Comparative Study and Analysis Of 3D Printed and Industry Printed Mould Cast.

Gurdeep Singh Sohal

Guide: MR. DINESH DUBEY,Assistant Professor,

Department of Mechanical Engineering,

RSR Rungta College of Engineering and Technology, Kokha Road, Kurud,bhilai.

Abstract:

The goal of this research is to identify and compare the quality of industrial and 3D Printed Mould specimens created by injection moulding and 3D printing. This is to see if new cutting-edge technologies employed in 3D printing may replace classic production processes such as injection moulding. 3D printing and injection moulding are both methods for generating plastic parts and components, but each has advantages and disadvantages. 3D printing is an additive printing method that produces items by building up layers of material, whereas plastic injection moulding produces parts and components by filling a mould with molten material that cools and solidifies.Although both injection moulding and 3D printing may be used for prototype, there are some significant distinctions between the technologies.

INTRODUCTION

When developing items or components, designers take into account a wide range of aspects that will eventually influence the performance and mechanical characteristics of any particular product. Because technology is always being created and fine-tuned, there is a wide range of production processes that may all generate identical-looking items with unique features. It is critical for an engineer to be able to discern between various strategies and choose an acceptable route to allow for best performance for the planned application.

Many firms presently employ tried-and-true technologies that have a high success rate, most notably injection moulding. Having said that, 3D printing is becoming increasingly popular, with many manufacturers viewing this cutting-edge technology as a viable substitute for injection moulding. This technology has shown to be perfect for prototyping, allowing producers to provide clients a visual representation of the product.

Each technique has advantages and disadvantages, although they are mainly limited to costs, lead times, adaptability, and efficiency. Several destructive and non-destructive mechanical tests may be done to acquire a better knowledge of these procedures and how they affect the mechanical characteristics of the specimen. The primary goal of this inquiry is to compare the differences in specimens produced by both methods of manufacture and to conduct various tests to determine whether approach is preferable.

1.1 The Key Differences

1. Injection moulding is preferable for high-volume production with low material waste.

2. 3D printing is a longer process, but it is easier to set up, allows for frequent design modifications, and is ideal for complicated designs.

1.2 3D Printing

3D printing (also known as additive manufacturing) has quick turnaround times of 1-2 weeks, making it perfect for rapid prototyping and designs that change often. This procedure may also create relatively tiny plastic parts and components, making it excellent for complicated or detailed designs. It is, however, ideally suited to print components for modest production runs of 100 pieces or less, as bigger runs can be time and money consuming.

1.3 Injection Moulding

Because injection moulding takes a long time to prepare for the fabrication of components (5-7 weeks for simple parts), it is not well adapted to rapid design modifications. Despite the lengthy turnaround times, this technique is suited for creating high-volume components (1,000+ units per run). The mould tool may also be used to create big or tiny components of any complexity.

CHAPTER – 2 LITERATURE

REVIEW 2.1 BACKGROUND

Chen-Yu Liu's original work was a direct evaluation of several fast prototyping technologies and their impact on mechanical characteristics. SLS was compared to other technologies such as FDM and Polyjet. Liu's thesis delved into considerable detail by comparing several construction orientations (Horizontal, Vertical, and Side) on various materials and studying the influence each has on the mechanical characteristics of said component. Numerous experiments, including tensile testing, water absorption testing, shore hardness testing, and microscopy, were carried out for the objective of the inquiry. According to the findings of Chen-Yu Liu's detailed investigation, the horizontal construction orientation surpassed the others in terms of dimensional accuracy, meaning that the actual dimensions of the specimens made were as near to the required measurements as feasible. Other areas of investigation revealed that Polyjet RP had the best tensile and hardness qualities, beating all other alternatives. Because the build orientation and kind of RP employed are determined by the intended application, there is no conclusive conclusion as to which is the best method/direction to use; rather, the data can be used as a reference for individuals interested in this area of manufacturing (Liu, 2013).

Joseph Ahlbrandt's Following on from Liu's work, Ahlbrandt's thesis gave a better understanding of 3D printing, as well as parallels to a typical manufacturing process, injection moulding. Ahlbrandt proceeded to employ the same RP procedures and a range of materials in each, which were then directly compared to specimens made by plastic injection moulding (PIM). The testing protocols used in this comparison were similar to those used in Liu's research, with the exception that PIM was also examined.

Ashokgundeti, Sivaramakrishna, The dimensional accuracy of 3D printing with PLA material is better than injection moulding with ABS, which is better than 3D printing with ABS, according to comparison research of 3D printing with injection moulding. There were 0.066mm, 0.068mm, and 0.13mm on average differences noted. The starting box is produced via injection moulding and 3D printing at 0.198mm and 0.165mm, respectively. Using an average surface roughness value of 0.45 microns, injection moulding has a smoother surface than 3D printing with PLA material, which comes in second at 2.34 microns. At 3.53 microns, a surface that is relatively rough is observed in 3D printing utilising ABS material. The cost of producing an electronic casing and a starter box using injection moulding in large quantities is calculated to be Rs. 15.86 and Rs. 148, respectively. The initial cost of purchasing the injection moulding equipment, machine die, and operational expenditures is, however, quite significant when compared to 3D printing.

Chengcheng Li and Chong Tan, In addition to the vast advances in science and technology that will continue to be produced, the current social climate is also marked by the rapid development and widespread use of sophisticated industrial technologies. Future industrial design will be impacted by 3D printing technology in almost every aspect. The emergence of three-dimensional printing technology has helped the industry, which depends heavily on creative design. Through research in the field of 3D printing in the field of industrial design, 3D printing technology has significantly increased the opportunities for industrial design. Industrial designers have the power to fundamentally alter the way that items are traditionally produced in order to create products that are more innovative and distinctive. Many manufacturing sectors are currently adopting 3D printing technology for product creation, which increases firm production efficiency and brings in a sizable profit. In order to meet client needs and advance humanity, designers will concurrently implement more sound ideas from a number of angles.

K Naresh, R Jayaganthan, M SelvaPriya, and R Velmurugan, A lot of factors affect how much an injection-molded product costs, which is often much more than a 3D-printed item (Energy, mould size, number of parts, etc). Using this method, it is exceedingly challenging to produce a component with complex 3D geometry, necessitating a higher initial mould cost. Therefore, it is critical to develop a different method of producing thermoplastic polymer components for uses such as fans, electric motors, radio-controlled aircraft, and toy helicopters. These buildings are subjected to frequencies below 20 Hz. Utilizing frequency characterisation research is crucial because it hasn't been extensively explored. With the help of cutting-edge, commercially available "Cura" software, the current study aims to construct a desktop-based in-house 3D printer that uses fused deposition modelling (FDM), as well as characterise the mechanical and thermal behaviour of two different thermoplastic polymers: polylactic acid and acrylonitrile butadiene styrene (ABS) (PLA). Specimens are printed using two different infill patterns, rectilinear and triangular, and four different layer heights (0.1, 0.2, 0.3, and 0.4 mm). When the mechanical properties of these 3D printed samples were compared to those found in the literature for injection moulding machines and other 3D printers, a fair amount of agreement was found. With the use of the dynamic mechanical analyzer (DMA) and differential scanning calorimetry (DSC), the viscoelastic properties and glass transition temperature (Tg) are investigated, respectively.

Michael Gabriel Mendible, Direct metal laser sintering (DMLS) with bronze, stainless steel machining, and jetted photopolymer (PolyJet) 3D printing with digital ABS were the three insert materials and production techniques that were examined. The insert surface temperature, longevity, and component properties were all evaluated during moulding trials. Computer simulation was used to obtain complementary data.

Mozaffar Mokhtari, Alistair Mcilhagger, Edward Archer, Eileen Harkin-Jones, and Atefeh Golbang, Injection moulding and 3D printing were used to compare the mechanical properties of high-performance PEEK nanocomposites with IF-WS2 loadings of 0.5, 1, and 2 wt percent (FDM). Despite having somewhat higher levels of crystallinity than injection-molded samples, the 3D printed samples had lower Young's modulus and tensile strength by about 82–87 percent and 73–85 percent, respectively. Due to inadequate inter-layer bonding, voids, and reduced packing density compared to injection moulded counterparts, 3D printed samples have inferior mechanical properties.

CHAPTER–3PROBLEM IDENTIFICATION

3.1 Problem Statement

1) **Quality Concern** - Parts made with traditional injection moulding techniques are more prone to have quality issues, especially non-dimensional flaws that are invisible to the naked eye. Each piece of moulding machinery and resin is unique. As a result, it is almost impossible to produce components that are completely uniform every time without some variance. These changes can occasionally be slight and absorbed throughout the procedure. The variation can occasionally be so severe that it negatively affects the part quality. In the ideal situation, the injection moulder discovers these problems during or after manufacture, and the customer is never made aware of the problem. However, occasionally faulty components reach the OEM and wind up in their finished product. Once this happens, they can result in field failures, which could endanger a company's reputation and brand and increase the possibility of product liability.

2) **Cost Concern** - If a process is poorly designed and produces excessive scrap, the higher cost may be passed on to the user in the form of an increase in price. High scrap and rework costs typically find their way back into a piece price to make up for them. However, if an injection moulder covers these costs internally, they run the risk of losing their ability to make a living. This could force companies to scale down crucial activities like investing, which could harm their long-term profitability. In the worst-case scenario, the company might even fold down or be sold. These incidents may severely damage a client's supply chain.

3) **Time Issue** - Production problems may cause delays in the delivery of parts, which may force an OEM's production line to shut down unannouncedly. Quality control must perform a time-consuming sorting process and/or another moulder production run when it discovers defective components. For an OEM, these delays can be very expensive.

3.2 The paper's goal is:

1) Using any 3D printer, create a 3D-printed mould.

2) Pour molten plastic into the 3D-printed mould.

3) Take a cast that was injection-molded.

4) Examine the differences in cast quality between 3D printed and injection-molded casts.

CHAPTER – 4 METHEDOLOGY

4.1 Approaches For this study, it goes like this:

1) Choosing a Minimal Design for a 3D-printed Mold

2) In this instance, a 3.5 Audio Jack Connector Mold is the design.

Choose any Commercial Industrial Injection Molded Jack Design.

4) 3D printing of the Jack Mold

5) Filling the design mould with molten plastic glue.

6) Take the mould out and evaluate it in comparison to the commercially produced design.

7) We'll gauge and contrast roughness, toughness, and hardness.

4.2 Utilization of 3D printers

There are a few things that all 3D printing applications have in common, as was already said. We often advise our 3D printing service customers to create between 1 and 50 units if their component quantities are small. It is important to look into alternative manufacturing processes as production quantities get close to the hundreds. The only option you may have is 3D printing if your design involves intricate geometry that is crucial to the functionality of your product, such an aluminium component with an inner cooling channel.

4.3 3D Printer Selected For This Project:

a) Creality 3D Ender-3

Enders 3 is a manual adjustable X, Y, and Z axis printer with a 220*220*250mm (x- 22cm, y- 22cm, and z- 25cm) printing size capacity. It is a 3D printer for basic and somewhat complex designs. Is the printer SD card based? This prints the model in.stl format after reading it from an SD card. To create models, filament material is needed.

Fig 4.1: Creality Enders 3 3D printer

b) Material for 3D printers:

3D printing filament serves as the thermoplastic feedstock for 3D printers that use fused deposition modelling. There are many different types of filament available, each with special characteristics that require printing at a specific temperature. The two standard sizes of filament are 1.75 mm and 2.85 mm. Although this is not to be confused with the less common filament size that is 3 mm in diameter, 2.85 mm filament is commonly wrongly referred to as "3 mm."

There are numerous nozzle and filament size combinations that can be used, and filament size should not be confused with nozzle size. The most frequent nozzle size is 0.4 mm, followed by 0.35 mm and 0.25 mm.

4.4 Software Used: UlimakerCura:

An open source 3D printer slicing programme is called Cura. David Braam, a creator of 3D printers, created it, and Ultimaker later hired him to maintain the software. The LGPLv3 licence governs the distribution of Cura. The LGPLv3 licence replaced the open source Affero General Public License version 3 that Cura was originally distributed under on September 28, 2017. This adjustment improved interaction with outside CAD applications. The code is developed on GitHub. Over a million people use UltimakerCura worldwide, and 1.4 million print jobs are completed each week. Although it is also compatible with other printers, it is the main 3D printing software for Ultimaker 3D printers.

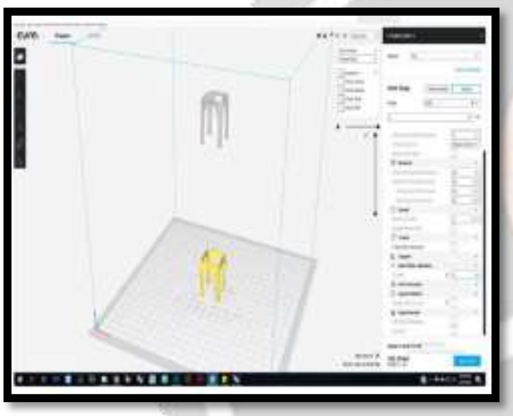

Fig4.2 :UltimakerCura Software

UltimakerCura divides the user's model file into layers and produces printer-specific g-code. Once finished, the g-code may be sent to the printer to create the actual thing. The open source programme can handle files in the most popular 3D formats, including STL, OBJ, X3D, and 3MF, as well as image file formats, including BMP, GIF, JPG, and PNG. It is compatible with the majority of desktop 3D printers.

4.5 Injection Molding:

Injection moulding, also known as injection moulding in the US, is a production technique that creates products by injecting molten material into a mould. There are many materials that can be used for injection moulding, but the most popular ones include metals (for which the process is known as die-casting), glassware, elastomers, confections, and most frequently, thermoplastic and thermosetting polymers. Material for the part is fed into a heated barrel, mixed (through a helical screw), and then injected into a mould cavity, where it cools and hardens to the cavity's shape. After a product is developed, frequently by an industrial designer or engineer, metal moulds, usually made of steel or aluminium, are built and expertly machined to produce the features needed for the item. The process of injection moulding is frequently used to create a wide variety of parts, from small pieces to complete car body panels. Advances in 3D printing technology, such the usage of photopolymers that don't melt during the injection moulding of some lower-temperature thermoplastics, can be used for some simple injection moulds.

4.6 Mold:

Molding equipment, often known as a die or mould, is used to create plastic objects.

Due to the high cost of building moulds, they were frequently used only in mass manufacturing when producing thousands of items. Aluminum, pre-hardened steel, hardened steel, and/or beryllium-copper alloy are frequently used to make moulds. The choice of material for a mould is mostly a matter of economics; steel moulds typically cost more to build but have a longer lifespan, which offsets the higher initial cost over a larger number of components produced before wearing out. Pre-hardened steel moulds are used for larger components or lower volume requirements since they are less wear-resistant; their typical Rockwell-C hardness varies from 38 to 35.

After machining, heat-treated hardened steel moulds are far superior in terms of wear resistance and durability. Rockwell C ratings typically range from 50 to 60. (HRC). Aluminum moulds are far less expensive, and they may be cost-effective for producing tens of thousands or even hundreds of thousands of parts when developed and made using modern computerised technology. In areas of the mould that need to quickly remove heat or that generate the most shear heat, beryllium copper is used. The moulds can be made using CNC machining or electrical discharge machining technologies.

Fig4.3 :Standard two plates tooling – core and cavity are inserts in a mould base – "familymould" of five different parts

4.7 Design Selected 3.5 Audio jack Connector:

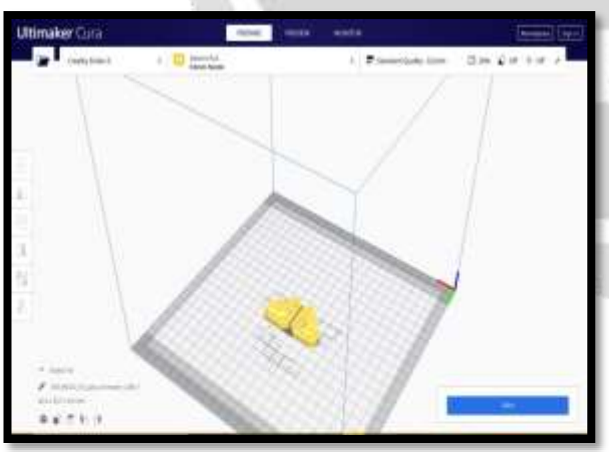

Fig4.4: Design 3D view In ultimaker Cura

An audio connector with dimensions of 62.4x33.7x8.4 mm was chosen as the design for 3D printed mould testing. Because large moulds require too much time, small size moulds are chosen. It takes roughly an hour to create this mould. Larger designs require 8 to 12 hours of work.

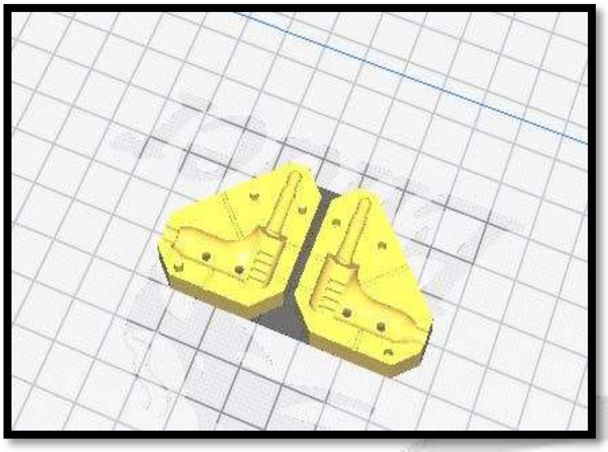

Fig4.5 : Design Mold Closeup View

4.8 The steps for creating a mould using a 3D printer are as follows:

1) The first design must be created using CAD software, such as Ultimaker Cura.

2) Subsequently, it must be transformed into.stl file format (because 3D printing hardware only recognises files with the.stl file extension).

3) The design is converted into a.stl file format by hitting the slice button in Ultimaker Cura.

4) Insert the SD card containing the file into the 3D printer hardware.

5. Decide whether to initialise the SD card.

6) Then, choose the file that you want to print.

7) Hardware will begin printing and display the proportion of remaining pages.

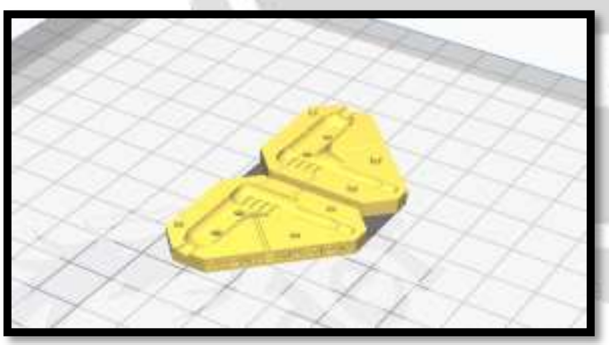

Fig4.6 : Design Closeup View 2

CHAPTER – 5 RESULT

5.1 3.5 Jack Mould Design In Enders 3 3D Printer

Fig5.1 :Mould making in 3D printer with Software Ultimaker Cura

First, a design is created in the 3D printer software. For this project, Ultimaker Cura is used to transform the design into.stl file format, which is then provided to the printing gear.

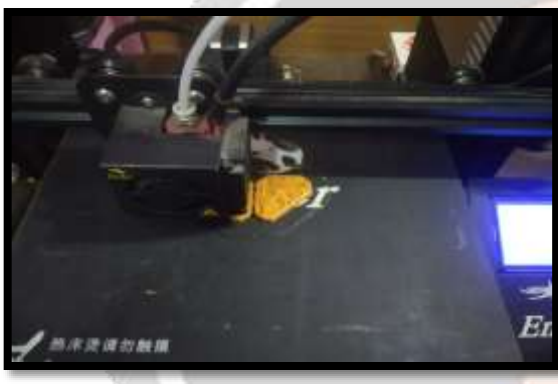

Fig5.2: Mould Design Making In 3D Printer

5.2 The 3D printed Mould exhibits the following characteristics as of this point:

1) This design takes an hour to make.

2) The exterior of the final mould structure is rough.

3) Prior to applying any cast work, cleaning and finishing are required.

4) Small size.

5) Low Heat Resistance.

6) Simple to Break.

7) Can only be used for casting with soft or low-temperature polymers.

8) There's a chance for intricate patterns.

Fig5.3: Mould After Cleaning

5.3 3D Printed Mould casting:

Fig5.4: Inserted Audio jack for outer covering and casting

The metal piece for the audio jack is placed on the mould to begin the casting process. Place Jack on one side of the mould, then use another mould part to seal it.

Fig5.5: Opening The 3D printed Mould after 5 minutes of cooling

Occasionally, because the casting materials can't effectively bond with one another due to poor adhesiveness, the cast breaks after cooling down.

Fig5.6: Taking Out The cast From 3D printed Mould

The casting jack cover is seen in the image above following proper casting. it is heat resistant but flexible.

5.4 The Industrial Cast's Points are as follows:

A. Compared to mould casting from 3D printers, industrial mould casting can withstand only somewhat high temperatures. Its outside finishing is also superior.

b. The industrial mould casting metal mould is ready.

c. Highly Heat Resistant.

d. The cast material is filled by injection moulding.

g. The outer layer of the Final Cast is complete.

5.5 Compare Industrial Mould cast With 3D Printed Mould Cast

Fig5.7 : Observation Comparison Between 3D Printed Mould cast and Industrial Mould Cast

5.6 Considerations for the Results:

The following are the points of comparison between the industrial mould cast and 3D printed mould cast:

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1) If you want to create your own components, one of the first things you should consider is the cost of investing in 3D printing vs die casting. While 3D printing has zero upfront expenses, die casting requires a significant upfront investment. Die casting has a far lower unit cost than printing, on the other hand. With either, you'll need to clean and replace parts frequently, which will cost more money.

2) The difference is in how these systems function. Similar to sculpting is die casting. The process involves pumping liquid metal into a mould or die, which produces a cycle time that is shorter (30-45 seconds) than printing. Additive manufacturing, often known as 3D printing, is the process of building an object layer by layer on a material (common materials include metals and polymers such as thermoplastic polymer, polylactic acid, and acrylonitrile butadiene styrene). Small, heated layers of material are deposited on top of one another in a procedure called deposition to produce the 3D object.

3) Because die casting produces extra trash, you must pay to have it hauled away. On the other side, you don't need to build a new die every time you make a new part because one die lasts for 80,000 shots. Die casting is also considerably quicker if you need a large number of the same part. It becomes more cost-effective when the mold/die expense is spread out across the entire sum.

4) Die casting is substantially faster when creating several identical components from the same material, hence producing large numbers is typically more economical.

5) There are a number of clear benefits to 3D printing. One benefit is that you won't need to build a die for every product you want to manufacture. A 3D printer can create any part with almost no complexity restrictions if it is set up properly.

6) Due to this capability, 3D printers are a good option for making a range of objects, especially complex ones. Particularly if the components are really intricate, you might not want to invest the time and resources necessary to create a die for a hundred distinct small pieces. Similar to this, a lot of parts could be too complex to cast in a single piece but easier to make using a 3D printer.

7) Time savings is the biggest benefit of 3D printing. Companies that produce products with short life cycles or that need to launch products before their competitors are essential to have the ability to design a part in a couple of days.

8) Bear in mind that not all 3D printers are created equal if you want to utilise one to create some or all of your parts. Some are quite cheap, which could be alluring in the short term but might affect the calibre of your final product. If you want to utilise 3D printing, you should be informed of the capabilities and limitations of the printer you choose.

9) If your budget permits it, think about buying a high-end 3D printer. These versions frequently provide better capabilities and higher quality. Prior to beginning high-volume production, metals are more suited for attaining the fit and function of the product.

CHAPTER – 6 CONCLUSION & FUTURE SCOPE

6.1 Conclusion:

Since plastic components are often precise parts that may need the accuracy offered by a 3D printer, 3D printing is routinely employed to create them. Additionally, plastic cannot be die cast as easily as metal, but high-quality plastic pieces may be injected. The best choice for small quantities of specialty products can be 3D printing. However, die casting is without a doubt the finest choice if it is necessary to produce several copies of a specific sort and size of item quickly. Several companies are integrating die casting and 3D printing for their industrial applications. There's no reason why die casting can't be used to mass make the reliable aluminium or zinc components that serve as any organization's framework. The use of 3D printing services may therefore be used for projects requiring further refining or small-batch production of a product.

In contrast to industrial moulds, which may need months to produce, 3D printing moulds may be made in as little as 2-3 hours and as much as 8-12 hours, as seen in the photographs above. Mold and casting made with 3D printing are designed for low-level production using constrained materials like low-temperature plastics. Die casting or industrial mouldcasting are the sole solutions if a high-quality and long-lasting cast is required. Therefore, the best alternative for numerous mass manufacturing is die casting, whereas 3D printers are the best choice for single use, quick design, and mould building.

6.2 FUTURE SCOPE

Die casting is an extremely popular, reliable, and effective way to make metal products. High-quality, homogenous parts in nearly any size, part shape, surface roughness, or finish are available from die cast components. Since other parts, such as studs, hinges, drill holes, and bosses, to mention a few, may be incorporated in the design, they also require a small number of extra procedures.

An established manufacturing method called die casting is now greatly aided by cutting-edge innovations like 3D printing. Since a 3D printer can produce practically anything you can imagine and create a sketch of, 3D printing, also known as additive manufacturing, gives engineers more design options.

1. Serial manufacturing will increasingly use 3D printing.

2. Integrated and user-friendly design software will improve for additive manufacturing.

3. More 3D printing applications and acceptability will be made feasible by emphasising education.

4. 3D printing will be a key production method in the dental industry.

5. The intelligence of 3D printing will increase.

6. The need for 3D printing service providers will increase.

7. 3D printing for metal will advance.

8. There is enormous commercial potential for composite 3D printing.

9. The industry will place a lot more focus on automation.

10. The additive manufacturing market will become more competitive.

The patterns suggest that 3D Printing has a bright future.

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