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An Empirical Analysis of a Component Fabriated Using 3D Printing Technique and Injection Moulding Process

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Abstract: This empirical analysis presents a comparative study of components fabricated utilizing 3D printing techniques and injection molding processes. Focused on the production of fiber gears and fiber T-joint pipes, the study aims to assess the strengths, limitations, and applicability of these manufacturing methods within these specific contexts. The investigation showcases the distinctive attributes of 3D printing, highlighting its process in rapidly prototyping intricate designs and enabling customizable features in both fiber gears and T-joint pipes. This empirical analysis compares 3D printing and injection molding techniques for fabricating fiber gears and fiber T-joint pipes. It highlights 3D printing's agility in customization and rapid prototyping, contrasting with injection molding's efficiency in mass production and standardized components. The study emphasizes the need for a nuanced approach in choosing the appropriate manufacturing method based on design complexity, volume requirements, and material properties. Overall, it provides crucial insights for industries aiming to optimize manufacturing processes for specific component needs.

Index Terms **- Printed Gear and T-Joint Pipes.**

I .INTRODUCTION

Fiber gears within a printer are integral components that perform a vital role in enabling the intricate mechanical movements required for the printing process to unfold seamlessly. These gears, fashioned from a diverse range of materials, find their prominence in the realm of printers, with plastic emerging as a prevalent choice owing to its multifaceted advantages.

The utilization of plastic gears in these mechanisms stands as a testament to their lightweight nature and exceptional durability, factors that contribute significantly to the efficacy and longevity of the printing apparatus. The pivotal significance of fiber gears in a printer cannot be overstated, as they serve as the linchpin in orchestrating the intricate dance of mechanical precision necessary for transforming digital designs into tangible prints. Gears are used where constant velocity ratio is required, and they provide low effect of forces on shafts on which gears are mounted. For power transmission purpose minimum two gears are required, the gear one which is in small diameter than other device is called pinion and other is called gear. When rotational speed applied between contacting gears, axis of rotation of two gears are different with respect to each other.[3]

The discerning choice of plastic gears in printers resonates with their remarkable durability, proving to be stalwart companions in the face of repetitive movements and operational stress. Their robustness serves as a shield against wear and tear, contributing significantly to the printer's reliability and sustained performance over time. Moreover, the resilience of plastic gears translates into cost-effective maintenance, reducing the need for frequent replacements and fortifying the printer's overall operational efficiency.

In the intricate symphony of printer mechanics, these fiber gears crafted from resilient plastic emerge as unsung heroes, bearing the weight of operational demands while orchestrating the ballet of movements required for flawless printing. Their presence signifies a thoughtful fusion of technological innovation and material expertise, aligning perfectly with the pursuit of optimal functionality and reliability within the realm of printing technology. As technology advances and printers evolve, the role of plastic fiber gears continues to stand resolute, symbolizing not just a choice of material, but a testament to the artistry and engineering finesse that goes into crafting these silent yet indispensable components. In essence, these gears epitomize the harmony between material science and mechanical prowess, underscoring their indispensable role in the intricate machinery of printers. Fiber T joint pipes stand as a pinnacle of engineering ingenuity, representing the convergence of innovation and functionality in the realm of piping systems. Crafted from a specialized blend of fiber-reinforced materials, these T-shaped conduits serve as a testament to the evolution of composite fibers and reinforced plastics, redefining the landscape of piping solutions. In stark contrast to their conventional metal counterparts, these pipes carve a niche with their remarkable attributes, offering a harmonious blend of lightweight design and unparalleled durability.

The core essence of fiber T joint pipes lies in their composition, meticulously fashioned from a symphony of composite fibers and reinforced plastics. This unique amalgamation of materials forms the bedrock of their strength and resilience, elevating them beyond mere conduits to veritable bastions of structural integrity. The strategic infusion of fiber reinforcement endows these pipes with an exceptional capacity to withstand varying degrees of pressure, making them a versatile choice for an expansive array of industrial applications. Moreover, the innate lightweight nature of these fiber T joint pipes emerges as a defining feature, revolutionizing the paradigms of traditional piping systems. Their reduced weight not only simplifies handling and installation but also contributes significantly to overall operational efficiency. This characteristic, coupled with their unparalleled durability, renders these pipes as stalwart assets in industries where robust and dependable piping solutions are imperative. For applications such as automotive and aerospace engineering, polymer gears have unique advantages over metal gears: low cost and weight, high efficiency, quietness of operation, functioning without external lubrication, etc. The performance of 3D printed gear has been investigated previously.[2]

FAILURE CHARACTERISTICS:

- **Fiber gears made by conventional method used in a printer:**

Failure Characteristic : Wear :

Abrasion: This happens when particles or debris get between the gear teeth, causing them to rub against each other and wear down over time. Abrasion causes the surfaces of the gear teeth to become roughened, which can increase friction and noise during operation. The abrasive action gradually removes material from the gear teeth, leading to dimensional changes, loss of tooth profile, and ultimately affecting the gear's performance and functionality. Abrasion can lead to an increase in the clearance between mating gear teeth, resulting in decreased efficiency, increased backlash, and potential gear misalignment. Abrasion generates wear debris, which can further exacerbate the wear process by acting as additional abrasive particles or accumulating within the gear system, causing further damage.

Prolonged abrasion can degrade the mechanical properties of the plastic material, such as hardness, tensile strength, and fatigue resistance, further accelerating the wear process and increasing the risk of failure. Abrasion generates heat due to friction between the gear teeth, which can further accelerate the wear process and potentially lead to thermal degradation of the plastic material. Polymer gear wear can be divided into three stages; running in, linear and final rapid wear as shown in Table 1.[1]

Table 1: Stages of polymer gear wear

Phase	Explanation
Running in wear	Occurs for a short time but the amount of wear is high
Linear wear	Low amount of wear can be seen but is progressive High wear rate but small amount of debris, indicating debris
Final rapid wear	is due to deformation undergone by the polymer gear caused by thermal effects

Figure 1: Fiber gears within a printer It is subjected to wear failure.

Fatigue: Repeated stress on the gears can lead to fatigue wear, where small cracks develop and propagate through the material until failure occurs. Fatigue in plastic gears refers to the failure that occurs over time due to repeated cyclical loading and unloading of the material. While plastic materials are generally known for their resilience and fatigue resistance, Fatigue in plastic gears often begins with the initiation of small cracks, typically at stress concentration points such as corners, notches, or defects in the material. Once initiated, these cracks can propagate gradually over time as the gear is subjected to cyclic loading during operation. The cyclic loading causes the crack to grow incrementally with each loading cycle. As the crack propagates, it weakens the material around it, leading to a gradual degradation of mechanical properties such as stiffness and strength. Eventually, the accumulated damage reaches a critical point where the remaining material is unable to withstand the applied load, leading to sudden and catastrophic fracture of the gear.

Friction: Friction between the gear teeth can cause material loss over time, especially if lubrication is inadequate. Friction in plastic gears occurs due to the resistance encountered when the gear teeth slide against each other during operation. While plastic materials generally exhibit lower friction coefficients compared to metals, friction can still occur and impact the performance and lifespan of plastic gears.

The choice of plastic material can significantly influence friction behavior. Some plastics have inherently low coefficients of friction, while others may require additives or surface treatments to reduce friction. The surface finish of the gear teeth plays a crucial role in friction. Smoother surfaces generally experience lower friction, while rough surfaces can lead to increased friction and wear. Proper machining or finishing processes can help achieve smoother gear surfaces.

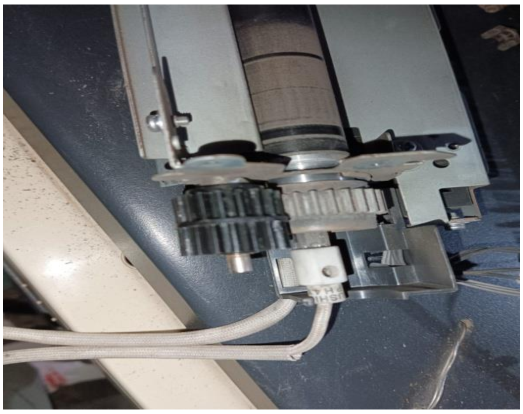


Figure 2: Friction between the gear teeth.

Improper design and manufacturing:

Gears that are poorly designed or manufactured may have uneven stress distribution, leading to premature wear in certain areas. Improper design and manufacturing processes can lead to various issues in plastic gears, affecting their performance, reliability, and longevity.

Selecting the wrong type of plastic material for the gear application can result in inadequate mechanical properties, such as insufficient strength, stiffness, or wear resistance. Poor tooth engagement or meshing characteristics may also lead to inefficient power transmission and reduced gear life. Inadequate surface finish or roughness can promote increased friction, wear, and noise in plastic gears. Improper machining or molding processes, such as excessive tool wear, poor mold alignment, or insufficient cooling, can result in surface irregularities that compromise gear performance and durability. Variations in gear dimensions, such as tooth thickness, pitch diameter, or concentricity, due to inaccuracies in the manufacturing process can lead to improper meshing, increased backlash, and reduced efficiency. Dimensional inaccuracies can also contribute to premature wear and failure of plastic gears. Improper design features, such as sharp corners, thin sections, or sudden changes in geometry, can create stress concentrations in plastic gears, leading to localized deformation, cracking, or failure under load.

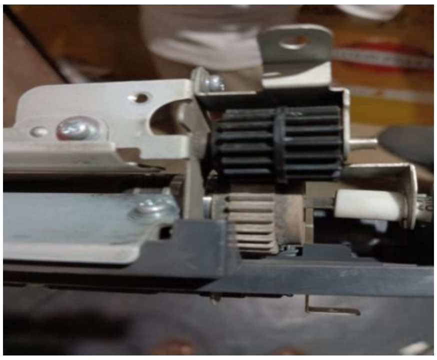


Figure 3: poorly designed or manufactured

- **Fiber T joint pipes made by conventional method used in agricultural realm with marked significance process:**

The failure characteristics of plastic T-joint pipes can vary depending on factors such as the type of plastic material used, the design of the joint, the application conditions, and the quality of installation.

T-joint Failure: T-joints are critical points where pipes are joined together. Failure at the joint can occur due to factors such as inadequate bonding or sealing, improper alignment during installation, or excessive stress concentration at the joint. Joint failures may result in leaks or complete separation of the pipes. In thermoplastic pipes, such as PVC (Polyvinyl Chloride) or HDPE (High-Density Polyethylene), T-joints are often created through fusion welding or solvent bonding. If the fusion or bonding process is not executed properly, it can result in weak joints susceptible to failure. Inadequate fusion can lead to leaks or even complete separation at the joint. Proper preparation of the joint surfaces before welding or bonding is critical for ensuring a strong and durable connection. Failure to adequately clean, smooth, or align the joint surfaces can compromise the integrity of the T-joint, leading to premature failure. T-joints may experience higher stress concentrations compared to straight sections of the pipe, especially if the branch pipe is carrying fluid under pressure. Defects in the manufacturing process, such as irregularities in the pipe wall thickness, inadequate fusion of pipe segments, or impurities in the material, can create weak points in the T-joint susceptible to failure under operational conditions.

Figure 4: Failure at the joint

Cracks: The crack failure of PE pipelines includes rapid crack propagation and slow crack growth. For rapid crack propagation (RCP), when the crack of PE pipelines occasionally happens, the crack rapidly grows at a large speed, which instantly causes the destruction of PE pipelines.[4] Plastic pipes may develop cracks due to various reasons such as impact, stress concentrations, or exposure to environmental factors like temperature fluctuations or UV radiation. Cracks can propagate over time, leading to leaks or structural failure.

Cracks on T-joint plastic pipes can be a concerning issue as they can lead to leaks, structural failure, and potentially catastrophic consequences if left unaddressed. Improper installation practices, such as excessive bending or twisting during assembly, inadequate fusion or bonding of joint components, or insufficient support for the T-joint, can create stress concentrations that promote crack initiation and propagation.Manufacturing defects in the plastic material, such as impurities, voids, or weak spots, can serve as initiation points for cracks. Poor-quality materials or improper storage conditions that expose the pipes to UV radiation or harsh chemicals can also accelerate material degradation and crack formation. Exposure to environmental conditions such as temperature fluctuations, UV radiation, chemical exposure, or soil movement can induce stress on the T-joint, leading to crack development over time.

Figure 5: Plastic pipes may develop cracks.

Fatigue: Cyclical loading or pressure fluctuations within the pipe system can induce fatigue failure in plastic T-joints, especially at points of stress concentration or manufacturing defects. Fatigue cracks may initiate and propagate over time, eventually leading to failure. Fatigue in T-joint plastic pipes refers to the progressive and localized structural damage that occurs when the material is subjected to cyclic loading or stress over an extended period. While fatigue is often associated with metal materials, plastic pipes can also experience fatigue failure, particularly in dynamic or fluctuating pressure environments.

Ensuring adequate support, proper alignment, and reinforcement at T-joints can help distribute stress more evenly and reduce the likelihood of fatigue failure. Additionally, incorporating features such as expansion joints or flexible couplings can absorb dynamic loads and minimize stress concentrations at critical points.

Figure 6: Cyclic Fatique Failures.

II. PROBLEM STATEMENT:

Feasibility study of use of 3D Printed parts for conventional injection moulded parts due to Failures.

The Components are:

• **Fiber Gear. (on printing machine) and Fiber T- joint pipe**

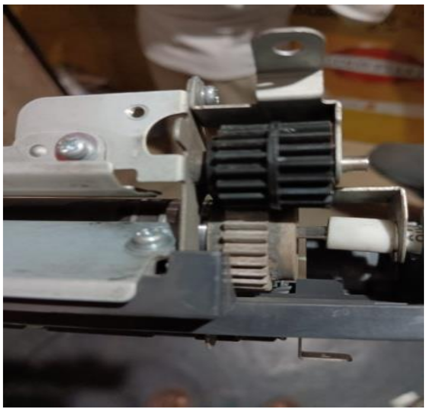


Figure 7: Fiber Gear (printing machine)

Figure 8: Fiber T- joint pipe

III . OBJECTIVE AND SCOPE :

III . I . OBJECTIVE:

• **Fabrication of Gear and T-Joint using 3D printing technique:** Fabricating gears and T-joints using 3D printing techniques can be highly advantageous due to the precision and customization capabilities offered by additive manufacturing. Here's a general process for fabricating these components Utilize CAD (Computer-Aided Design) software to design the gear and T-joint according to your specific requirements. Ensure proper dimensions, tolerances, and structural integrity. Choose a suitable 3D printing technology based on your material requirements, resolution needs, and budget. Common options include Fused Deposition Modeling (FDM), Stereolithography (SLA), and Selective Laser Sintering (SLS). Select a 3D printing filament or resin that offers the necessary mechanical properties and durability for your application. For gears, materials like ABS, PLA, or nylon are often used, while for T-joints, consider factors such as strength and flexibility.

Calibrate the 3D printer according to the specifications of the chosen material. Ensure the build plate is leveled, and the printer is properly calibrated for optimal print quality. Once the printing is complete, remove the printed parts from the build platform carefully. Remove any support structures using appropriate tools. Perform any necessary finishing processes, such as sanding or smoothing, to improve surface quality and remove imperfections. For functional gears, ensure that the teeth are clean and free from defects that could affect performance. Test the fabricated gears and T-joints to ensure they meet the desired specifications and functionality. Conduct stress tests or functional tests to assess durability and performance under simulated conditions. Iterate on the design or printing parameters if necessary to optimize the components for their intended use.

• **Comparison of 3D Printed components with Injection Moulded parts to meet the Design Requirements:** Comparing 3D printed components with injection molded parts involves considering various factors to meet specific design requirements. Injection molding typically has higher upfront tooling costs but lower per-unit costs for high-volume production. 3D printing, on the other hand, has lower upfront costs but higher per-unit costs, making it

more economical for low-volume production or prototyping. Injection molding can produce parts at a much faster rate compared to 3D printing once the tooling is ready.3D printing is slower, especially for complex or large parts, as it builds layer by layer. 3D printing excels in producing complex geometries with intricate details without additional tooling costs. Injection molding is better suited for simpler geometries and larger production runs.

Injection molding offers a wider range of material options, including engineering-grade plastics and elastomers, suitable for various applications. However, 3D printing has been expanding its material selection, offering options like ABS, PLA, nylon, and even metal and composite materials. Injection molding typically provides smoother surface finishes with tighter tolerances, suitable for applications where appearance and precision are critical. While 3D printing can achieve high surface quality with post-processing techniques, it may not match the consistency of injection-molded parts. Injection-molded parts generally exhibit higher strength and durability due to the denser material and uniform structure. However, 3D printing technologies are improving, and certain materials like nylon and carbon fiber-reinforced polymers can offer comparable strength properties.

3D printing allows for rapid prototyping and easy customization, making it ideal for iterative design processes and low-volume production of custom parts. Injection molding requires new tooling for each design iteration, which can be costly and time-consuming. Injection molding can generate more waste during the setup process and may require more energy for operation. 3D printing can be more environmentally friendly for small-scale production or when using biodegradable or recycled materials.

• **Validation of Results:** Validating the results of 3D printed components against injection molded parts involves ensuring that the printed parts meet the required specifications and performance criteria. Measure key dimensions of both the 3D printed and injection molded parts using precise instruments such as calipers or coordinate measuring machines (CMM). Compare these measurements against the design specifications to ensure dimensional accuracy. Evaluate the surface finish of both parts visually and tactically. Assess the smoothness, uniformity, and presence of any defects such as layer lines or surface irregularities in the 3D printed part compared to the injection molded part.

Use surface roughness measurement tools if necessary. Conduct mechanical tests to assess the strength and durability of the parts.

This may include tensile testing, compression testing, impact testing, or flexural testing. Compare the results of these tests between the 3D printed and injection molded parts to ensure that they meet the required mechanical properties. Perform functional tests to evaluate the performance of the parts under real-world conditions. For example, if the parts are components of a mechanical assembly, assemble them and test their functionality.

Assess factors such as fit, clearance, movement, and overall performance. Subject both parts to environmental conditions relevant to their intended use, such as temperature, humidity, exposure to chemicals, or UV radiation.

Evaluate how each part responds to these conditions and compare their performance. Conduct lifecycle testing to simulate the expected lifespan of the parts. This may involve subjecting them to repeated cycles of stress or strain to assess their durability over time. Compare the degradation or wear patterns between the 3D printed and injection molded parts. If any discrepancies or failures occur during testing, perform a detailed analysis to identify the root cause. This may involve examining the microstructure of the materials, analyzing stress concentrations, or investigating manufacturing defects. Use statistical methods to analyze the test results and determine if there are significant differences between the performance of the 3D printed and injection molded parts. Consider factors such as mean values, standard deviations, and confidence intervals. systematically comparing the dimensional accuracy, surface finish, mechanical properties, functional performance, environmental resistance, lifecycle durability, and failure modes of 3D printed components and injection molded parts, you can validate the results and ensure that the printed parts meet the required standards and specifications.

III . II .SCOPE:

Areas of application of Fiber Gear:

• **Used in the Printer Presses**: Plastic gears used in printer presses are typically designed to meet specific requirements of the printing machinery. These gears must be durable, precise, and resistant to wear, as they play a critical role in the smooth operation of the printer. The choice of plastic material is crucial for printer press gears. Common materials include acetal (Delrin), nylon, POM (polyoxymethylene), or PEEK (polyether ether ketone). These materials offer high strength, low friction, and good wear resistance. Printer press gears require precise engineering to ensure accurate alignment and smooth meshing with other components. Computer-aided design (CAD) and computer numerical control (CNC) machining are often used to manufacture gears with tight tolerances. Plastic gears must be able to withstand the loads and stresses encountered during printing operations.

Engineers calculate the torque, speed, and forces exerted on the gears to determine the appropriate size and strength required. Printer press gears are subjected to continuous motion and contact, which can lead to wear over time. Special additives or surface treatments may be applied to enhance wear resistance and prolong the lifespan of the gears. Printer press environments may expose gears to high temperatures or chemical agents from inks and cleaning solutions. The selected plastic material should be able to withstand these conditions without deformation or degradation.

• **Used in Heat Rollers:** Plastic gears used in heat rollers, which are commonly found in printers, copiers, laminators, and other similar equipment, have specific requirements due to the high temperatures involved in their operation. One of the most critical factors for plastic gears in heat rollers is their ability to withstand high temperatures without deforming or losing their mechanical properties. The selected plastic material must have a high heat resistance to ensure reliable performance. Engineering thermoplastics such as PEEK (polyether ether ketone), PPS (polyphenylene sulfide), PEI (polyetherimide), or specialty grades of nylon are commonly used for plastic gears in heat rollers due to their excellent heat resistance and mechanical strength.

Plastic gears must maintain their dimensional stability even when exposed to fluctuating temperatures during the heating and cooling cycles of the heat roller. Dimensional changes can affect gear meshing and lead to performance issues. Heat rollers are subjected to continuous rotation and contact with other components, which can cause wear over time. Plastic gears should possess good wear resistance to ensure a long service life and maintain consistent performance. Plastic gears in heat rollers may come into contact with chemicals such as toner particles, cleaning solutions, or lubricants. The selected plastic material should be resistant to these chemicals to prevent degradation or deterioration of the gears.

• **In Hydralic and Pneumatic Press fiber Gears are used:** Using fiber gears in hydraulic and pneumatic presses can offer specific advantages and considerations compared to traditional metal gears. Fiber gears are typically made from materials such as reinforced plastics (e.g., fiberglass-reinforced nylon) or composite materials (e.g., carbon fiber reinforced polymers). These materials offer advantages such as lightweight, corrosion resistance, and damping properties. Fiber gears are often lighter than their metal counterparts, resulting in lower inertia. This can lead to quicker response times in hydraulic and pneumatic systems, enhancing the overall efficiency and performance of the press. Fiber materials can dampen vibrations more effectively than metal gears. In hydraulic and pneumatic systems, this damping effect can help reduce noise and vibration levels, improving the working environment and potentially extending the lifespan of other press components.

Fiber gears are inherently resistant to corrosion, making them suitable for use in environments where exposure to moisture or chemical agents is a concern. This corrosion resistance can contribute to the longevity of the press and reduce maintenance requirements. Fiber gears can be molded into complex shapes more easily than metal gears. This allows for greater design flexibility, enabling engineers to optimize gear profiles for specific applications and achieve more efficient power transmission in hydraulic and pneumatic presses. Fiber materials generally have good temperature stability, but the specific performance can vary depending on the type of fiber and resin used. It's essential to select materials that can withstand the operating temperatures experienced in the press system to prevent deformation or degradation of the gears.

Area of application of Fiber T-Joint Pipe:

• **Used in Sprinklers Pipe for Connection:** A T-joint in a plastic pipe used for connecting sprinklers serves as a junction point where the main pipeline splits into two branches to accommodate additional sprinkler heads or to divert water flow in different directions.

The T-joint and the pipe itself should be made from durable, UV-resistant plastic materials suitable for outdoor use. Common materials include PVC (polyvinyl chloride), CPVC (chlorinated polyvinyl chloride), or HDPE (high-density polyethylene), depending on the specific requirements of the application. The T-joint should be compatible with the diameter and type of the main pipeline and the connecting pipes. It's essential to ensure that all components have matching sizes and fittings to achieve a secure and leak-free connection. The T-joint and the pipes should have a pressure rating suitable for the operating pressure of the sprinkler system. It's crucial to select components that can withstand the maximum pressure expected during normal operation to prevent failures or leaks.T-joint connections in plastic pipes for sprinkler systems can be assembled using solvent cement, threaded fittings, compression fittings, or push-to-connect fittings, depending on the pipe material and application requirements. Proper installation techniques should be followed to ensure watertight seals and structural integrity. The location of the T-joint should be easily accessible for maintenance, repairs, and adjustments to the sprinkler system. Considerations should be made to ensure that the joint is not buried or obstructed, making it difficult to access when needed.

- **Used in Construction Industry for Connecting the Pipes:** T-joint plastic pipes are commonly used in the construction industry for connecting pipes in various plumbing and drainage systems. Plastic pipes used in construction applications are often made from PVC (polyvinyl chloride), CPVC (chlorinated polyvinyl chloride), PEX (cross-linked polyethylene), or HDPE (high-density polyethylene). The material should be chosen based on factors such as compatibility with the transported fluids, temperature resistance, and durability. T-joints must match the diameter and type of the pipes they are connecting. It's crucial to ensure that all components have compatible sizes and fittings to achieve a secure and leak-free connection. The T-joint and pipes should have a pressure rating suitable for the operating pressure of the plumbing or drainage system. It's essential to select components that can withstand the maximum pressure expected during normal operation to prevent failures or leaks. T-joint connections in plastic pipes for construction applications can be assembled using solvent cement, threaded fittings, compression fittings, or push-to-connect fittings. Proper installation techniques should be followed to ensure watertight seals and structural integrity. The location of T-joints should be easily accessible for maintenance, repairs, and inspections. Considerations should be made to ensure that the joints are not buried or obstructed, making them difficult to access when needed.

T-joints and pipes should be designed to withstand the demands of construction environments, including exposure to chemicals, temperature variations, and physical stresses. UV-resistant materials and corrosion-resistant fittings can help prolong the lifespan of the system.

IV .DESIGN DETSAILS:

FIBER GEAR :

CALCULATIONS:

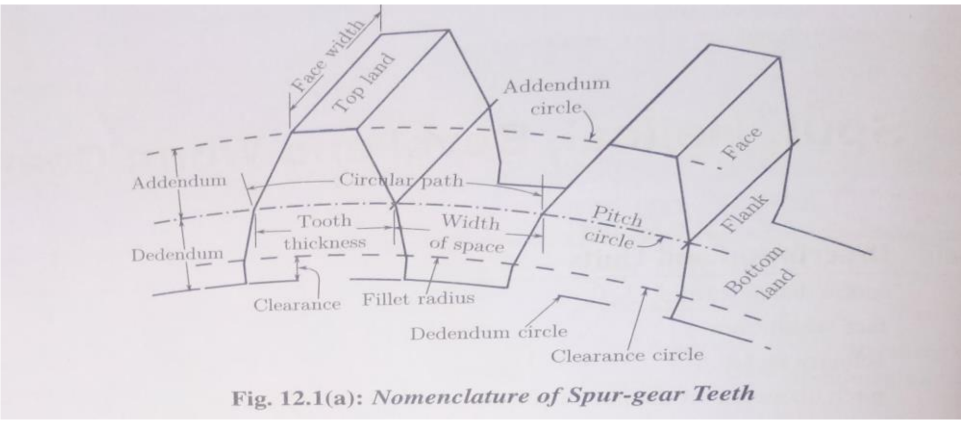


Figure 9: Nomenclature of spur gear teeth

Fiber gear Data:

Type of the gear = spur gear

D= Outer diameter of the gear = 36mm

Outer Diameter (OD) = 30mm (without Gear teeth).

Thickness = 2.3mm.

d= inter diameter of the gear = 25.4mm

Gear length Tooth = 8mm.

Gear (tooth) Thickness = 1.5mm.

Total Length = 15mm.

Gear Ratio = 34/27 = 1.26

n= z = No of tooth = 34

pressure angle = α = 20 deg full depth

tf = 1, tooth factor for standard tooth

tc = 0.15 or 0.25,tooth clearance factor

Particular:

Spur gears:

The module = m= D/z = D / n+2

Where D=diameter of the gear =36mm

n= no of tooth=27

m=36/34+2

m=1mm.

2. **The diametral pitch** = Pd = 1/m

=1/1

=1mm.

3. **The circular pitch** = p = π/Pd

= π/1

=3.1415mm.

4. **The base circle diameter** = dp = D cos α

=30 cos 20deg

=28.19mm.

5. **Lewies from factors or correction factor** = k = y = (0.154 – (0.912/n))

For 20deg involute system

=(0.154 – (0.912/34))

= 0.1271

6.**The dedendum circle** = dr = D – 2(tf +tc –k)m

= 36- 2(1+0.15 -0.1271)*1

= 33.95mm or 34mm.

7. **Height of tooth** = h = $m(1+(1/2)\pi)$

=1*(1+(1/2) π)

= 2.5707mm.

8.**Addendum circle** = do = dr +2h

= h = (2tf +tc)m

h=(2*1 +0.15)*1

h =2.15mm.

do = 33.95 + 2*2.15

=38.25mm.

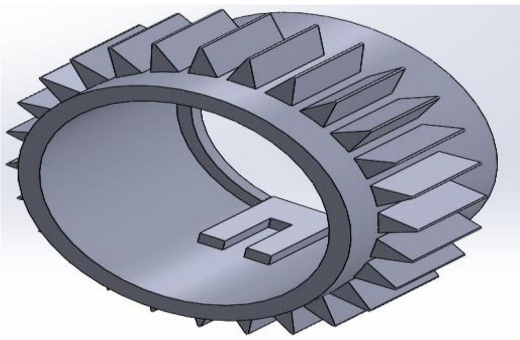


Figure 10: Modal prepare by using Solid Edge software based on about calculation.

FIBER T-JOINT PIPE:

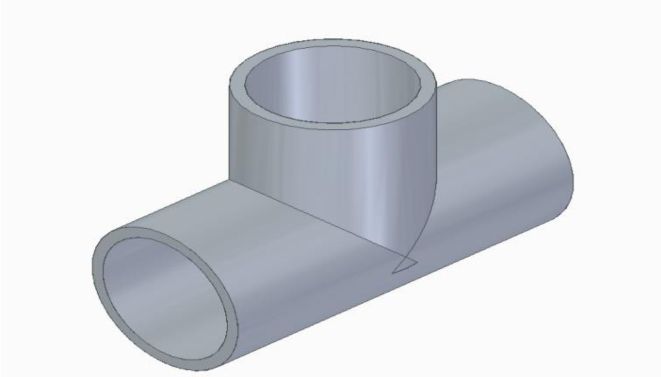


Figure 11: Modal prepare by using Solid Edge software based on dimensions.

3D PRINTED GEAR MODEL:

Figure 12: Modal prepare by using 3D printing machine based on dimensions

3D PRINTED T JOINT PIPE:

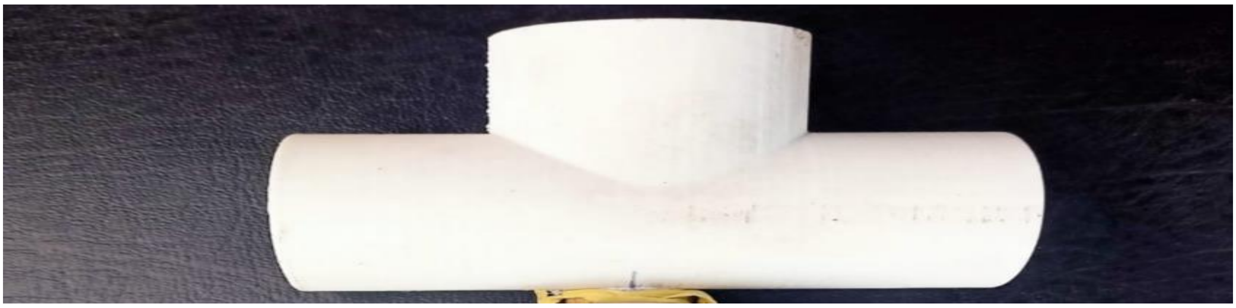


Figure 13: Modal prepare by using 3D printing machine based on dimensions.

V. TESTING PROCESS:

Figure 14: Testing process flowchart for printed gear

Testing the Printer Gear :

The Both 3D printed and Injection Moulded gear is runned with certain amount of load and some amount of wear out can observe in this Gear model.

The Gear is tested before and After running it with certain amount of speed (400-500rpm) and with some load(0.25-0.45kg).

The Both 3D printed and Injection Moulded gear is runned with certain amount of load and some amount of wear out can observe in this Gear model.

The Gear is tested before and After running it with certain amount of speed (400-500rpm) and with some load(0.25-0.45kg).

Three Testing are conducted before and after running the Gear:

1. Gear Weigth before and after the test.
2. Gear Diameter before and after the test.
3. Sine centre using slip gauge.

Figure 15: Gear Running Model

1. **Gear weigth Analysis- Test 1**

Number Of Test Conducted	Time in Seconds	Speed in RPM and Load in kg	Injection Moulded Model	Injection Moulded Model	Injection Moulded Model	3D Printed Model	3D Printed Model	3D Printed Model
Test	Time period	400-500rpm	Before Test (In Grams)	After Test(In Grams)	Difference	Before Test(In Grams	After Test(In Grams)	Difference
Test-1	15 minutes	0.25-0.45kg load	6.5gm	6.48gm	0.02gm	5.7gm	5.68gm	0.02gm
Test-2	30 minutes	0.25-0.45kg load	6.48gm	6.4gm	0.08gm	5.68gm	5.65gm	0.03gm
Test-3	45-60 minutes	0.25-0.45kg load	6.4gm	6.3gm	0.1gm	5.65gm	5.6gm	0.05gm

The Weigth of the Both Gears are varies compare to Injection Moulding 3D printed Gear is slight better.

comparing the weight of gears produced through injection molding and 3D printing, with the 3D printed gears being slightly lighter. That makes sense since 3D printing often allows for more intricate designs and the ability to optimize structures for weight reduction. This can be advantageous in applications where minimizing weight is important, such as in aerospace or automotive industries.

- **Gear weigth Analysis- Test 1**

The 3D Printed and Injection moulding Gears are weigthed to see the difference in before and after testing the Gear .So This made how much amount of wear out can see here. 3D printed model has less wear out compare to the 3D printed part. The following Figures are the test what we are done.

Figure 16: Gear weigthing Before and after the test

2. Gear diameter before and after Running The Gear.-Test 2

SL NO	Injection Moulded Model	Injection Moulded Model	Injection Moulded Model	3D Printed Model	3D Printed Model	3D Printed Model
Test	Before test(In mm)	After test(In mm)	Difference	Before test(In mm)	After test(In mm)	Difference
1.	30.8mm	30.6mm	0.2mm	30.8mm	30.7mm	0.1mm

The 3D Printed Gear and Injection moulded gear are runned and checked the diameter of the both Gears using Vernier Caliper. The 3D printed model has less difference.

3. Eccentricity of the gear using slip gauge: test- 3

Eccentricity of the gear using slip gauge

Number of Teeth	Injection moulded model	3D printed model
1	0	0
2	-0.02	0.05
3	0	-0.04
4	0.01	0.03
5	0.02	0.05
6	0.01	0.02

7	-0.02	0
8	-0.02	-0.05
9	-0.01	0.05
10	-0.02	-0.06
11	-0.02	0
12	0	0.05
13	0	0
14	0.01	0.05
15	0	-0.1
16	0.05	0.05
17	0.02	-0.02
18	0.04	0.1
19	0.03	0.05
20	0.02	0.04
21	-0.02	-0.1
22	0.03	-0.05
23	0.05	0.01
24	-0.04	0.05
25	0.02	0.06
26	0.01	0.02
27	0	0.1
28	-0.02	-0.02
29	0.03	-0.05
30	-0.02	-0.01
31	0	-0.02
32	0	-0.05
33	0	0
34	0.01	0.05

Eccentricity of the gear using slip gauge

The Printer Gear is tested using slip gauge to know the difference in Wear out in each gear so certain amount of variation take place in both 3D Printed and Injection Moulded Gear. Sine Centre test is done to analyse the amount of wear out difference in each teeth and there are 34 teeth each teeth has slight difference

The Eccentricity of the gear is one of the common defect of gear is done using Slip Gauge because to know the how much wear out take place in each teeth. So This Will determine the amount of variation by comparing this two modles.

- **Testing process flowchart for printed T joint pipe**

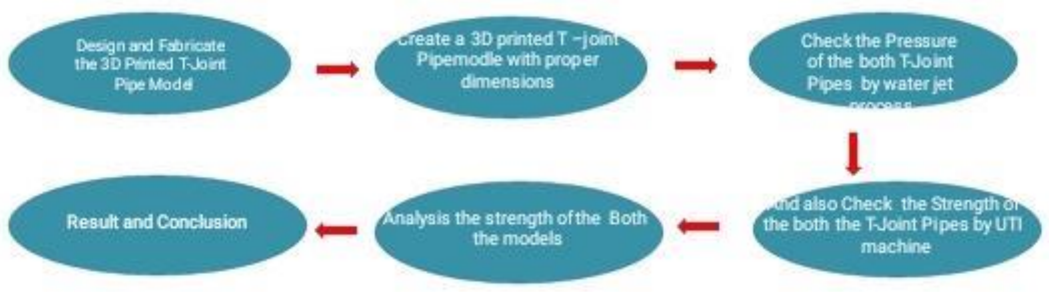


Figure 17: Testing process flowchart for printed T joint pipes

T-Joint Pipe Testing

Experiment is conduced for both the Fiber and 3D Printed –Joint Pipe as both T Joint pipe are stabled and no break down take place, so to determine their Strength, Tensile and compressive strength has to be take place. The Pressure is determine during the process it is measured in Mpa. Capacity of 2HP motor is 7.5 bars, and in that we are taken 3 readings 0.1Mpa, 0.15Mpa and 0.20Mpa .

SL No	Pressure in Mpa/Bar	2HP Motor in RPM	Injection moulded T-Joint Pipe in Mpa/Bar(pressure)	3D Printed T-Joint Pipe in Mpa / Bar(pressure)
1	Pressure 1	1500	0.1/ 1bar	0.1/ 1bar
2	Pressure 2	1500	0.15/ 1.5bar	0.15/ 1.5bar
3	Pressure 3	1500	0.20/ 2bar	0.20/ 2bar

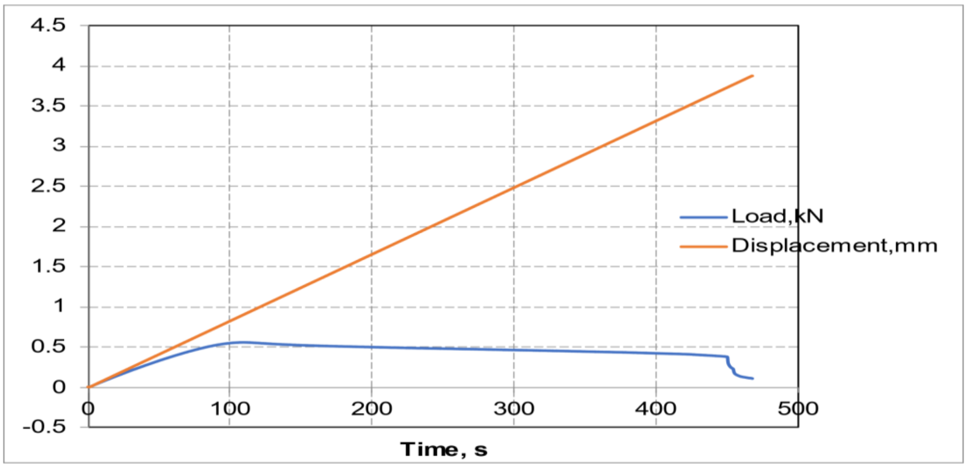
Experiment is conduced for both the Fiber and 3D Printed –Joint Pipe as both T Joint pipe are stabled and no break down take place, so to determine their Strength, Tensile and compressive strength has to be take place. The Pressure is determine during the process it is measured in Mpa. Capacity of 2HP motor is 7.5 bars, and in that we are taken 3 readings 0.1Mpa,0.15Mpa and 0.20Mpa.

Experiment is conduced for both the Fiber and 3D Printed –Joint Pipe as both T Joint pipe are stabled and no break down take place, so to determine their Strength, Tensile and compressive strength has to be take place. The Pressure is determine during the process it is measured in Mpa. Capacity of 5HP motor is 15 bars, and in that we are taken 3 readings for 3D printed model 0.3Mpa, 0.35Mpa and 0.4Mpa and for Injection moulded model 0.2Mpa , 0.25Mpa , 0.3Mpa.

SL No	Pressure in Mpa/Bar	5HP Motor in RPM	Injection moulded T-Joint Pipe in Mpa/Bar(pressure)	3D Printed T-Joint Pipe in Mpa / Bar(pressure)
1	Pressure-1	3000	0.2/ 2bar	0.3/ 3bar
2	Pressure-2	3000	0.25/ 2.5bar	0.35/3.5bar
3	Pressure-3	3000	0.3/ 3bar	0.4 /4bar

3D Printed T-Joint Pipe with the Pressure gauge

- **T- pipe Tenslie Strength is tested to analysis of the 3D printed Modle (Specimen 1)**



Test inputs: Total Steps :	1	1	1	1	1
Step no :	Control mode:	Rate / Time :	Hold Time	End of step 1	End of step 2
1	0.500 mm/min				

Date :	29-Feb-24	**Batch 1**
Time and place :	18:58:15	COLLEGE VVCE
Specimen ID and Sample	1	
Operator :	Shivakumar m	
Temperature :	30 C	
Area gauge :	18sq-mm	
Length :	40mm	
Width :	6mm	
Thickness :	3mm	

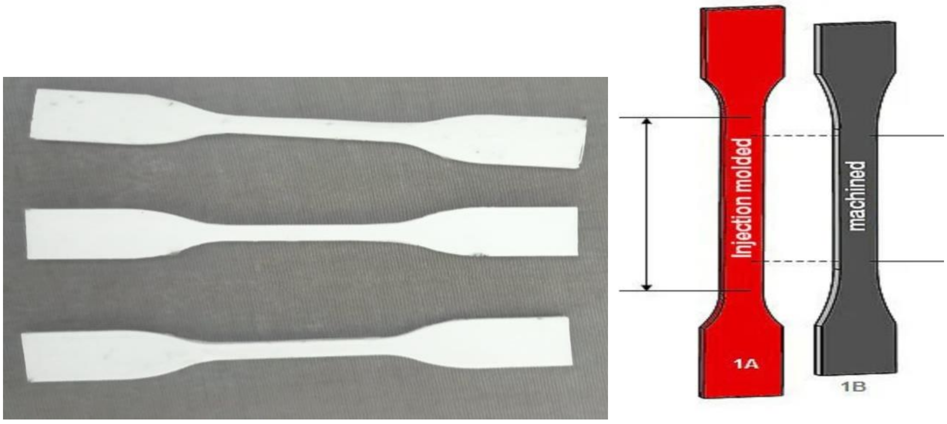
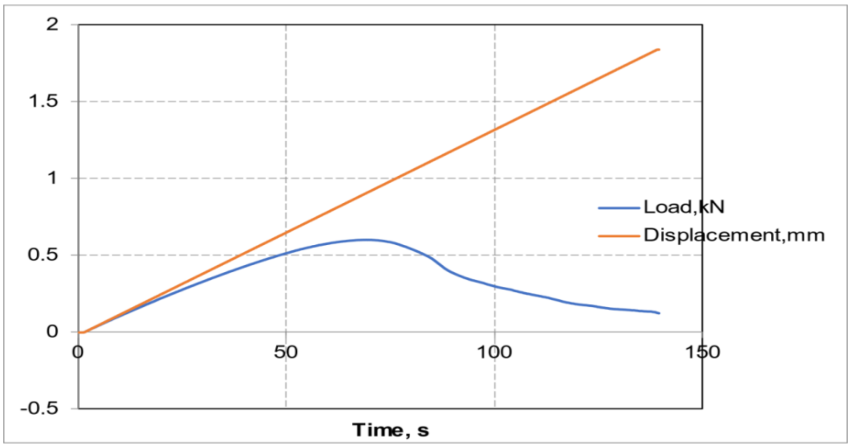


Figure 18: T- pipe Tenslie Strength is tested to analysis of the 3D printed Modle (Specimen 1 and 3)

- **T- pipe Tenslie Strength is tested to analysis of the 3D printed Modle (Specimen 3)**



Test inputs: Total Steps :	**1**	**1**	**1**	**1**	**1**
Step no :	Control mode:	Rate / Time :	Hold Time	End of step 1	End of step 2
1	0.800 mm/min				

Date :	29-Feb-24	**Batch 1**
Time and place :	19:16:12	COLLEGE VVCE
Specimen ID and Sample	3	
Operator :	Shiva kumar m	
Temperature :	30 C	
Area gauge :	18 sq-mm	
Length :	40 mm	
Width :	6 mm	
Thickness :	3 mm	

- **T Pipe UTM Tensile strength test Injection Moulded model (Specimen 2)**

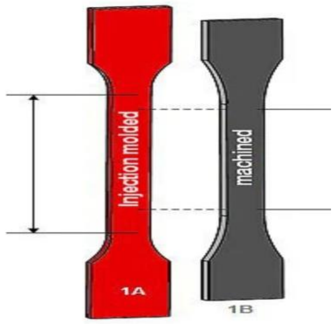
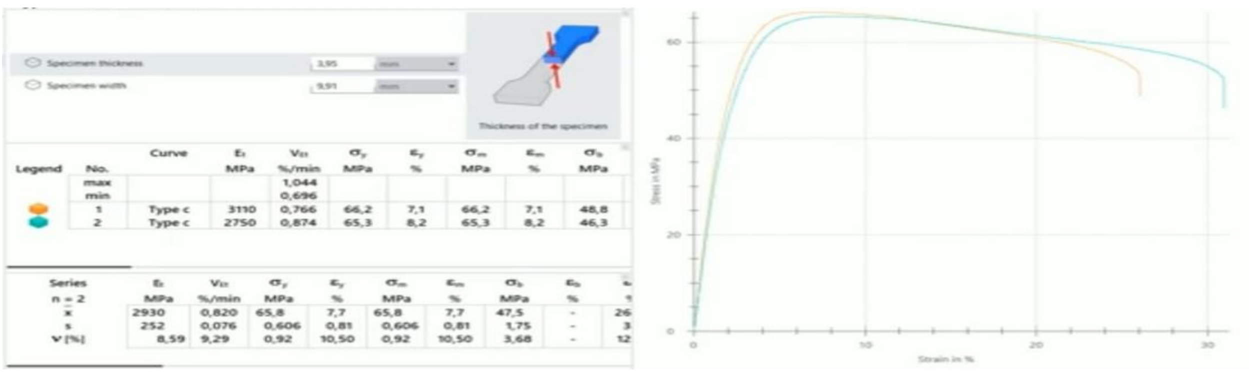
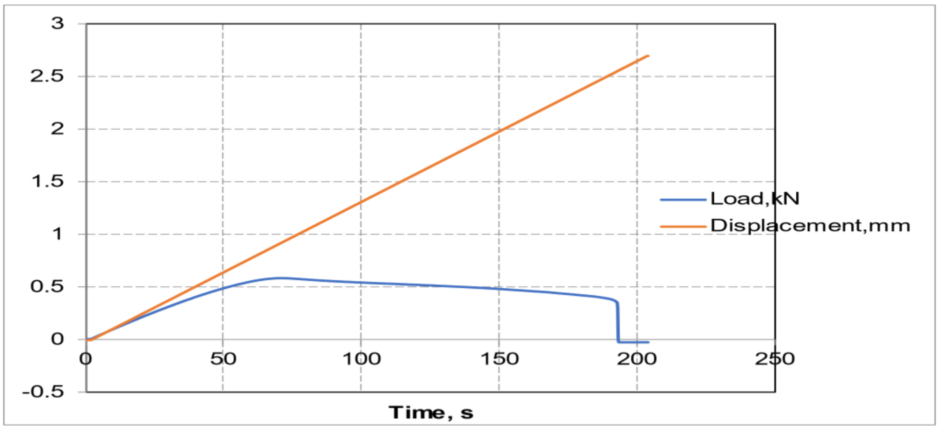


Figure 19: T Pipe UTM Tensile strength test (Injection Moulded model)





As per this test 3D Printed modle has some high tensile by analysing the Graphs

Date :	29-Feb-24	**Batch 1**
Time and place :	19:09:11	COLLEGE VVCE
Specimen ID and **Sample**	2	
Operator :	Shiva kumar m	
Temperature :	30 C	
Area gauge :	18 sq-mm	
Length :	40 mm	
Width :	6 mm	
Thickness :	3 mm	

As per this test 3D Printed modle has some high tensile by analysing the table

VI .RESULTS:

As per the comparision of the both injection moulded and 3D Printed modle which determines us that , The 3D printed Gear as well as the T Joint Pipe has more strength compare to the injection moulding model. The test Results are show above by this testing analysis , The 3D Printed Gear has more stability and hardness as shown. Finally our analysis has completed and It works experimentally. The increased strength of the 3D printed model compared to the injection molded model can be attributed to With 3D printing, you have more flexibility in choosing materials tailored to specific strength requirements. Some 3D printing materials, such as certain types of polymers or composites, may offer superior strength characteristics compared to traditional injection molding materials. 3D printing allows for more complex and optimized designs that can distribute stress more effectively throughout the part. This means that designers can create structures that are stronger and more resilient to external forces. In the case of additive manufacturing, the layers are fused together during the printing process, resulting in strong layer adhesion. This can result in parts that are less prone to delamination or failure along layer lines compared to injection molded parts, which are formed in a single mold. 3D printing enables the inclusion of localized reinforcements or lattice structures within the part, which can significantly enhance its strength without adding excess weight. Injection molding often generates more material waste during the manufacturing process, whereas 3D printing can be more material-efficient, resulting in parts with a higher strength-to-weight ratio. There are several reasons why a 3D printed model might exhibit greater stability compared to an injection molded Depending on the material used for 3D printing, it's possible to achieve properties like high strength, durability, and resilience, which can contribute to stability. 3D printing allows for the creation of intricate and complex geometries that may be difficult or impossible to achieve with injection molding. These optimized designs can distribute stress more effectively, enhancing stability. Complex parts often require assembly in traditional manufacturing methods like injection molding, which can introduce weak points. With 3D printing, complex designs can often be printed as a single piece, reducing the number of joints and potential failure points. 3D printing can offer more consistent material properties throughout the entire structure, whereas injection molding might have variations in material properties due to factors like cooling rates and material flow. With 3D printing, it's easier and quicker to iterate designs and test them, leading to optimized final products with improved stability. he increased hardness in the 3D printed model compared to the injection molded model could be attributed The material used in 3D printing might inherently possess higher hardness characteristics compared to the material used in injection molding. Different types of plastics or resins can be used in both processes, and some materials commonly used in 3D printing, like certain types of thermoplastics or resins, may have higher hardness values than typical injection molding materials.

3D printing builds objects layer by layer, allowing for precise control over the internal structure of the part. This layering process can create strong bonds between the layers, resulting in a denser and potentially harder final product compared to the solid, homogeneous structure of an injection molded part.

With 3D printing, designers have more freedom to optimize the internal geometry of the part for strength and hardness. They can create complex lattice structures or infill patterns that enhance mechanical properties, including hardness. After 3D printing, additional post-processing steps such as annealing or surface treatments can further increase the hardness of the printed part.

VII. CONCLUSION:

- The empirical analysis comparing a component fabricated using 3D printing techniques and injection molding processes unveils nuanced insights into the strengths and limitations of both manufacturing methods.
- Through this study, it becomes evident that 3D printing showcases unparalleled prowess in swiftly producing intricate, custom-designed components. Its additive manufacturing approach, allowing layer-by-layer construction from digital models, offers unparalleled design flexibility and rapid prototyping capabilities.
- This enables the creation of complex geometries and customized features that might be impractical or challenging to achieve through traditional manufacturing methods like injection molding.
- On the other hand, injection molding stands out for its efficiency in high-volume production and the ability to produce components with consistent quality and material properties.
- The process involves injecting molten material into molds, resulting in robust and standardized components suitable for various industries and applications.

- This empirical analysis serves as a foundation for informed decision-making in manufacturing, emphasizing the need to consider factors like design complexity, production volume, material properties, and customization requirements when determining the optimal fabrication technique for a given component. Both 3D printing and injection molding contribute significantly to modern manufacturing, offering diverse solutions tailored to the demands of various industries and applications.

VIII. ACKNOWLEDGMENT

Acknowledged. An empirical analysis comparing a component fabricated using 3D printing and injection moulding would provide valuable insights into their respective strengths, weaknesses, and performance characteristics.

IX. REFERENCES

[1]. A Review on Failure Characteristics of Polymer Gear W. M. Ghazali1 , D. M. N. D. Idris1* , A. H. Sofian2 , J. P. Siregar1 , M. S. S. Edrus1

[2]. A parametric study of 3D printed polymer gears Ye Zhang1 & Ken Mao1 & Simon Leigh1 & Akeel Shah1 & Zhiming Chao1 & Guotao Ma1

[3]. Design and Development of Spur Gear by using Three Dimensional Printing

[4]. Failure Mode and the Prevention and Control Technology of Buried PE Pipeline in Service: State of the Art and Perspectives Pengcheng Li,1 Fei Wang,2 Jiajia Gao,3 Dong Lin,1 Jian Gao,1 Jianguo Lu , 4 Enxi Qiu,4 and Chang Liu1