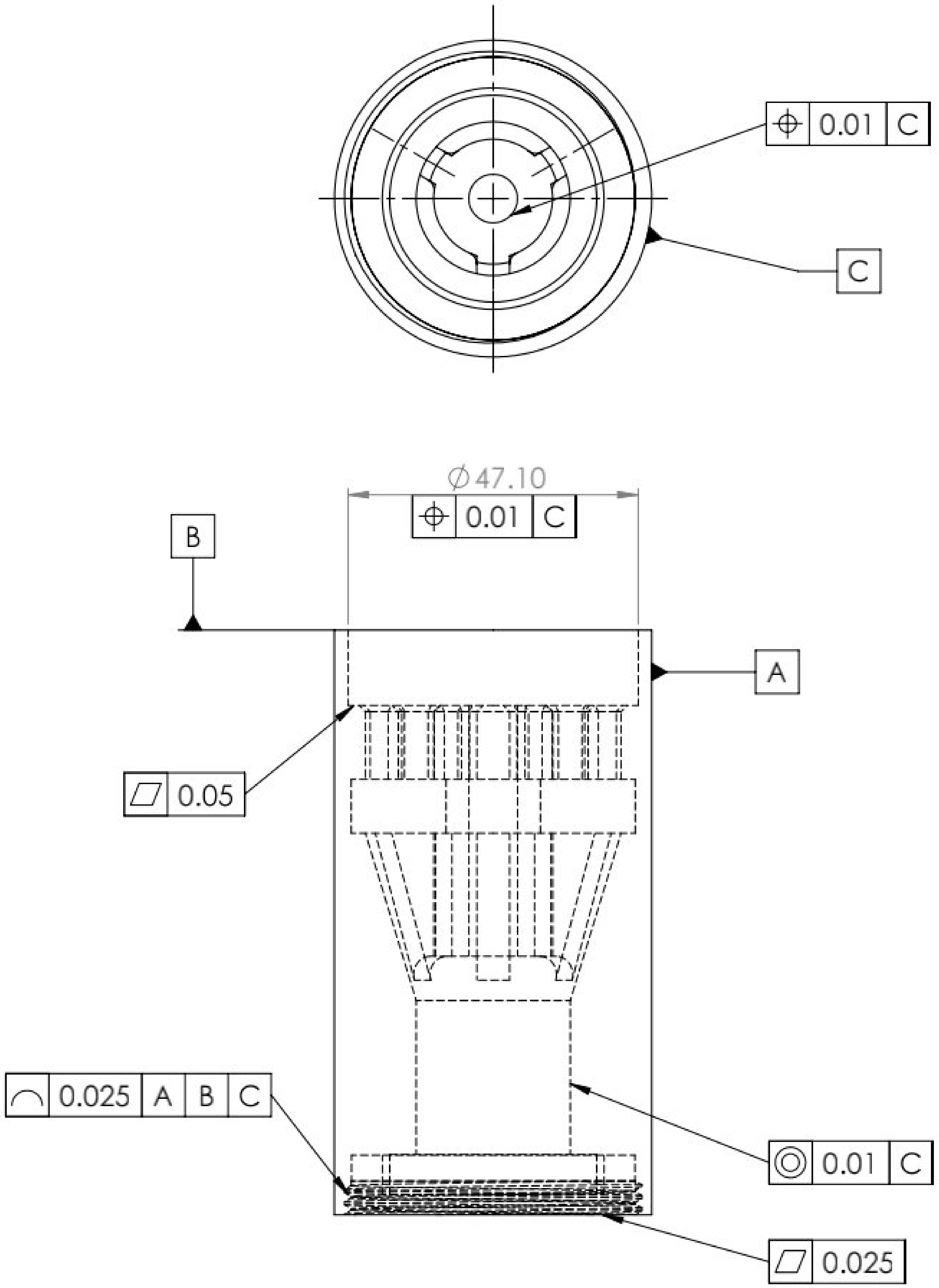
Technical drawings are one of the basic requirements in product designing. It serves many functions that are crucial to communicate the thought and details behind the design. By specifying the dimensions and communicating design choices to the board of directors, feedback can be received on how to improve the design and ensure no underlying flaws are overlooked.

Technical drawings are usually sufficient for the purpose of product design presentation and syncing with other members in the product design team. However, when it comes to finally communicating the product dimensions and shapes to the manufacturer; a lot more than dimensions is left to be desired; or more appropriately said, required!

GD&T stands for Geometric Dimensioning and Tolerancing. As can be deduced from the name, not only does it include the dimensions of the designed part, it also specifies the specific features and default tolerancing of the parts.

The accuracy at which details of the product is allowed to be made is specified according to the datums. The position, parallelism, perpendicularity and surface line profile are all very crucial aspects of a part drawing that may be disastrous if manufactured without tolerances referring to suitable datums.

With GD&T, a standard communication medium can be utilized to accurately control the final product. This ensures an easier, more efficient and more cost effective communication within the company; as the need for back and forth iterations of product samples are eliminated.



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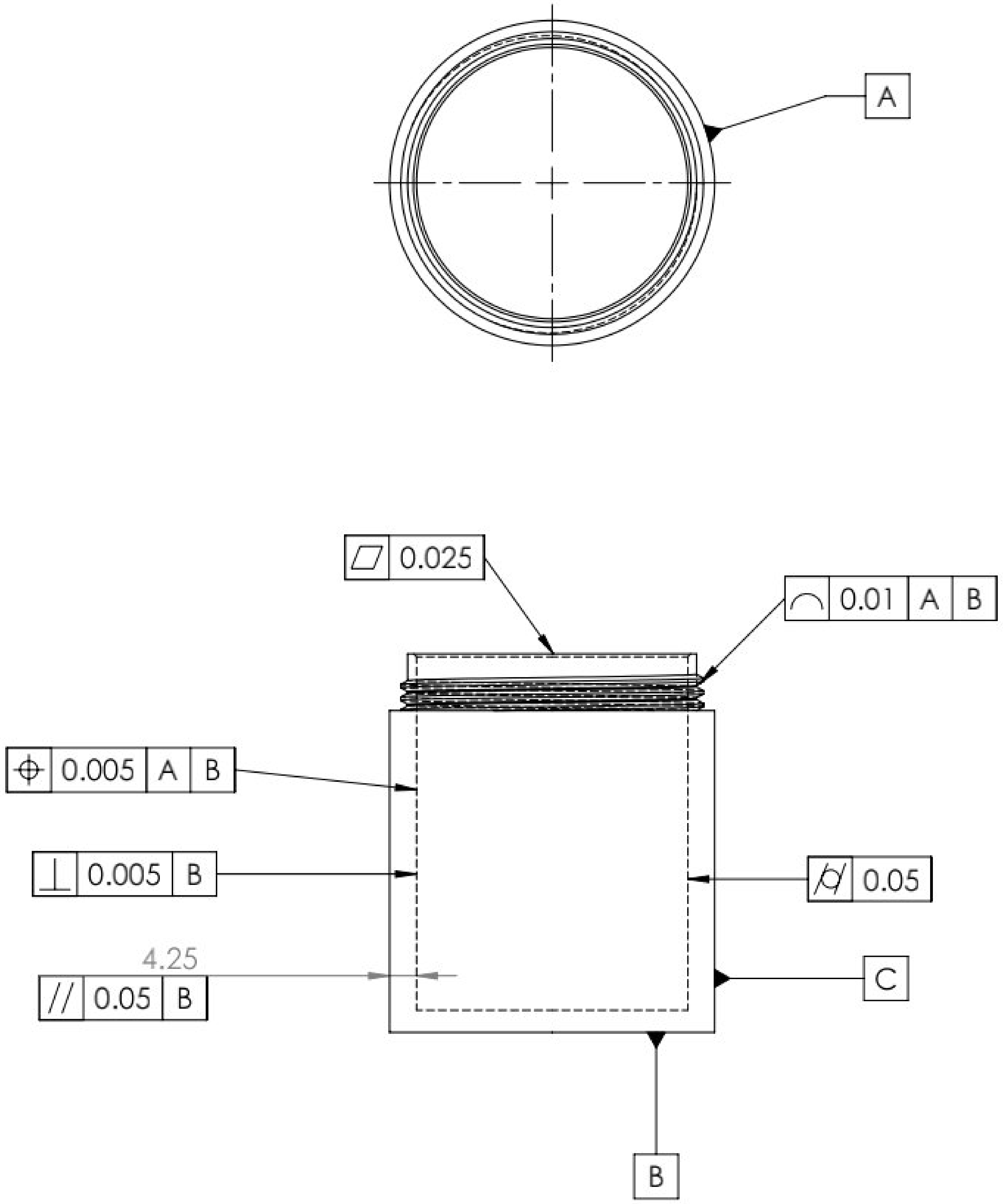

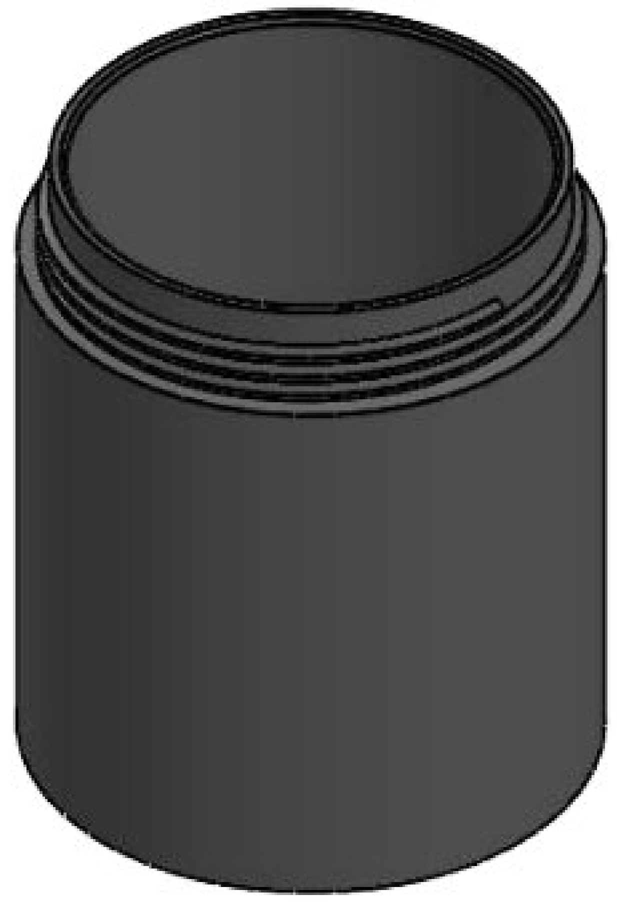

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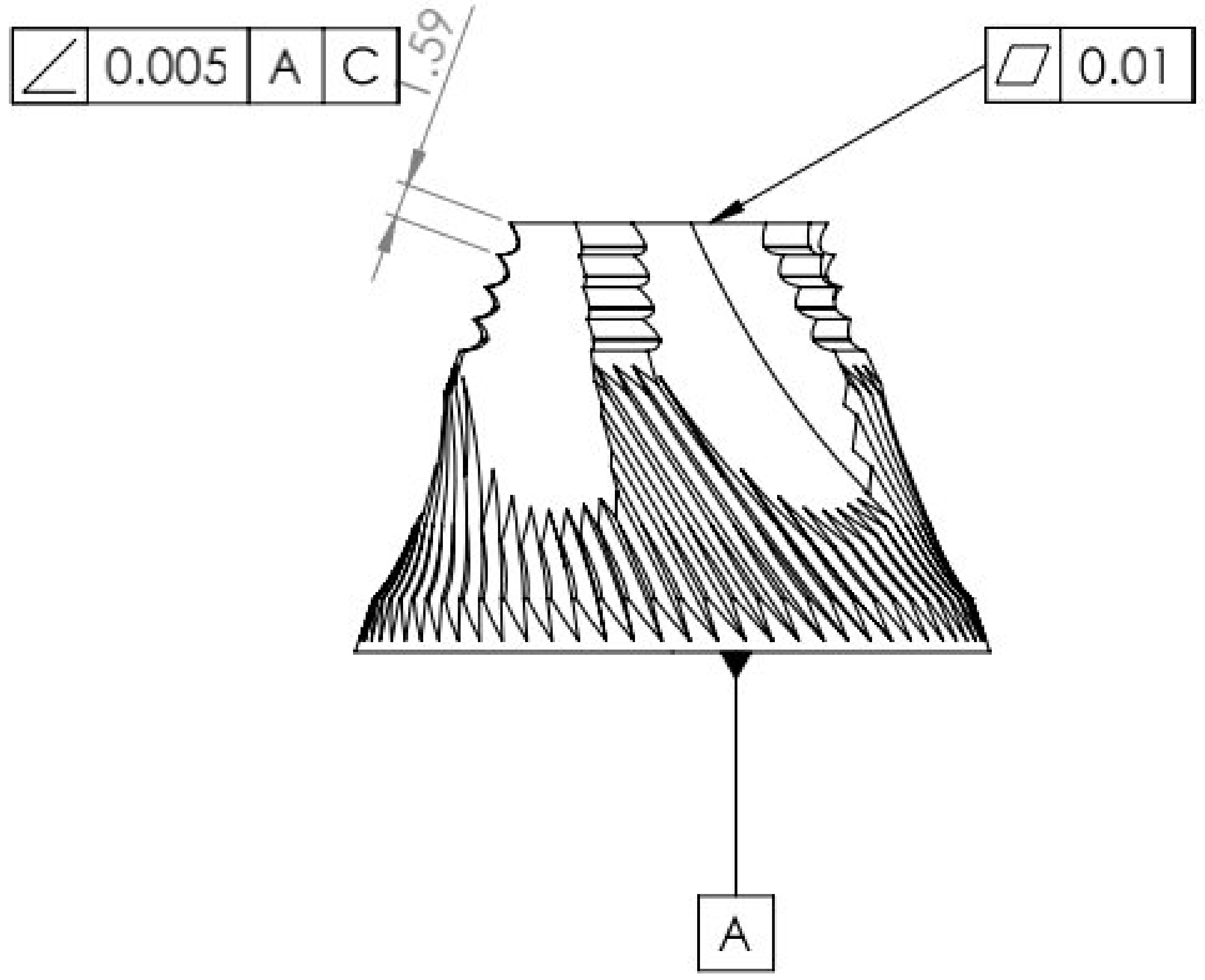

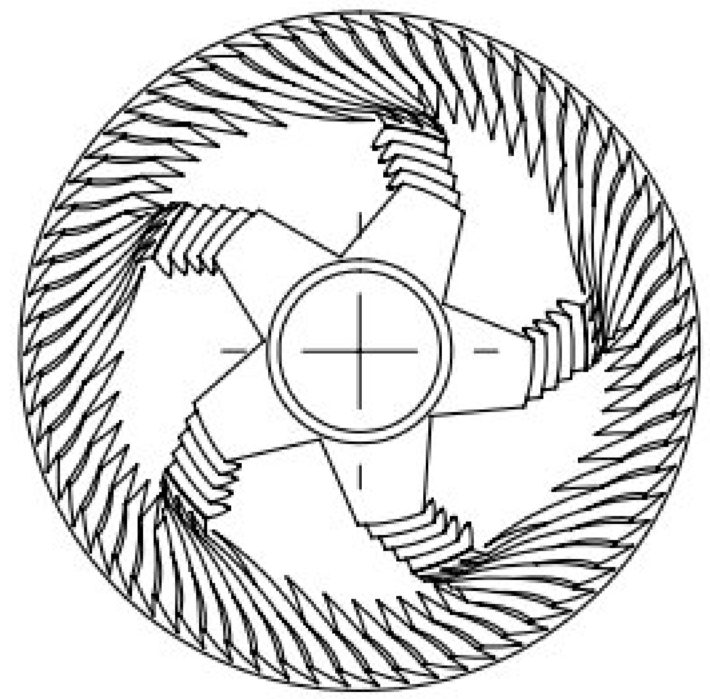

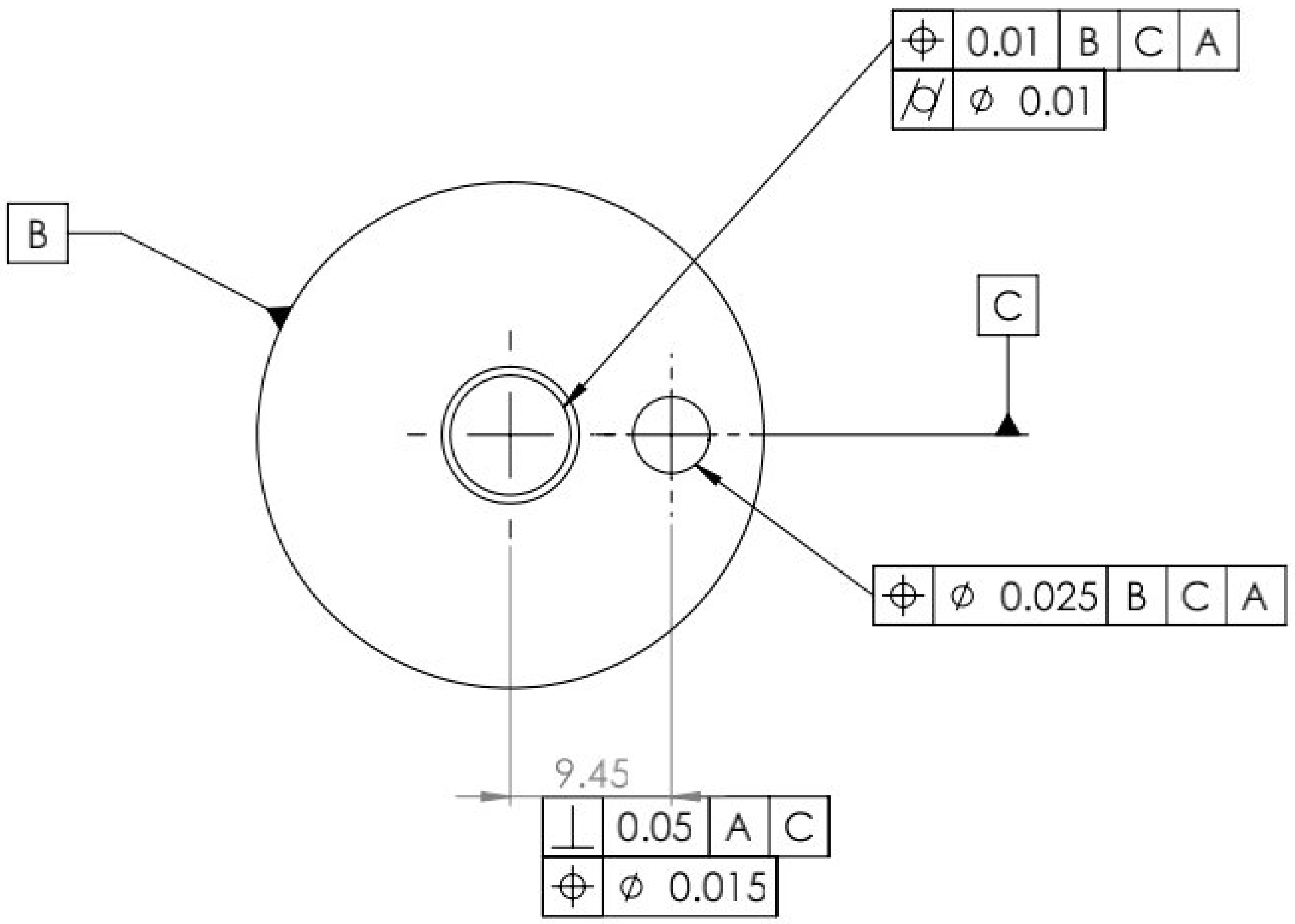

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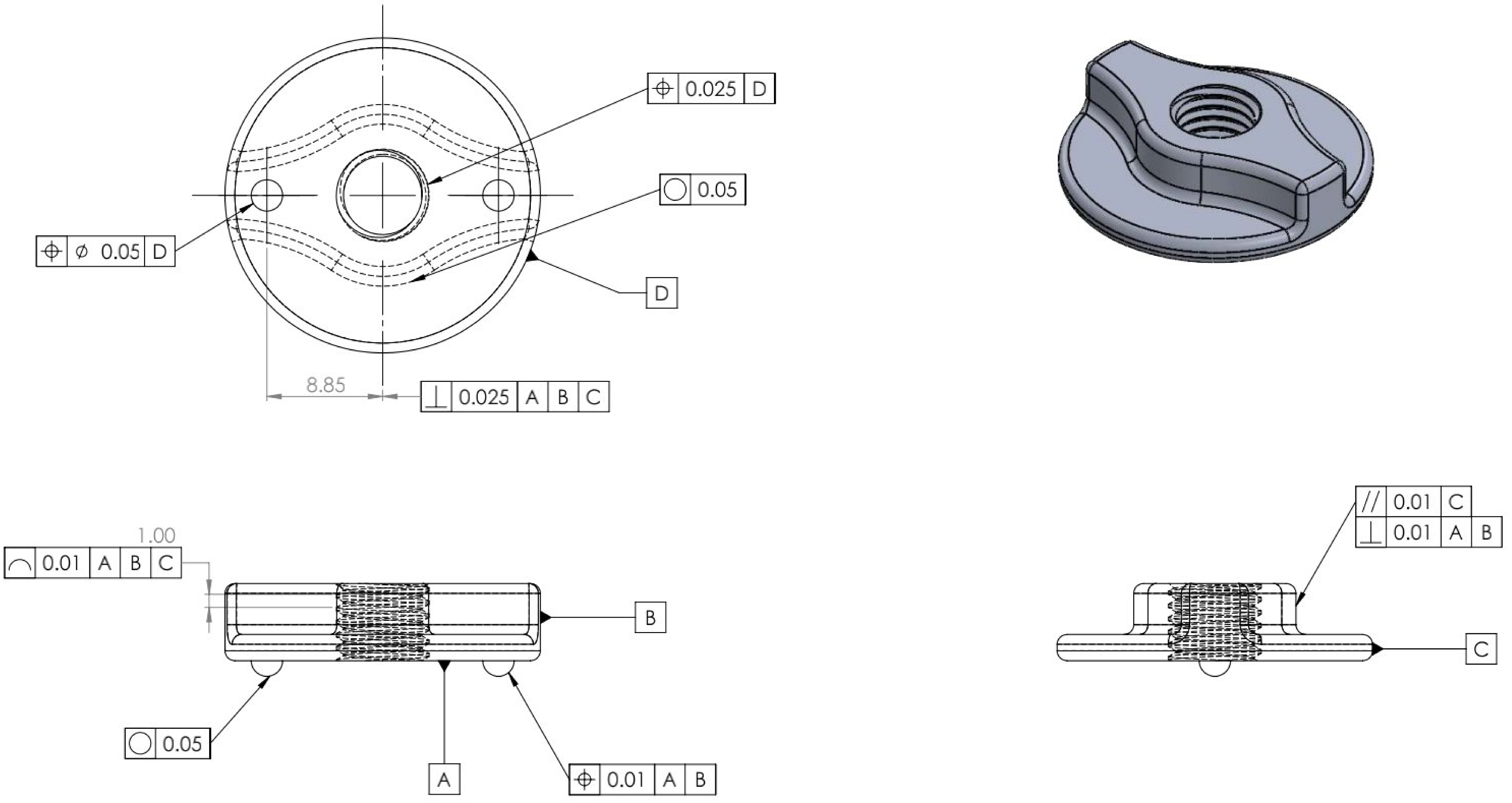

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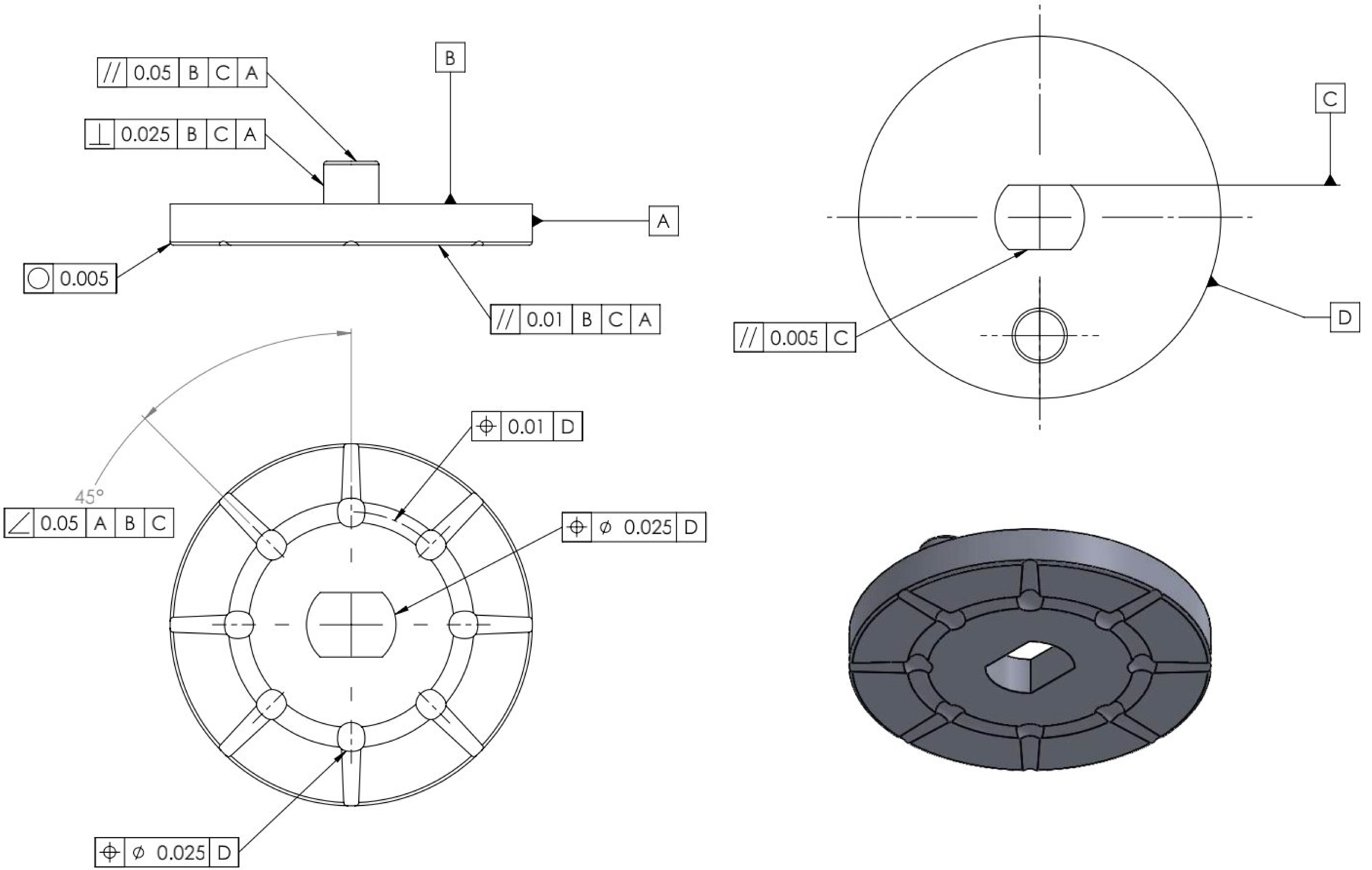
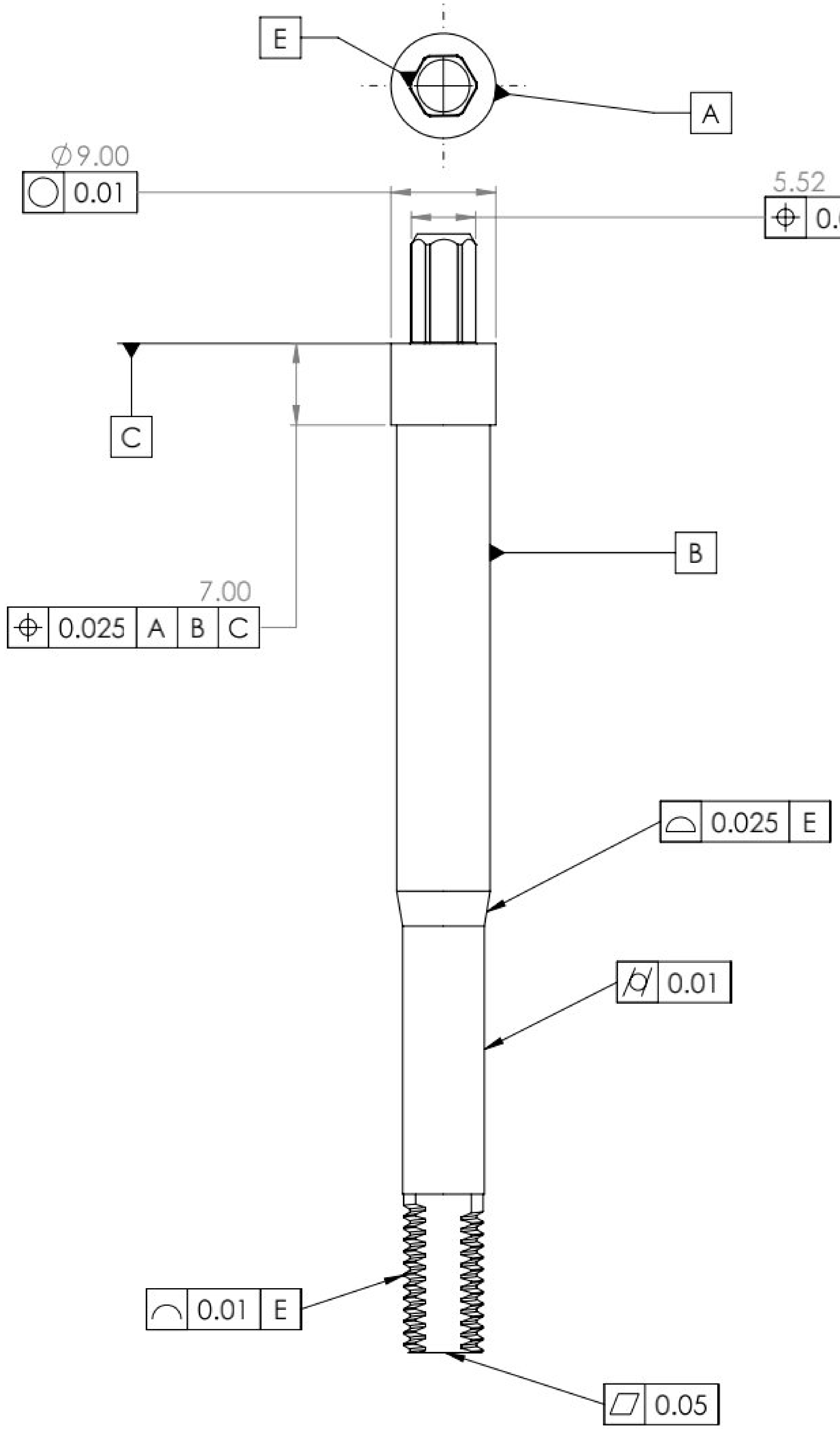
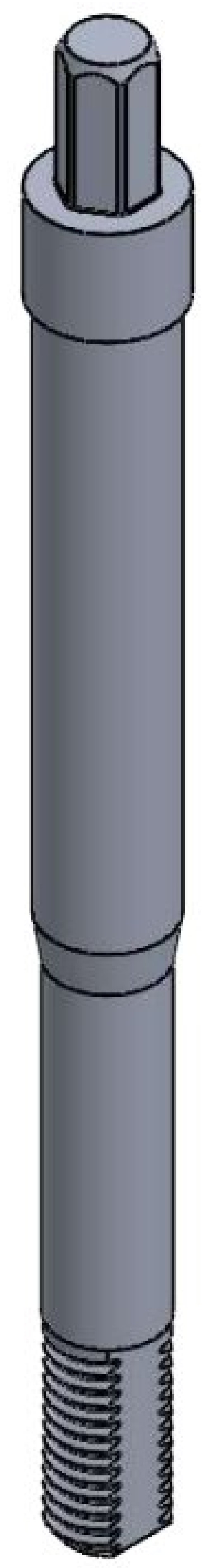
TITLE: Dial	COURSE: SEMM 2713	DATE: 04-JUL-2023	
	SECTION: 40	SCALE: 3:1	



UTM UNIVERSITI TEKNOLOGI MALAYSIA SCHOOL OF MECHANICAL ENGINEERING	TITLE: Dial Slot Board	COURSE: SEMM 2713 SECTION: 40	DATE: 04-JUL-2023 SCALE: 3:1





UNIVERSITI TEKNOLOGI MALAYSIA
SCHOOL OF MECHANICAL ENGINEERING

TITLE: Turning Shaft	COURSE: SEMM 2713	SECTION: 40	DATE: 04-JUL-2023
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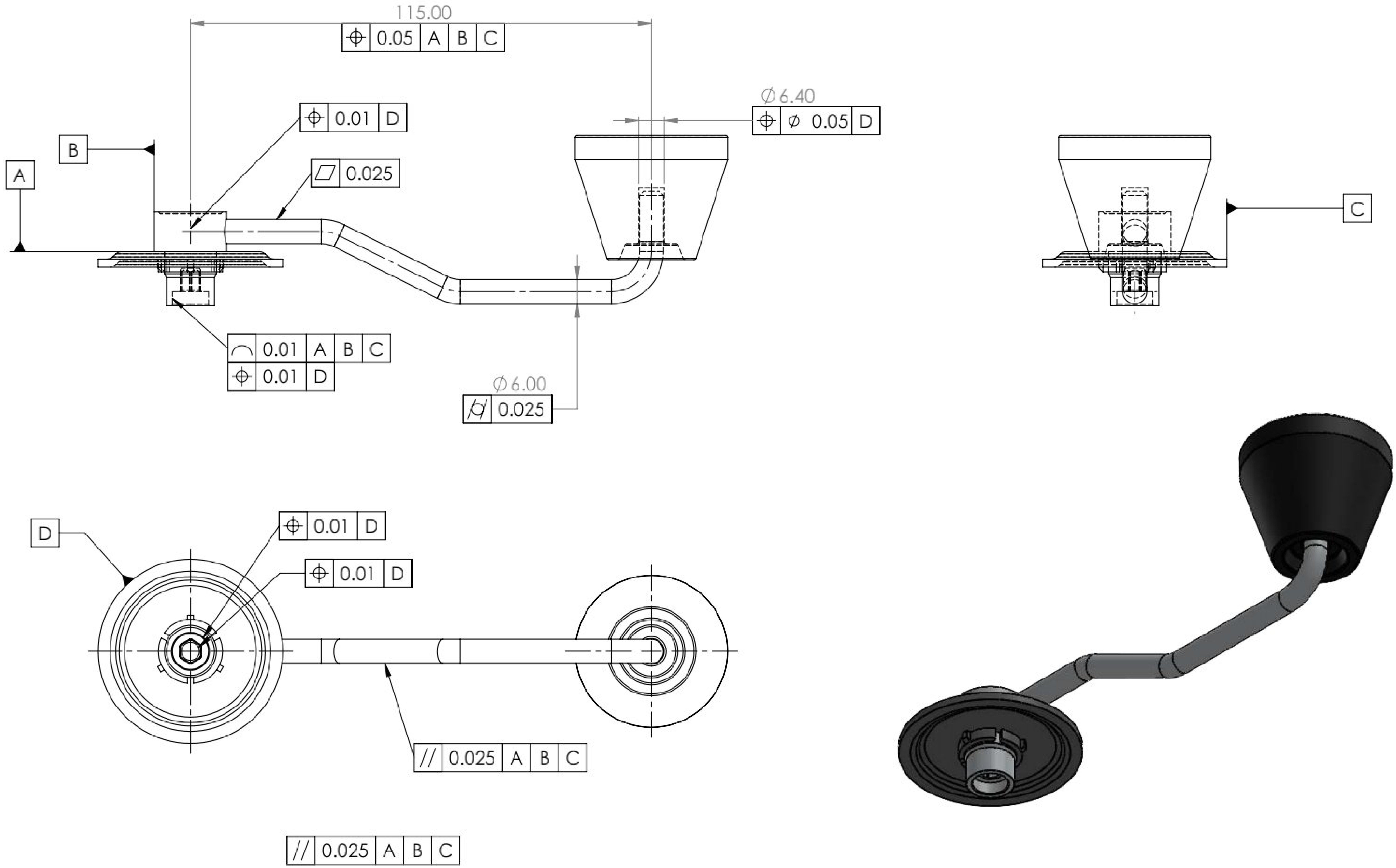


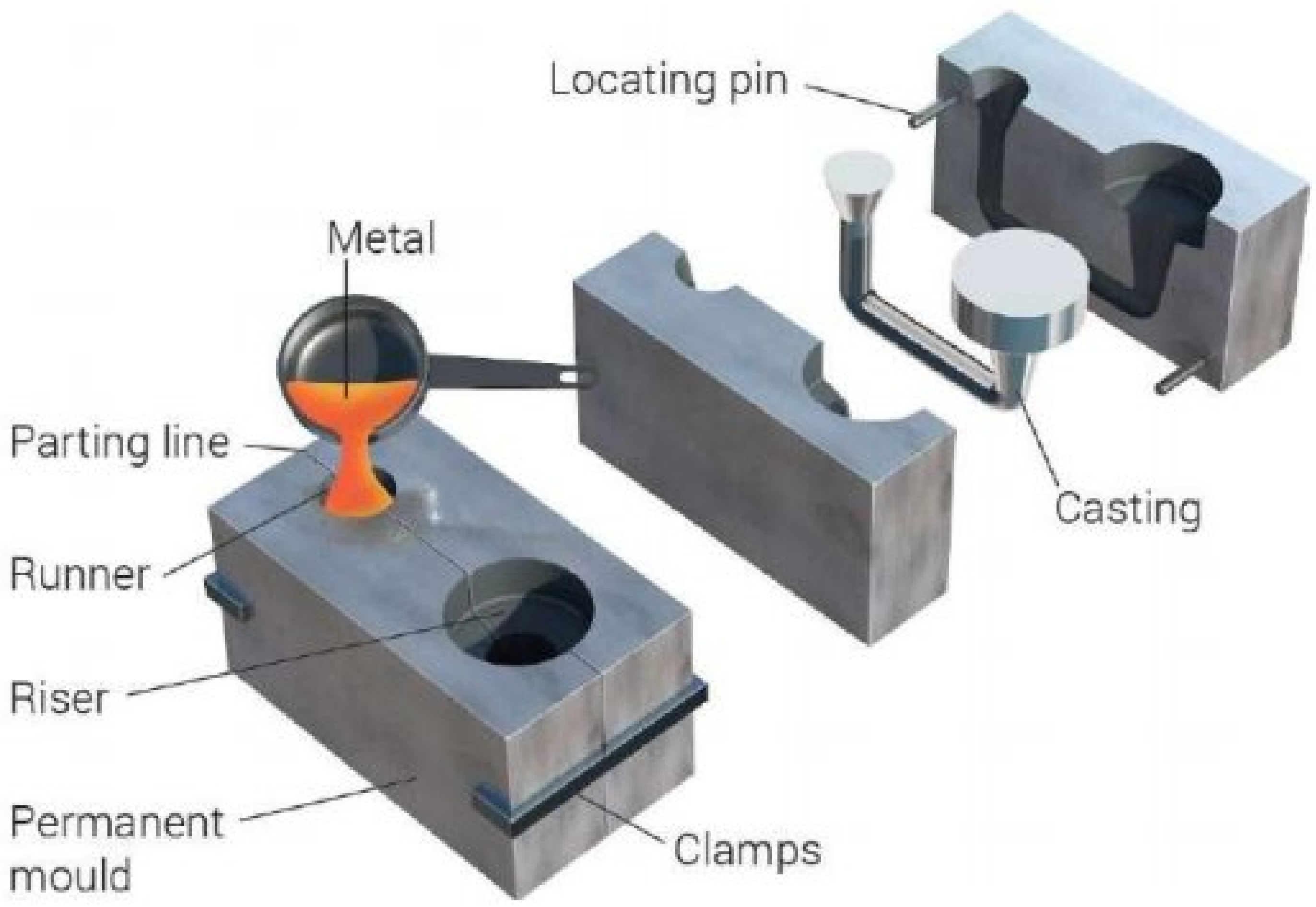
UTM UNIVERSITI TEKNOLOGI MALAYSIA	UNIVERSITI TEKNOLOGI MALAYSIA SCHOOL OF MECHANICAL ENGINEERING	TITLE: Lid & Handle Lever	COURSE: SEMM 2713 SECTION: 40		DATE: 04-JUL-2023 SCALE: 1:1

5.0 Type of Equipment

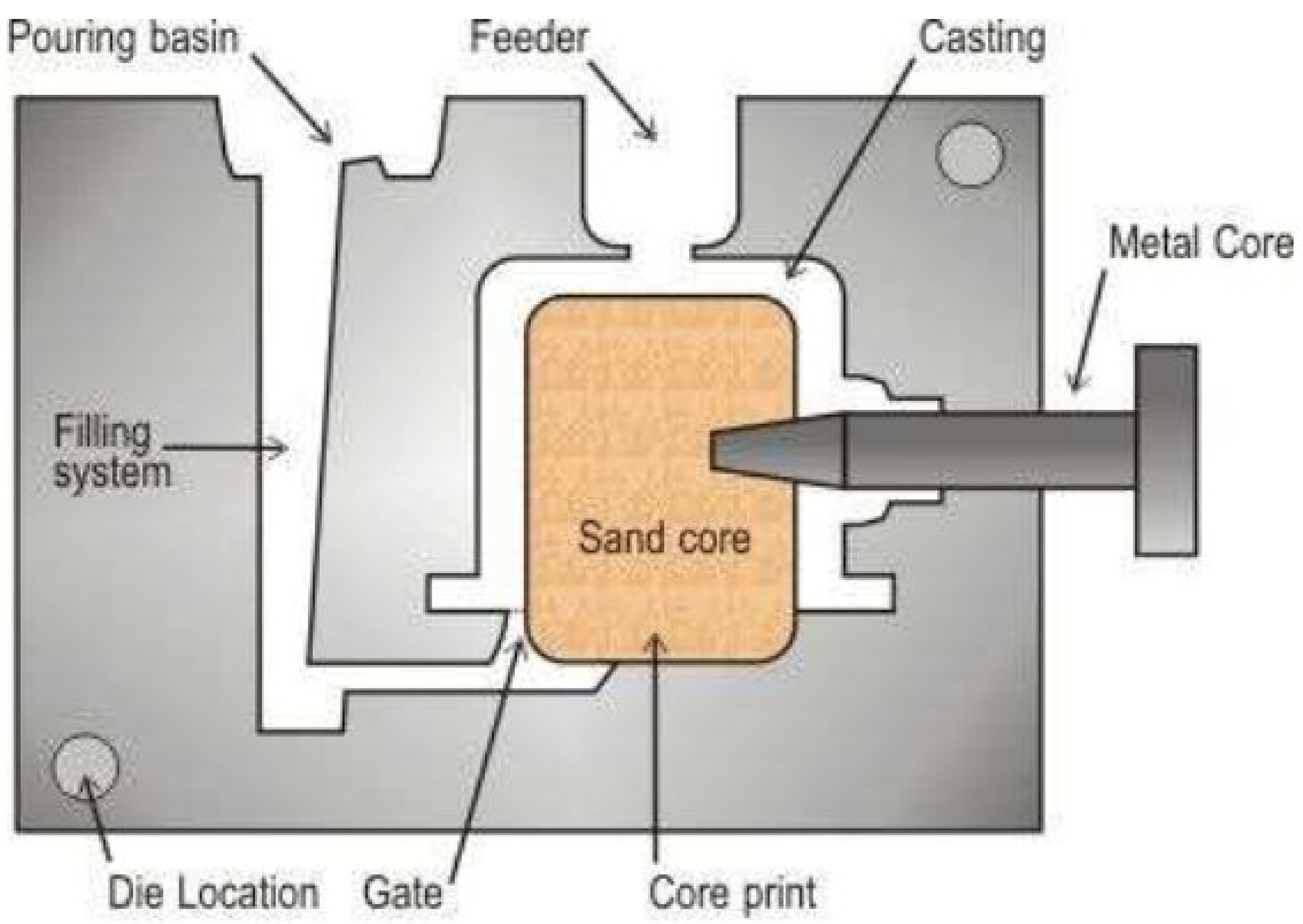
5.1 Gravity Die

Casting

Known as permanent mold casting, is a casting process that utilizes reusable metal molds to produce solid, high-quality metal components. Here are the main parts and machines used in the gravity die casting process:



5.1.1 Parts Used in Gravity Die Casting:



The mold, also known as the die or tool is composed of high strength metal, typically steel or iron. It consists of two parts: a cavity that determines the shape of the casting and a gating system that helps the molten metal flow. To ensure durability the mold is designed for repeated use and preheated before casting.

Cores are utilized when there is a need to create internal cavities or intricate shapes within the casting. Usually made of sand or metal they are inserted into the mold to form hollow sections or complex features in the final product.

Ejector pins play a crucial role in removing the casting from the mold. Positioned strategically within the mold.

They are activated after solidification to push out the newly formed object. Cooling channels are integrated into the mold to facilitate heat extraction from molten metal for proper solidification. These channels allow cooling fluids like water or air to circulate and regulate cooling rate as well as control the solidification process.

5.1.2 Machines Used in Gravity Die Casting:

Gravity Die Casting Machine: This machine is specifically designed for gravity die casting operations. It consists of a stationary or tilting casting table on which the mold is mounted. The machine is equipped with a crucible or ladle to hold and pour the molten metal into the mold cavity. The force of gravity is used to fill the mold cavity as the molten metal flows from the crucible into the mold.

Furnace: A furnace is used to melt the metal alloys used in the casting process. The furnace heats the metal to its liquid state and maintains it at the desired temperature for casting. Different types of furnaces, such as electric resistance furnaces or gas-fired furnaces, can be used depending on the specific casting requirements and metal alloys being used.

Preheating the mold is an essential step in gravity die casting to optimize the casting process and improve the quality of the castings. To achieve this die preheating equipment, such as electric or gas fired heaters is employed to heat the mold to a specific temperature before casting. Preheating serves to regulate solidification, minimize thermal stress and enhance the surface finish of the castings.

After removing the casting from the mold it may be necessary to perform trimming and finishing operations in order to eliminate any excess material, smoothen rough edges and achieve the final desired shape and surface finish. These operations can be carried out using various machines like milling machines, lathes, or grinding machines.

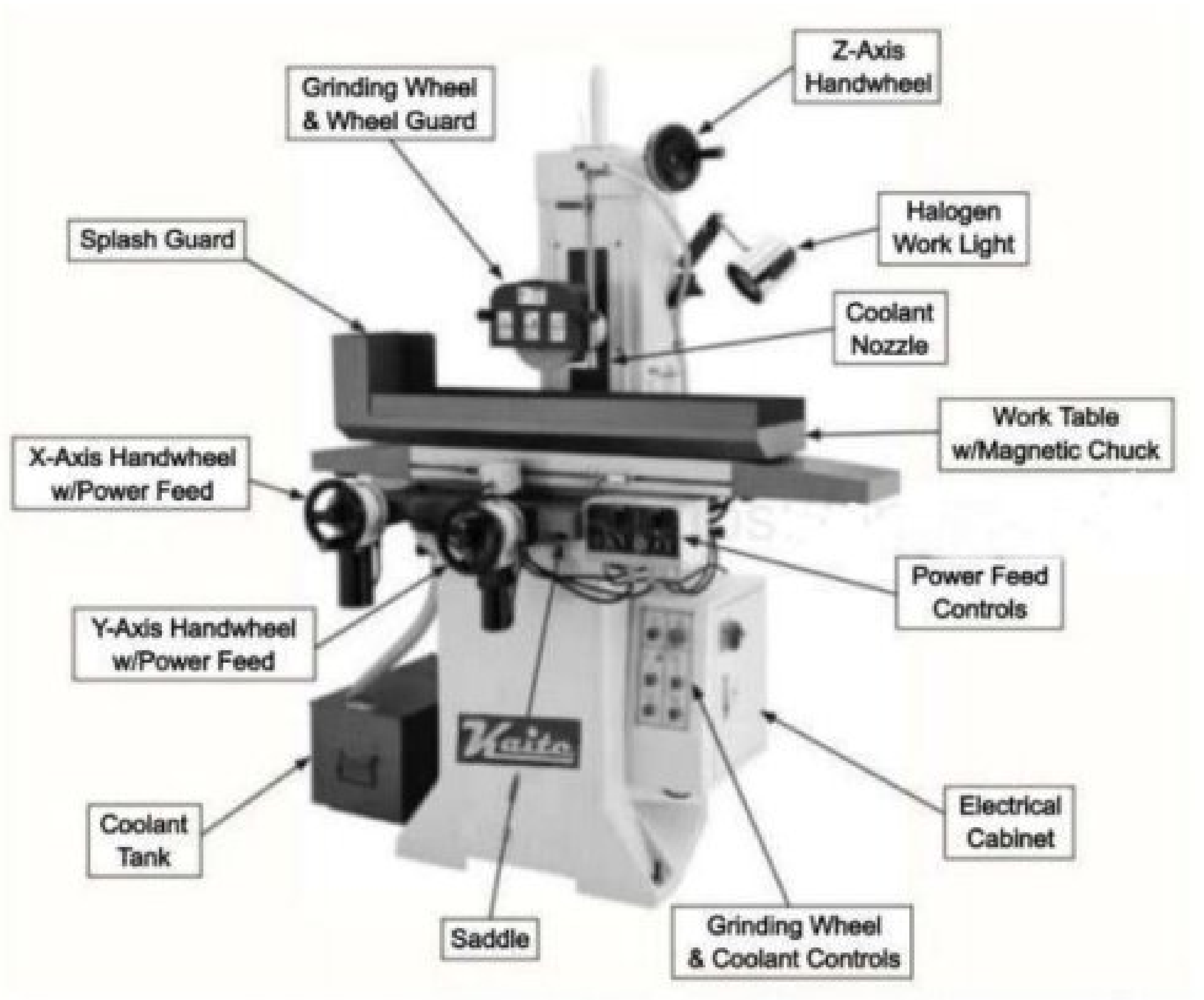


Fig. Finishing Process Machines

Fig. Lathe Machine

It's worth noting that in gravity die casting manufacturers have flexibility in choosing these machines based on factors such as production scale, part complexity, and specific process requirements. To improve efficiency and maintain consistent quality standards. Manufacturers may opt for customized or automated equipment.

5.2 CNC Machining:

CNC machining, a highly automated and precise process utilizes computer controlled machines to intricately shape and remove material from a workpiece. This method is widely employed in diverse industries, such as aerospace to achieve accurate and intricate shapes.

Fig. CNCMachine

5.2.1 Machines in CNC Machining

CNC Milling Machine:

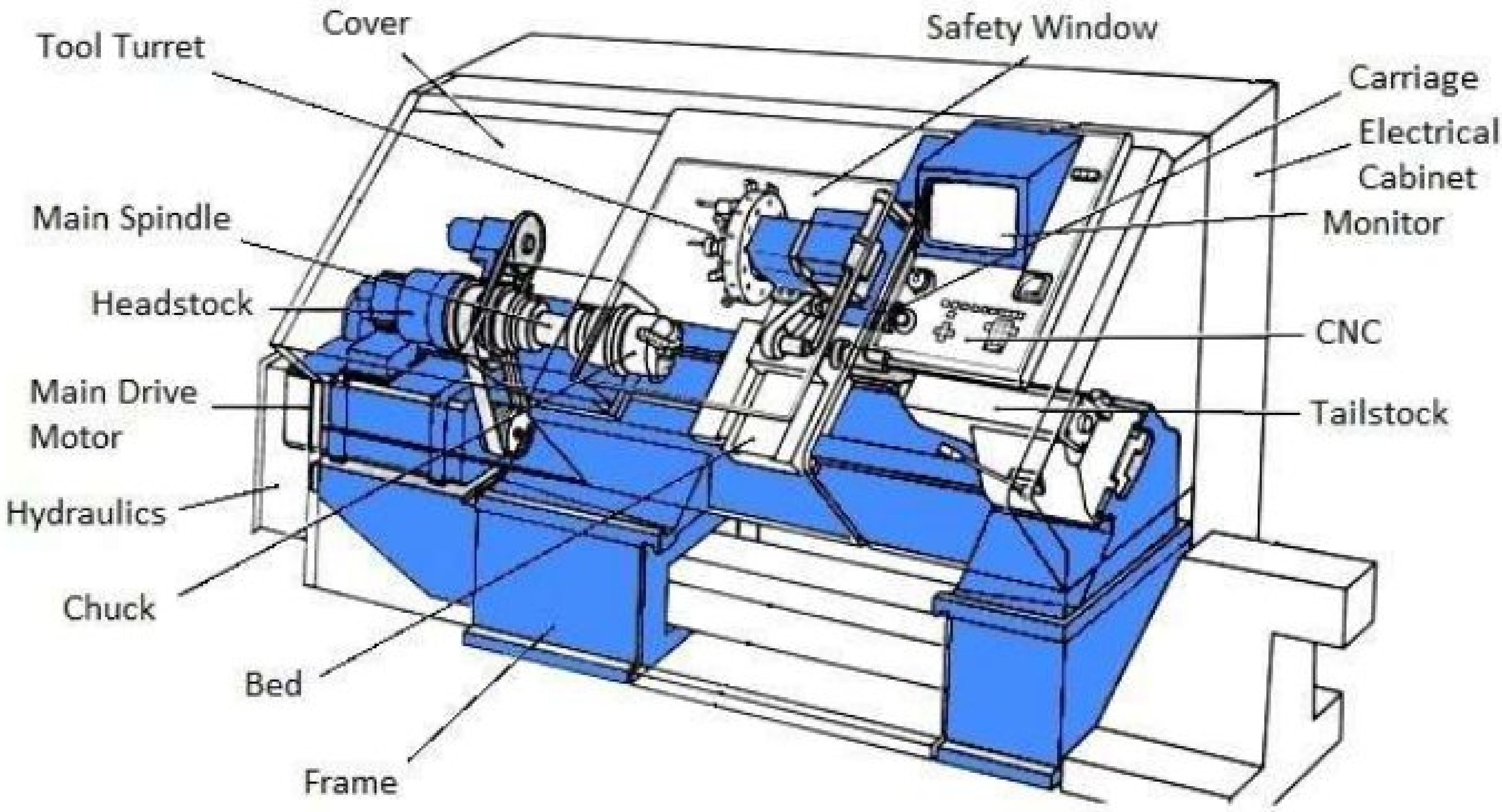


Fig. internals of CNC Milling Machine

CNC milling machines rely on computer technology to operate rotary cutters that eliminate material from a workpiece. These machines are capable of executing various tasks, such as drilling, cutting, and contouring with exceptional accuracy to attain intricate shapes and features. In the aerospace field. CNC milling machines find extensive application for machining engine components, turbine blades, and other crucial parts.

CNC Lathe:

CNC lathes are computer-controlled machines used for turning operations. They rotate the workpiece while cutting tools remove material to create cylindrical shapes, threads, or other features. CNC lathes are utilized in the aerospace industry for machining shafts, engine components, and other cylindrical parts.

CNC Grinding Machine:

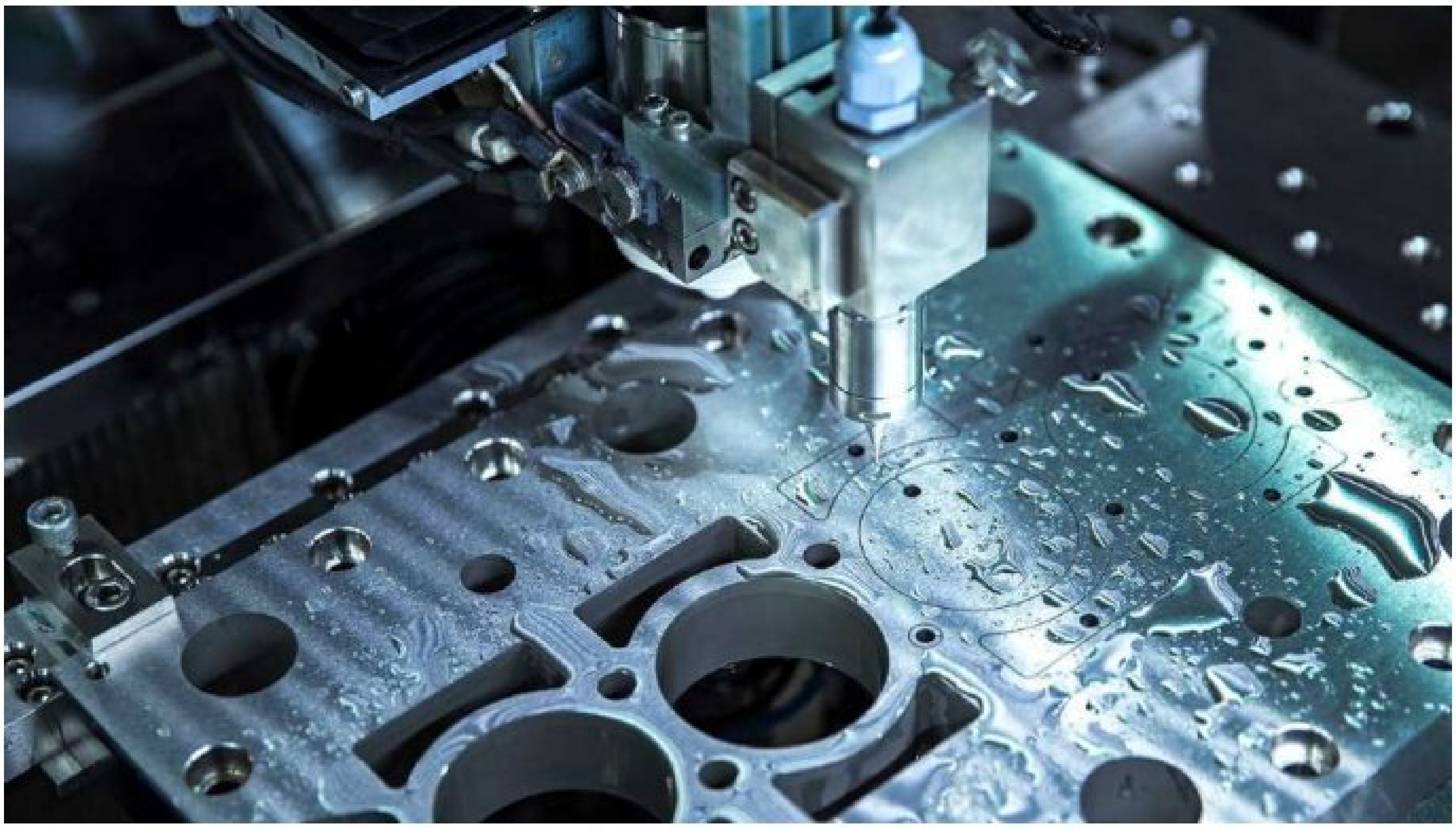


Fig. Grinding Machine

CNC grinding machines use computer control to precisely remove material from a workpiece using grinding wheels. They are capable of achieving tight tolerances, fine surface finishes, and complex geometries. CNC grinding machines are commonly used in aerospace applications for precision machining of turbine components, bearing surfaces, and other critical parts.

5.3 Procedures

Steps in Machining Processes:

The specific steps involved in gravity die casting and CNC machining processes can vary depending on the part being produced and the desired specifications. However, some general steps in machining processes include:

Set Up and Preparation:

This involves securing the workpiece in the machine, aligning it properly, and mounting necessary tools or fixtures.

Tool Selection:

Choosing appropriate cutting tools, grinding wheels, or other tooling based on the desired operation, material, and specifications.

Machining Operations:

Performing machining operations such as turning, milling, or grinding based on the required dimensions, features, and surface finishes.

Quality Control:

Inspecting the workpiece during and after machining to ensure it meets the required tolerances, surface finishes, and specifications.

6.0 Green Manufacturing & Sustainability

Gravity die casting and CNC machining are manufacturing processes commonly used in various industries. Let's evaluate their sustainability aspects and potential areas for improvement:

6.1 Gravity Die Casting:

Gravity die casting is not inherently considered a green manufacturing process due to certain factors:

a) Energy Consumption: Gravity die casting involves heating the metal to its molten state, which requires significant energy input. The melting process typically involves the use of furnaces or other heating equipment, which can contribute to high energy consumption and greenhouse gas emissions.

b) Material Waste: Although gravity die casting can produce precise and high-quality components, there is still a certain level of material waste involved. The excess material, such as overflow or flash, needs to be trimmed or removed, resulting in material waste.

To improve the sustainability of gravity die casting, the following measures can be implemented:

a) Energy Efficiency: Manufacturers can adopt energy-efficient furnaces and equipment to minimize energy consumption during the melting process. Additionally, optimizing the heating and cooling cycles and implementing effective insulation can reduce energy waste.

b) Material Optimization: By carefully designing the mold and gating system, material waste can be minimized. This involves minimizing the use of excess material and designing efficient gating systems that reduce the need for excessive trimming or machining.

c) Recycling and Waste Management: Implementing effective recycling and waste management practices can help reduce the environmental impact of gravity die casting. This includes recycling and reusing metal scraps and implementing proper disposal procedures for waste materials.

6.2 CNC Machining:

CNC machining also presents sustainability challenges, but it offers certain advantages over traditional machining methods:

a) Material Waste: CNC machining involves removing material from a solid block or workpiece to obtain the desired shape. This can result in a significant amount of material waste, especially when machining complex or intricate parts.

b) Energy Consumption: CNC machines require electrical power to operate, which contributes to energy consumption. The energy usage can be substantial, particularly for heavy-duty machining operations or when running multiple machines simultaneously.

To improve the sustainability of CNC machining, the following approaches can be considered:

a) Design Optimization: By implementing design-for-manufacturability principles, parts can be designed with minimal material waste in mind. This involves optimizing part geometry, nesting components for efficient material usage, and minimizing excess material allowances.

b) Machining Efficiency: Optimizing machining parameters, such as cutting speeds, feed rates, and tool selection, can improve efficiency and reduce energy consumption. Advanced tooling technologies, such as high-speed machining and optimized tool paths, can also enhance productivity and reduce machining time.

c) Recycling and Material Management: Implementing recycling programs for metal chips and scraps generated during CNC machining can help reduce waste. Recycling programs can involve collecting and reprocessing the waste materials for reuse, reducing the reliance on virgin raw materials.

d) Coolant Management: Proper coolant management, such as recycling or filtering coolant fluids, can reduce waste and minimize environmental impact. Using environmentally friendly and biodegradable coolant fluids can also contribute to sustainability.

By implementing these strategies, both gravity die casting and CNC machining can move towards greener manufacturing practices and contribute to overall sustainability goals.

7.0 Conclusion

In conclusion, this report highlights and describes the type of processes involved in manufacturing each component of a hand coffee grinder. Analyzing and discussing each step, from material selection, to types of process, estimated cost, alternative processes and types of machines used in the manufacturing. Furthermore, in line with the recent sustainability movements, a section is dedicated to discuss green-manufacturing and eco-friendly alternatives of the manufacturing processes, as well as sustainable changes to be made in the procedures.

Lastly, the report effectively illustrates the technical drawings of each component, highlighting the importance of GD&T in manufacturing through practical examples, and discusses each process required to obtain the end product from start to finish.

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