Design and Analysis of Screw Operated Gripper and RPT Estimation

Mr. G.Vishnu Vardhan Sri Raj*, Mr. P.Arun Kumar*, Mr. P Jagadeesh Varma*, Mr. G.Rajkumar*, Mr. G.Akhil*, Mr. VVN Sarath, Dr G Avinash****

***UG students, **Faculty, Department of Mechanical Engineering College, Pragati Engineering College (A)**

ABSTRACT: The objective of the paper is to build a three fingered gripper for a flexible robotic arm to have the capability of mimic the motion of a snake such that work space of the robotic arm is maximized. In this paper a three fingered gripper is designed with payload capacity of 2kg by considering flexible design, ease of manufacture, low cost and recyclable material as the constraints. The designing of three fingered gripper is done in AUTODESK FUSION360. Based on the design, it is identified that the screw operated gripper has more flexibility and better efficiency when compared with other designs hence the performance of screw operated gripper is analysed using Ansys software. From the analysis, based on the deformation and stress values, it is ensured that designed screw operated gripper made of ABS (Acrylonitrile butadiene styrene) material is capable of handling 2kg of load. The printing time and cost estimation is carried out by slicing of screw operated gripper by using Ultimaker Cura software.

Key words: RPT, CURA, FUSION360, ABS, FRA

I. INTRODUCTION

Grippers are special devices designed to help robots handle objects in the real world. Grippers are also known as 'end-effectors' or 'manipulators'. Some grippers look just like hands, while others look like a hand with two or three fingers. Some grippers don't look like hands at all; they look more like robot claws. Other grippers come with giant suction cups. Some grippers look like a soft round ball. Some have magnetized tips. And grippers receive their power in different ways, from electrical to pneumatic (air) and hydraulic (hydraulic fluid).

Payload refers to the entire weight the robot arm is able to support, including the gripper. Just as your arm and hand can only lift certain weights at the gym, a robot can only handle so much weight without faltering. So, when choosing your robot hand, you must consider the payload capabilities of the robotic arm and the gripper itself.

Robotics is a mixture of geometric transformations, control theory, stepper / DC motors, digital signal processing and a real-time operating system. Robot is a reprogrammable and multifunctional manipulator designed to move materials / pieces from one place to another through different movements programmed to perform a series of tasks and the robot can also be classified according to its application method as a way of control, operating parameters, environmental conditions, structural design, structure materials, technology level. The two main types of control are servant and non-servant. The volume of the work space of a robot can be articulated in a rectangular, cylindrical, spherical or spherical shape. The growing competition of industrial robots for tasks normally performed by human hands has led to the need for more efficient handling equipment, in particular pre-tensioning instruments (more commonly called clamps). This is one of the reasons why tweezers deserve special attention. However, industrial robots are not simply a substitute for people often in applications beyond the normal (physical or temporary) capacity of conventional labour.

II. LITERATURE SURVEY

A. Krishnaraju et al [1] designed a three fingered robot mechanism which has the potential to fulfil various demand in industry and factories. So far there are so many mechanisms available for robot gripper in three fingered robot gripper mechanism is a type of mechanism which is used in industrial robots for moving object, which has higher gripper ratio. The kinematic system has been designed for one degree of freedom and the kinematic design of robot structure is developed using SAM mechanism software. The gripper modelling has been designed using Pro-E Wildfire5.0 software and a three finger gripper is fabricated by aluminium material for 5 kg payload. The gripper mechanism has three fingers which are used to hold the object in a balanced way to meet the challenges faced on the industrial life. The fingers are also provided with senses to identify the type of object.

S. Chandra Sekhar et al [2] published a paper. In this paper, the design of an open source, low cost, single actuator under actuated gripper that can be created through fast and commonly accessible through rapid prototyping techniques and simple off the shelf components. This work establishes

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the design of an adaptive, three fingered griper utilizing simple 3D printed components and readily obtainable off the self-parts, modular and adjustable finger designs are provided.

Vinod G. Gokhare et al [4] This is a research paper on 3D printing and the various materials used in 3D printing and their properties which become a notable topic in technological aspects. First, define what is meant by 3D printing and what is significant of 3D printing. We will go into the history of 3D printing and study about the process of 3D printing and what materials used in the manufacture of 3D printed objects and select the best materials among them which are suitable for our 3D printing machine. Also, see the advantages of 3D printing as compared to additive manufacturing.

Suraj Kumar Vishwakarma et al [5] presented detailed Theoretical study of ABS material in various doping, surface finishing and polymerization techniques. The effects of metallization, Thermal Decomposition, polymeric varistor on ABS material have been investigated. A complete overview of various environment friendly techniques like nickel electroplating, copper metallization, surface etching and modification by treatment with atmospheric plasamaon ABS have been studied. On the other hand some mechanical characterization by Injection Moulding and Fatigue crack propagation of PC/ABS alloy has been theoretically concluded

M. Aslam et al [6] designed a miniature Smart Robotic Foot (SRF), equipped with an integrated vacuum pump, a suction cup, a pressure sensor and a micro-valve which is also fabricated and tested. A mock up robot equipped with the SRF was used to study the load-carrying potential of the system. The SRF weighs 35 g with a 40mm suction cup, support weights in the range of 1.2–3.5 kg under various test conditions and surfaces.

S Kaviyarasan and I Infanta Mary Priya [7] design and fabricated a three finger adaptive gripper. The primary aim of implanting the robot is to reduce the human effort. Gripping of objects has been a difficult task for robots. The challenge during gripping would be to assume object and pick it. In this paper, adaptive gripper has the capabilities with this dexterous adaptive electric gripper. Three fingers grippers mean maximum versatility and fixable adaptive control. Its hands as wide variety of part geometrics and size. Its precise control interface allows straight forward control the finger position, speed and force or pressure. These fingers produced by 3D printing and fingers are analysed to check if the finger is flexible. The force is measured using a force sensing resister. Controlled gripper finger is sensed and gripped with adaptive force which is being analyzed in this paper.

A three fingered gripper is to be designed for a flexible robotic arm. Three fingered gripper is designed with payload capacity of 2kg by considering flexible design, ease of manufacture, low cost, and recyclable material as the constraints

III. RESULTS AND DISCUSSION FOR ANSYS

Stress is the force applied to a material, divided by the material's cross-sectional area. Strain is the deformation or displacement of material that results from an applied stress.The stress distribution and deformation of the gripper base for the maximum loading condition are shown in the fig 1 and fig 2.

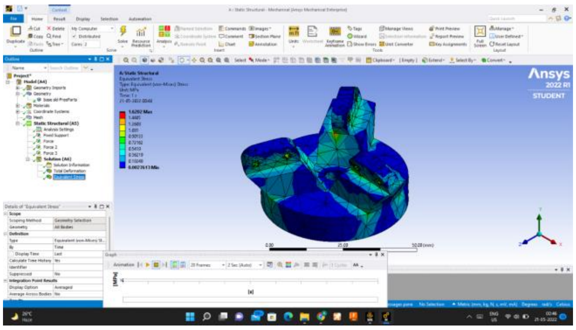


Fig 1 Stress Distribution in Gripper Base

The minimum and maximum stresses are 1.6202Mpa and 0.00276Mpa.The minimum and maximum deformation are 0m and 0.011144mm The stress and deformation values produced by link operates gripper made up of ABS material are 1.75Mpa and 0.025mm. The stress and deformation values produced by screw operated gripper are 0.1.6202Mpa and 0.011144mm.

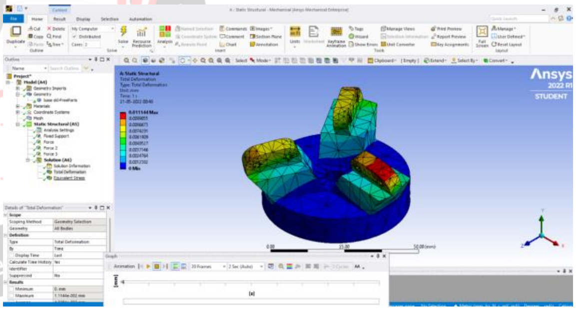
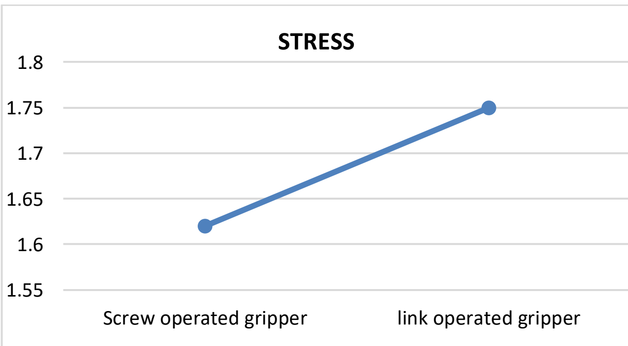


Fig 2 Deformation in Gripper Base

Table 1 Stress and Deformation of various Grippers

DESIGN	STRESS	DEFORMATION
Link Operated Gripper	1.75Mpa	0.025mm
Screw Operated Gripper	1.6202Mpa	0.011144mm



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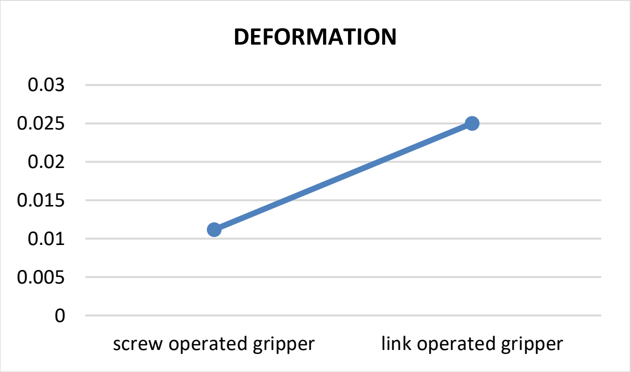

Fig 3 Stress and Deformation of Various Grippers

The stress and deformation values produced by the link operated gripper are more when compared with the screw operated gripper.so we choose screw operated gripper design as it has less stress and deformation values when compared to the link operated gripper.

IV. RAPID PROTOTYPING

With the invention of computer sin 1950s and internet in 1990s, the core way of doing things has gone through mammoth changes. In the present century, no other invention or innovation has affected the mankind more than technology did. These technologies simplified our lives, opened up new avenues and opportunities and gave us a hope for a better future. But in the larger scope, it generally takes decades to build an ecosystem across a particular technology to take it to the masses and achieve the truly disruptive nature of that technology.

It is widely believed that 3D printing/ additive manufacturing/ Rapid Prototyping has a vast potential to become one of these path breaking technologies. A lot of media coverage has been dedicated to 3D printing across many channels, newspapers and online resources. This 3D printing has evolved to such a level that it began to challenge the conventional manufacturing processes, revolutionizing design industry, and imposing new geopolitical, economic, social, demographic, and environmental and security implications to our daily lives.

The fundamental differentiating principle that keeps 3D printing ahead of the conventional systems is that it is an additive manufacturing process. In this radically different manufacturing method based on advanced technology that builds up parts, additively, in layers at the sub mm scale. This is the sole factor that radically differentiates additive manufacturing from any other existing traditional manufacturing techniques.

3D printing is an enabling technology that encourages and drives innovation on an unprecedented design freedom while being a tool less process that reduces prohibitive costs and lead times. Components can be designed to avoid assembly requirements with intricate geometry and complex features can be created at no extra cost.

The Rapid Prototyping process is described by the following flow chart

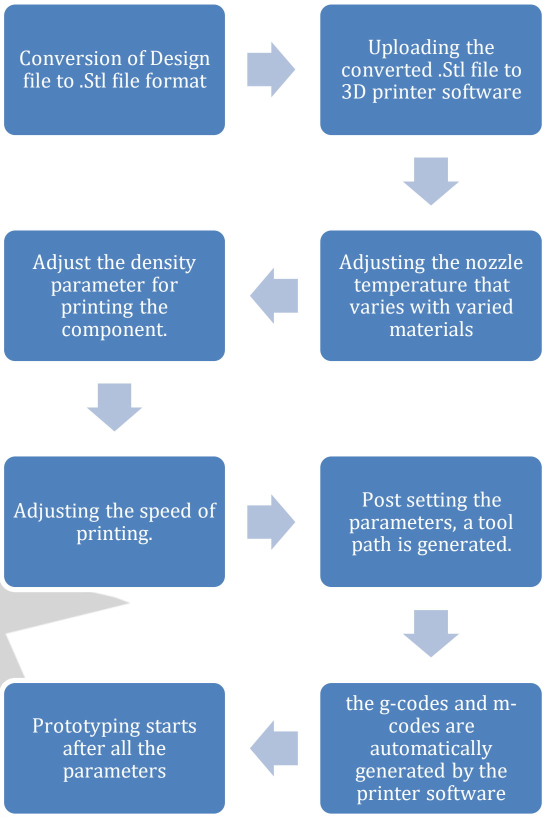

Fig 4 Flow Chart of Rapid Prototyping

8.2 RAPID PROTOTYPING PROCESSES

Rapid prototyping is the fast fabrication of a physical part, model or assembly using 3D computer aided design (CAD). The creation of the part, model or assembly is usually completed using additive manufacturing, or more commonly known as 3D printing.

8.2.1 Selective Laser Sintering (SLS):

Laser sintering and laser melting are interchangeable terms that often refer to a laser based rapid prototyping process that works with powdered materials. The laser is traced on a bed of powder of tightly compacted powdered material, according to the date fed to the machine, in the X-Y axes. As the laser interacts with the surface of the powdered material it sinters, or fuses, the particles to each other forming a solid. As each layer is completed the powder bed drops incrementally and a roller smoothens the powder over the surface of the bed prior to the next pass of the laser for the subsequent layer to be formed and fused with the previous layer.

The build chamber is completely sealed as it is necessary to maintain a precise temperature during the process specific to the melting point of the powdered material of choice. Once finished the entire powder bed is removed from the machine and the excess powder can be removed to leave

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the printed parts. One of the key advantages of this process is that the powder bed serves as an in-process support structure for the over hangs and the undercuts, and therefore complex shapes that could not be manufactured in any other way are possible with this process. However. On the downside, because of the high temperatures required for laser sintering, cooling times can be considerable.

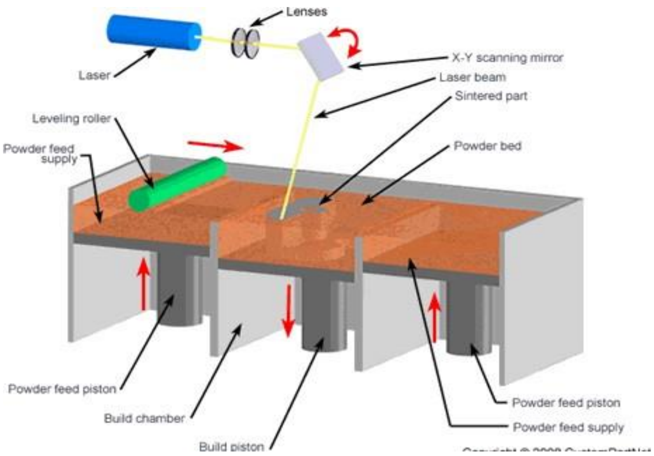

Fig 5 Selective Laser Sintering Process

Fused Deposition Modelling

3D printing by extrusion of thermoplastic material is easily the most common and recognizable 3DP process. The most popular name for the process is Fused Deposition Modeling (FDM). However, this is a trade name, registered by Stratasys, the company that originally developed it. Stratasys FDM technology has existed since the early 1990s and today is an industrial-level 3D printing process. However, the proliferation of entry-level 3D printers that have emerged since 2009 largely utilizes a similar process, generally called Freeform Fabrication (FFF), but in a more basic way because of the patents that Stratasys still has. The first RepRap machines and all subsequent developments use the extrusion methodology. However, after the filing of the Stratasys patent infringement against Afinia, there is a question mark on how the market will enter the market now, with all the machines potentially in the Stratasys firing line for patent infringement.

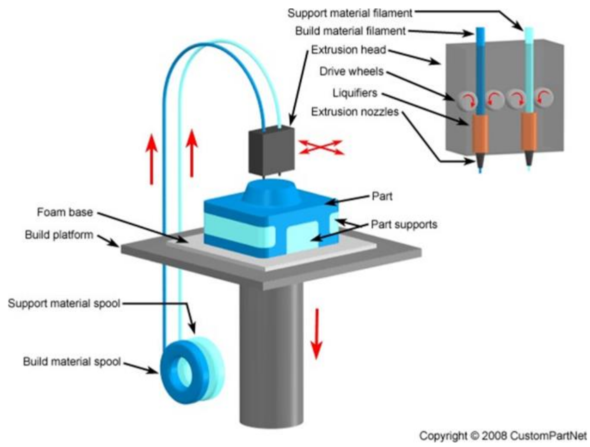

Fig 6 Fused Deposition Modelling

This process works by melting the plastic filament that is deposited through a heated extruder one layer at a time, onto a platform according to the 3D data supplied to the printer. Each layer hardens as it is deposited and bonds to the previous layer. These processes require support structures for any applications with overhanging geometries. For FDM, this entails a second, water-soluble material, which allows support structures to be relatively easily washed away, once the print is complete. The process can be slow for some specific part geometries and layer to layer adhesion can be a problem, resulting in parts that are not watertight. Again, post- processing using Acetone can resolve these issues.

Stereo lithography

Stereo lithography is widely regarding as the first and foremost Rapid Prototyping process. It was the first to be commercialized. This is a laser based process that works with photopolymer resins that react with the laser and cure to form a solid in a very precise way. It is a complex process but simply put the photopolymer resin is held in a vat with a movable platform inside. A laser beam is directed in the X-Y axes across the surface of the resin according to the 3D data supplied to the machine (the .stl file), whereby the resin hardens precisely where the laser hits the surface. Once the layer is completed, the platform within the vat drops down by a fraction (in the Z axis) and the subsequent layer is traced out by the laser. This continues until the entire object is completed and the platform can be raised out of the vat for removal.

Digital Light Processing

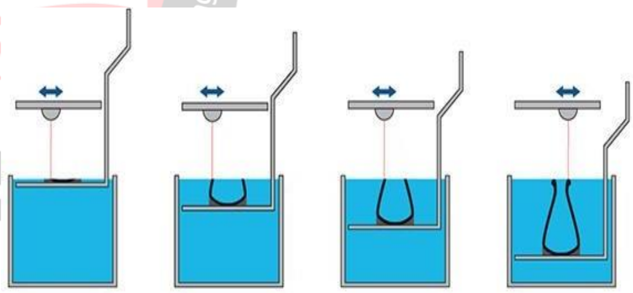

Fig 7 Stereo Lithography

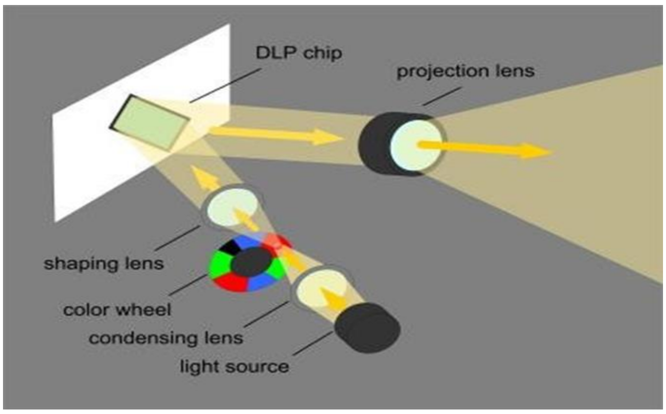

Fig 8 Digital Light Processing

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Digital Light Processing (DLP) is a process similar to that of Stereo Lithography, in that it is a process that works with photopolymers. The major difference is the light source. DLP uses a more conventional light source, such as an arc lamp with a liquid crystal display panel, which is applied to the entire surface of the vat of photopolymer resin in a single pass, generally making it faster than stereo lithography. DLP produces highly accurate parts with excellent resolution, but its similarities also include the same requirements for the support structures and post-curing. Also like Stereo lithography, DLP produces highly accurate parts.

8.2.5 Selective Deposition Lamination (SDL)

SDL is a proprietary 3D printing process developed and manufactured by Mcor technologies. There is a temptation to compare this process with the Laminated Object Manufacturing (LOM) process developed by Helisys in 1990's due to similarities in layering and shaping paper to form the final part. However, that is where any similarity ends.

The SDL process builds parts layer by layer using standard copier paper, new layer is fixed to the previous one by using an adhesive, which is applied selectively according to the data supplied to the machine. This means that a much higher density of adhesive is deposited in the area that will become the part, and a much lower density of adhesive is applied in the surrounding area that will serve as the support, ensuring relatively easy weeding or support removal.

After a new sheet of paper is feed into the printer from the paper feed mechanism and placed on top of the selectively applied adhesive on the previous layer, the build plate is moved up to a heat plate and pressure is applied. This pressure ensures a positive bond between the two sheets of paper. The build plate then returns to the build height.

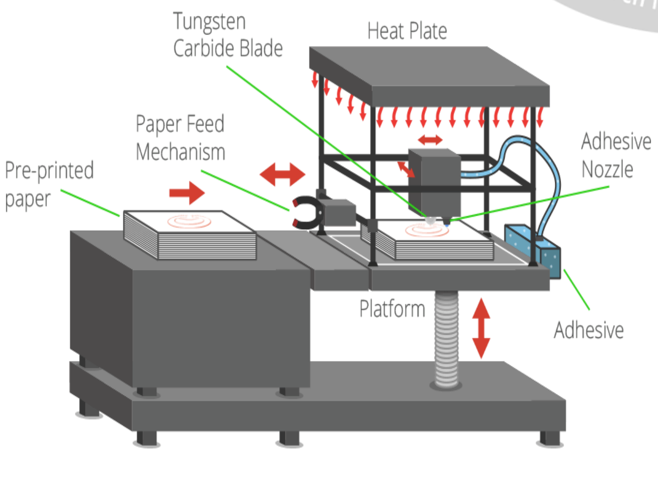

Fig 9 Selective Deposition Lamination

8.2.5 Electron Beam Melting

Electron Bea Melting rapid prototyping technique is a proprietary process developed by Swedish company Arcam. This metal printing method is very similar to the Direct Metal Laser Sintering (DMLS) process in terms of the formation of the parts from metal powder. The key difference is the heat source, which, as the name suggests is an electron beam, rather than a laser, which necessitates that the procedure is carried out under vacuum conditions.

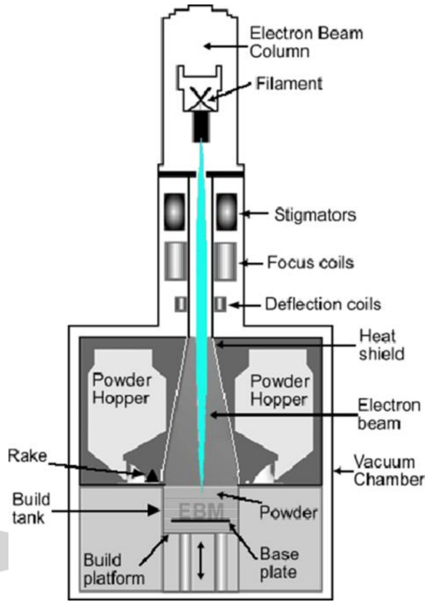

Fig 10 Electron Beam Melting

EBM has the capability of creating fully dense parts in a variety of metal alloys and as a result the technique has been particularly successful for a range of production applications in the medical industry, particularly for implants. However, other hi-tech sectors such as aerospace and automotive have also looked to EBM technology for manufacturing fulfillment.

SELECTION OF RAPID PROTOTYPING METHOD

The usage costs for FDM printers are mainly related to the nozzles and filaments. As mentioned before, most FDM printers use the same standardised materials and you are not dependent on a particular manufacturer. The prices for these materials have decreased in recent years. 1 kg PLA filament can be purchased for $25.

The usage costs for SLA printers are higher and do not only include the material. After printing 2-3 litres of resin, the resin tank needs to be replaced. Depending on the manufacturer and the model, a resin tank costs about $40 to $80.

The construction platform also needs to be replaced from time to time. This is because it is often damaged when the user removes the printed model. A platform costs around $100.The resin is also expensive: 1 litre of standard resin costs between $80 and $150.

The FDM process has the following advantages

- Filament reusable.
- Low cost and less complex.

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- Easily portable and variety of material choice.

By considering the above advantages we selected FDM processes.

V. CONCLUSION

The three fingered griper was designed to carry a payload capacity of 2Kg and was required to maneuver through various obstacles without damaging the scenario. In this paper exhibits a screw operated gripper was designed and analysed to achieve the given problem statement.

ABS material is selected for the manufacturing of gripper because ABS is a bit more durable, is about 25% lighter, and has four times higher impact resistance. ABS does require more effort to print than PLA because it's more heat resistant.

The deformation induced in screw operated gripper is 0.011144mm and stress induced in the gripper is 1.62Mpa when maximum loading condition is applied. Hence the designed model is well enough to withstand the prescribed load.

The slicing of screw operated gripper was done in Ultimaker Cura software. The screw operated gripper was designed using ABS material as base material having a density of 1.0-1.05 gcm^{-3} and the print density being 100%.The total material consumption of gripper manufacturing is 134 grams. The estimated printing time and cost of screw operated gripper are 1 day 1 hour 4 minutes and Rs 6600/-.The Screw operated gripper was designed for the carrying of a maximum payload capacity 2Kg.

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