IARJSET
ISSN (O) 2393-8021, ISSN (P) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
Impact Factor 8.311 ⁒ Peer-reviewed & Refereed journal ⁒ Vol. 12, Issue 5, May 2025
DOI: 10.17148/IARJSET.2025.125327

Prototyping Of A Three-Piston Brake Caliper Bracket Using Reverse Engineering

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Abstract: A three-piston brake caliper bracket is a vital component of automotive braking systems, providing structural support and precise alignment. It ensures secure mounting of the caliper, enabling efficient braking performance. Designed for even force distribution across the brake pads and rotor, it enhances braking efficiency, especially in high-performance or heavy-duty vehicles. Made from high-strength steel or aluminum alloys, it withstands extreme stresses and heat. Precision machining ensures optimal alignment, minimizing vibrations and maximizing braking power. This bracket exemplifies engineering innovation, contributing to safety, durability, and reliability in braking systems.

Keywords: Three-piston brake caliper bracket, Automotive braking systems, Braking performance, Force distribution, High-performance vehicles, Heavy-duty vehicles, High-strength steel, Aluminum alloys, Precision machining, Reverse engineering, Prototyping, 3D scanning, CAD model, SolidWorks, AutoCAD, CNC machining, 3D printing, Structural integrity testing, Thermal resistance, Braking efficiency.

INTRODUCTION

A THREE-PISTON BRAKE CALIPER BRACKET

The three-piston brake caliper bracket plays a crucial role in modern braking systems, particularly in high-performance and heavy-duty applications. This component ensures proper alignment and secure mounting of the caliper while also distributing braking forces efficiently.

Prototyping a three-piston brake caliper bracket is a critical step in the development and improvement of automotive braking systems. This process involves creating a tangible, functional model of the bracket to validate its design, material performance, and overall compatibility with other braking components. Prototyping allows engineers to test the bracket's structural integrity, thermal resistance, and precision alignment under simulated or real-world conditions.

This stage is essential for identifying potential design flaws and optimizing the bracket for durability, efficiency, and cost effectiveness before full-scale production. By utilizing advanced prototyping techniques such as 3D printing, CNC machining, or casting, engineers can experiment with different materials and configurations. The insights gained from prototyping contribute to ensuring that the three-piston brake caliper bracket performs reliably in high-performance and heavy-duty applications.

Figure 1 THREE PISTION BRAKE CALIPER BRAKET

PROTOTYPING OF A THREE-PISTON BRAKE CALIPER BRACKET USING REVERSE ENGINEERING

Prototyping is a critical phase in the development of a three-piston brake caliper bracket, ensuring that the design meets performance and durability requirements before full-scale production. Reverse engineering plays a significant role in this process by allowing manufacturers to analyze existing designs, identify areas for improvement, and create accurate 3D models for modification and enhancement.

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➢ IMPORTANCE OF PROTOTYPING
Prototyping enables engineers to:
- Validate Design Concepts: Ensuring the bracket meets mechanical and thermal stress requirements.
- Test Fit and Functionality: Checking alignment with caliper and rotor assembly.
- Identify Design Flaws Early: Preventing costly errors in final production.
- Improve Manufacturing Efficiency: Refining the design for better manufacturability.


Figure 2 BRAKE CALIPER

➢ ROLE OF REVERSE ENGINEERING
Reverse engineering helps in:
- Capturing accurate geometry from an existing bracket.
- Analyzing material properties and structural integrity.
- Modifying the design to enhance performance or reduce weight.
- Developing CAD models for simulations and rapid prototyping.

Material Selection
The choice of material significantly affects the performance and durability of the brake caliper bracket. Some commonly used materials include:

Aluminum Alloys
- 6061-T6 Aluminum: Lightweight, high strength, good corrosion resistance.
- 7075-T6 Aluminum: Higher strength but slightly lower corrosion resistance compared to 6061.
- Advantages: Reduced unsprung mass, better heat dissipation.
- Disadvantages: Can be prone to fatigue under extreme loads.

Steel Alloys
- AISI 4130 (Chromoly Steel): High strength, excellent fatigue resistance.
- Stainless Steel (304, 316): Corrosion-resistant, durable, but heavier.
- Advantages: High strength, cost-effective for heavy-duty applications.
- Disadvantages: Heavier than aluminum, slower heat dissipation.

Carbon Fiber Composites (Emerging Material)
- High strength-to-weight ratio, excellent thermal properties.
- Costly and complex to manufacture.

LITRETURE REVIEW

DR. SARAH JOHNSON (MIT) [1] EXPLORES THE ROLE OF REVERSE ENGINEERING IN AUTOMOTIVE PART DEVELOPMENT. HER RESEARCH DELVES INTO HOW EXISTING DESIGNS ARE ANALYZED TO IMPROVE MATERIAL EFFICIENCY AND PERFORMANCE. JOHNSON HIGHLIGHTS THE USE OF REVERSE ENGINEERING IN PROTOTYPING COMPONENTS LIKE BRAKE CALIPER BRACKETS, SHOWCASING HOW IT HELPS REFINE DESIGNS FOR IMPROVED DURABILITY AND FUNCTIONALITY.
PROF. RAJESH GUPTA (IIT BOMBAY) [2] EMPHASIZES THE IMPORTANCE OF INTEGRATING SIMULATION TESTING DURING THE REVERSE ENGINEERING PROCESS. HIS STUDY FOCUSES ON PROTOTYPING BRAKE SYSTEM COMPONENTS, NOTING THAT EARLY-STAGE VALIDATION HELPS DETECT STRESS POINTS AND THERMAL INCONSISTENCIES, LEADING TO SAFER AND MORE EFFICIENT DESIGNS.
DR. EMILY CARTER (UNIVERSITY OF MICHIGAN) [3] DISCUSSES ADVANCEMENTS IN 3D PRINTING AND THEIR APPLICATION TO BRAKE SYSTEM PROTOTYPES. HER FINDINGS UNDERLINE HOW

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ADDITIVE MANUFACTURING ACCELERATES THE CREATION OF INTRICATE, LIGHTWEIGHT DESIGNS LIKE THREE-PISTON BRAKE CALIPER BRACKETS WHILE MAINTAINING STRUCTURAL INTEGRITY.

DR. AHMED KHALIL (UNIVERSITY OF TORONTO) [4] INVESTIGATES MATERIAL INNOVATIONS IN BRAKE CALIPER BRACKET PROTOTYPES. HIS WORK HIGHLIGHTS THE USE OF HYBRID COMPOSITES FOR REDUCED WEIGHT AND ENHANCED THERMAL RESISTANCE, DEMONSTRATING THEIR COMPATIBILITY WITH REVERSE ENGINEERING WORKFLOWS.

PROF. MARIA GONZALEZ (TECHNICAL UNIVERSITY OF MADRID) [5] EXPLORES THE IMPACT OF CAD-BASED REVERSE
ENGINEERING IN BRAKING SYSTEM DEVELOPMENT. HER STUDY SHOWS HOW DETAILED DIGITAL MODELS OF THREE-PISTON CALIPER
BRACKETS ALLOW FOR ITERATIVE IMPROVEMENTS AND PRECISION-FOCUSED DESIGNS.

EXPERIMENTATION

3.1 METHODOLOGY

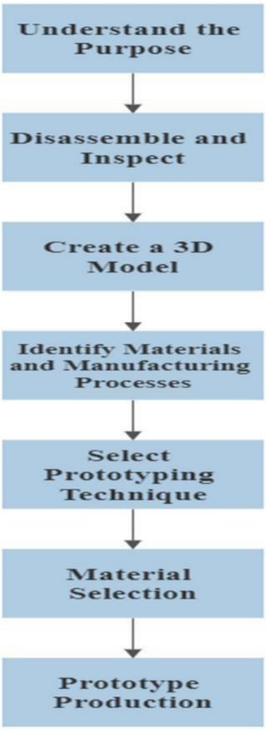

FIGURE 3 PROCESS CHART OF METHODOLOGY

REVERSE ENGINEERING

Introduction To Reverse Engineering:

Reverse engineering (also known as backwards engineering or back engineering) is a process or method through which one attempts to understand through deductive reasoning how a previously made device, process, system, or piece of software accomplishes a task with very little (if any) insight into exactly how it does so. It is essentially the process of opening up or dissecting a system to see how it works, in order to duplicate or enhance it. Depending on the system under consideration and the technologies employed, the knowledge gained during reverse engineering can help with repurposing obsolete objects, doing security analysis, or learning how something works.

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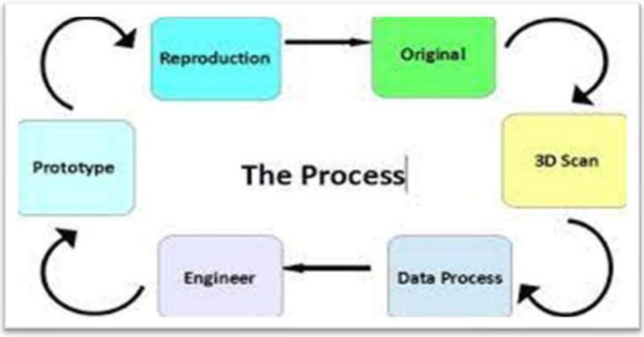

Figure 4 The process

Overview:

There are many reasons for performing reverse engineering in various fields. Reverse engineering has its origins in the analysis of hardware for commercial or military advantage. However, the reverse engineering process may not always be concerned with creating a copy or changing the artifact in some way. It may be used as part of an analysis to deduce design features from products with little or no additional knowledge about the procedures involved in their original production.

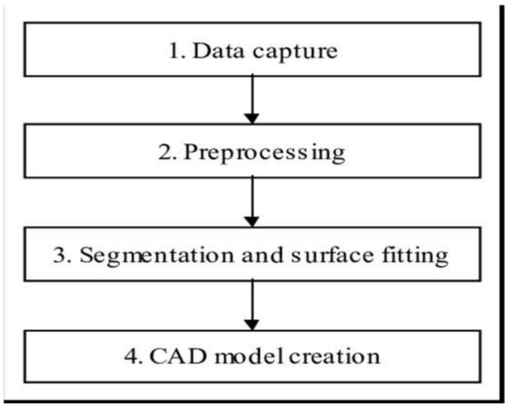

Figure 5 Procedure

In some cases, the goal of the reverse engineering process can simply be a redocumentation of legacy systems. Even when the reverse-engineered product is that of a competitor, the goal may not be to copy it but to perform competitor analysis. Reverse engineering may also be used to create interoperable products and despite some narrowly-tailored United States and European Union legislation, the legality of using specific reverse engineering techniques for that purpose has been hotly contested in courts worldwide for more than two decades.

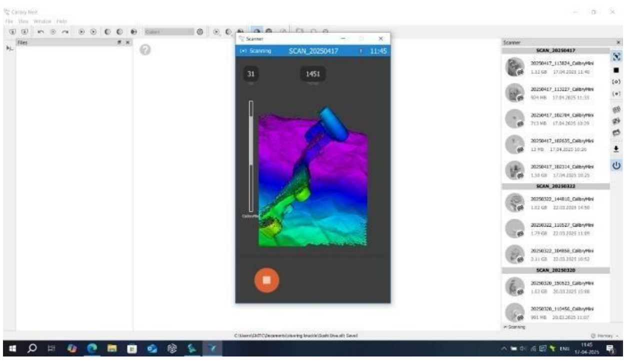

Figure 6 Software interface of scanned object

Software reverse engineering can help to improve the understanding of the underlying source code for the maintenance and improvement of the software, relevant information can be extracted to make a decision for software development

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and graphical representations of the code can provide alternate views regarding the source code, which can help to detect and fix a software bug or vulnerability. Frequently, as some software develops, its design information and improvements are often lost over time, but that lost information can usually be recovered with reverse engineering. The process can also help to cut down the time required to understand the source code, thus reducing the overall cost of the software development. Reverse engineering can also help to detect and to eliminate a malicious code written to the software with better code detectors. Reversing a source code can be used to find alternate uses of the source code, such as detecting the unauthorized replication of the source code where it was not intended to be used, or revealing how a competitor's product was built. That process is commonly used for "cracking" software and media to remove their copy protection, or to create a possibly-improved copy or even a knockoff, which is usually the goal of a competitor or a hacker.

Malware developers often use reverse engineering techniques to find vulnerabilities in an operating system to build a computer virus that can exploit the system vulnerabilities. Reverse engineering is also being used in cryptanalysis to find vulnerabilities in substitution cipher, symmetric-key algorithm or public-key cryptography. 20

Technical Uses Of Reverse Engineering There are other uses to reverse engineering:
Interfacing: Reverse engineering can be used when a system is required to interface to another system and how both systems would negotiate is to be established. Such requirements typically exist for interoperability.
Military or commercial espionage: Learning about an enemy's or competitor's latest research by stealing or capturing a prototype and dismantling it may result in the development of a similar product or a better countermeasure against it.
Obsolescence: Integrated circuits are often designed on proprietary systems and built on production lines, which become obsolete in only a few years. When systems using those parts can no longer be maintained since the parts are no longer made, the only way to incorporate the functionality into new technology is to reverse-engineer the existing chip and then to redesign it using newer tools by using the understanding gained as a guide. Another obsolescence originated problem that can be solved by reverse engineering is the need to support (maintenance and supply for continuous operation) existing legacy devices that are no longer supported by their original equipment manufacturer. The problem is particularly critical in military operations.

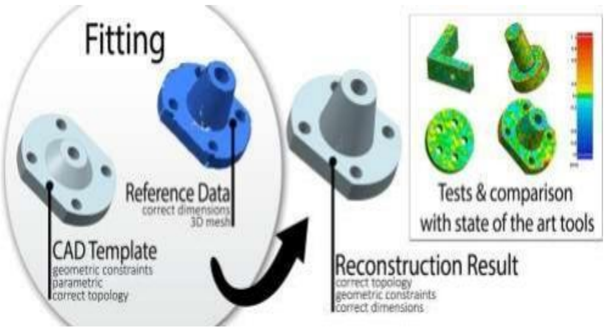

Figure 7 Reverse engineering process

Product security analysis: That examines how a product works by determining the specifications of its components and estimate costs and identifies potential patent infringement. Also, part of product security analysis is acquiring sensitive data by disassembling and analyzing the design of a system component. Another intent may be to remove copy protection or to circumvent access restrictions.
Competitive technical intelligence: That is to understand what one's competitor is actually doing, rather than what it says that it is doing.
Saving money: Finding out what a piece of electronics can do may spare a user from purchasing a separate product.
Repurposing: Obsolete objects are then reused in a different-but-useful manner. **Design:** Production and design companies applied Reverse Engineering to practical craft-based manufacturing process. The companies can work on “historical” manufacturing collections through 3D scanning, 3D re-modeling and re-design. In 2013 Italian manufactures Baldi and Savio Firmino together with University of Florence optimized their innovation, design, and production processes.

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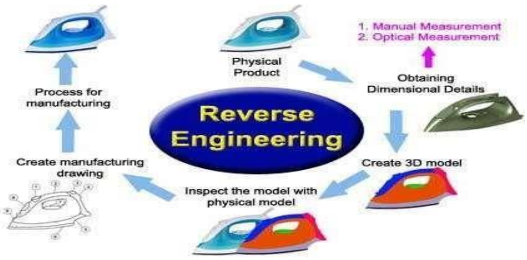

Figure 8 Process of Reverse Engineering

Machines:
As computer-aided design (CAD) has become more popular, reverse engineering has become a viable method to create a 3D virtual model of an existing physical part for use in 3D CAD, CAM, CAE, or other software. The reverse engineering process involves measuring an object and then reconstructing it as a 3D model. The physical object can be measured using 3D scanning technologies like CMMs, laser scanners, structured light digitizers, or industrial CT scanning (computed tomography). The measured data alone, usually represented as a point cloud, lacks topological information and design intent. The former may be recovered by converting the point cloud to a triangular-faced mesh. Reverse engineering aims to go beyond producing such a mesh and to recover the design intent in terms of simple analytical surfaces where appropriate (planes, cylinders, etc.) as well as possibly NURBS surfaces to produce a boundary-representation CAD model. Recovery of such a model allows a design to be modified to meet new requirements, a manufacturing plan to be generated, etc.

Stages Of Reverse Engineering:
The 3 stages of reverse engineering:
Reverse engineering is taking apart an object to see how it works in order to duplicate or enhance the object. The practice, taken from older industries, is now frequently used on computer hardware and software. You can reverse engineer by constructing models that describe the existing software and the presumed intent. This process of reverse engineering has three main stages:

1) Implementation Recovery:
In implementation recovery, you prepare an initial model that forms the basis for reverse engineering. Because the initial model will serve as a reference, it should purely reflect the implementation and have no inferences. The first task is to browse existing documentation and learn about an application. The resulting context clarifies the developer's intent and makes it easier to communicate with application experts. You should finish this task in a few hours. What you learn is incidental to the actual reverse engineering, but it is important because it helps you notice more as you proceed.
The next step is to enter the database structure into a modeling tool by typing or automation. Some tools can read the system tables of an RDBMS and seed a model. If you use these tools, you should at least skim the database structure to get a feel for the development style.

2) Design Recovery:
During design recovery, you undo the mechanics of the database and perform only straightforward actions. You should postpone conjecture and interpretation until the analysis-recovery stage. Typically, you can perform design recovery autonomously, without help from application experts. During this stage, you resolve three main issues. Identity. Most often, unique indexes will be defined for the candidate keys of the entity types. Otherwise, look for unique combinations of data; such data can suggest, but do not prove, a candidate key. You can also infer candidate keys by considering names and conventions of style. A suspected foreign key may imply a corresponding candidate key.
Foreign keys. Foreign key (references from one table to another) determination is usually the most difficult aspect of design recovery. Matching names and data types can suggest foreign keys. Some DBMSs, such as RDBMSs, let developers declare foreign keys and their referent, but most legacy applications do not use this capability. Queries. When queries are available, you can use them to refine your understanding of identity and foreign keys.
The final product of design recovery still reflects the DBMS paradigm and may include optimizations and errors. In practice, the model will seldom be complete. Portions of the structure may be confusing. 24

3) Analysis Recovery:
The final phase is analysis recovery interpret the model, refine it, and make it more abstract. It is primarily during this phase that you should consult with available application experts. Analysis recovery consists of four main tasks.
- **Clarification:** Remove any remaining artifacts of design. For example, an analysis model need not include file and database access keys; they are merely design decisions and contain no essential information.

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- **Redundancy**: Normally remove derived data that optimize the database design or that were included for misguided reasons. You may need to examine data before determining that a data structure is a duplicate.
- **Errors**: Eliminate any remaining database errors. I include this step during analysis recovery because you must thoroughly understand the database before concluding that the developer erred. In the earlier stages, an apparent error could instead have been a reasonable practice or the result of incompletely understanding the database.
- **Model integration**: Multiple information sources can lead to multiple models. For example, it is common to have a reverse-engineered model from study of the structure and data. A forward-engineered model might be prepared from a user manual. The final analysis model must fuse any separate mode.

Multi information sources can lead to multiple models. For example, it is common to have a reverse-engineered model from study of the structure and data. A forward-engineered model might be prepared from a user manual. The final analysis model must fuse any separate mode.

In the earlier stages, an apparent error could instead have been a reasonable practice or the result of incompletely understanding the database. Introduction To 3d Scanning
3D scanning is the process of analyzing a real-world object or environment to collect three-dimensional data of its shape and possibly its appearance (e.g., color). The collected data can then be used to construct digital 3D models.

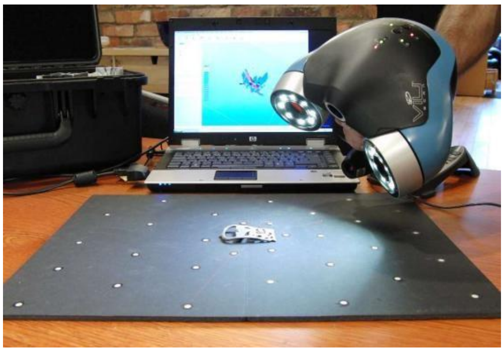

Figure 9 Scanning of an object

A 3D scanner can be based on many different technologies, each with its own limitations, advantages and costs. Many limitations in the kind of objects that can be digitized are still present. For example, optical technology may encounter many difficulties with dark, shiny, reflective or transparent objects. For example, industrial computed tomography scanning, structured-light 3D scanners, LiDAR and Time Of Flight 3D Scanners can be used to construct digital 3D models, without destructive testing.

Collected 3D data is useful for a wide variety of applications. These devices are used extensively by the entertainment industry in the production of movies and video games, including virtual reality. Other common applications of this technology include augmented reality, motion capture, gesture recognition, robotic mapping, industrial design, orthotics and prosthetics, reverse engineering and prototyping, quality control/inspection and the digitization of cultural artifacts.
Functionality:

The purpose of a 3D scanner is usually to create a 3D model. This 3D model consists of a polygon mesh or point cloud of geometric samples on the surface of the subject. These points can then be used to extrapolate the shape of the subject (a process called reconstruction). If color information is collected at each point, then the colors or textures on the surface of the subject can also be determined.

Figure 10 Calibry Scanner equipment

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Technology:
There are a variety of technologies for digitally acquiring the shape of a 3D object. The techniques work with most or all sensor types including optical, acoustic, laser scanning, radar, thermal, and seismic. A wellestablished classification divides them into two types: contact and non-contact. Non-contact solutions can be further divided into two main categories, active and passive. There are a variety of technologies that fall under each of these categories.

Reconstruction:
From point clouds:
The point clouds produced by 3D scanners and 3D imaging can be used directly for measurement and visualization in the architecture and construction world.
From models:
Most applications, however, use instead polygonal 3D models, NURBS surface models, or editable feature-based CAD models (aka solid models).

- **Polygon mesh models**: In a polygonal representation of a shape, a curved surface is modeled as many small faceted flat surfaces (think of a sphere modeled as a disco ball). Polygon models—also called Mesh models, are useful for visualization, for some CAM (i.e., machining), but are generally "heavy"
(i.e., very large data sets), and are relatively un-editable in this form. Reconstruction to polygonal model involves finding and connecting adjacent points with straight lines in order to create a continuous surface. Many applications, both free and nonfee, are available for this purpose (e.g. Gilgamesh, MeshLab, PointCab, kubit PointCloud for AutoCAD, Reconstructor, imagemodel, PolyWorks, Rapidform, Geomagic, Imageware, Rhino 3D etc.).
- **Surface models:** The next level of sophistication in modeling involves using a quilt of curved surface patches to model the shape. These might be NURBS, TSplines or other curved representations of curved topology. Using NURBS, the spherical shape becomes a true mathematical sphere. Some applications offer patch layout by hand but the best in class offer both automated patch layout and manual layout. These patches have the advantage of being lighter and more manipulable when exported to CAD. Surface models are somewhat editable, but only in a sculptural sense of pushing and pulling to deform the surface. This representation lends itself well to modelling organic and artistic shapes. Providers of surface modellers include Rapidform, Geomagic, Rhino 3D, Maya, T Splines etc.

Solid CAD models: From an engineering/manufacturing perspective, the ultimate representation of a digitized shape is the editable, parametric CAD model. In CAD, the sphere is described by parametric features which are easily edited by changing a value (e.g., centre point and radius).

These CAD models describe not simply the envelope or shape of the object, but CAD models also embody the "design intent" (i.e., critical features and their relationship to other features). An example of design intent not evident in the shape alone might be a brake drum's lug bolts, which must be concentric with the hole in the centre of the drum. This knowledge would drive the sequence and method of creating the CAD model; a designer with an awareness of this relationship would not design the lug bolts referenced to the outside diameter, but instead, to the center. A modeler creating a CAD model will want to include both Shape and design intent in the complete CAD model.

Vendors offer different approaches to getting to the parametric CAD model. Some export the NURBS surfaces and leave it to the CAD designer to complete the model in CAD (e.g., Geomagic, Imageware, Rhino 3D).
Others use the scan data to create an editable and verifiable feature based model that is imported into CAD with full feature tree intact, yielding a complete, native CAD model, capturing both shape and design intent (e.g. Geomagic, Rapidform). For instance, the market offers various plug-ins for established CAD-programs, such as SolidWorks. Xtract3D, DezignWorks and Geomagic for SolidWorks allow manipulating a 3D scan directly inside SolidWorks. Still other CAD applications are robust enough to manipulate limited points or polygon models within the CAD environment (e.g., CATIA, AutoCAD, Revit).

Figure 11 Digital picture of Scanning

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From Laser Scans:

Laser scanning describes the general method to sample or scan a surface using laser technology. Several areas of application exist that mainly differ in the power of the lasers that are used, and in the results of the scanning process. Low laser power is used when the scanned surface doesn't have to be influenced, e.g., when it only has to be digitized. Confocal or 3D laser scanning are methods to get information about the scanned surface. Another low-power application uses structured light projection systems for solar cell flatness metrology, enabling stress calculation throughout in excess of 2000 wafers per hour.

The laser power used for laser scanning equipment in industrial applications is typically less than 1W. The power level is usually on the order of 200 mW or less but sometimes more. From Photographs:

3D data acquisition and object reconstruction can be performed using stereo image pairs. Stereo photogrammetry or photogrammetry based on a block of overlapped images is the primary approach for 3D mapping and object reconstruction using 2D images. Close-range photogrammetry has also matured to the level where cameras or digital cameras can be used to capture the close-look images of objects, e.g., buildings, and reconstruct them using the very same theory as the aerial photogrammetry. An example of software which could do this is Vexcel FotoG 5. This software has now been replaced by Vexcel GeoSynth. Another similar software program is Microsoft Photosynth.

Figure 12 Calibry scanner

Multi-spectral images are also used for 3D building detection. The first and last pulse data and the normalized difference vegetation index are used in the process.

New measurement techniques are also employed to obtain measurements of and between objects from single images by using the projection, or the shadow as well as their combination. This technology is gaining attention given its fast-processing time, and far lower cost than stereo measurements

Object Reconstruction:

3D reconstruction from multiple images is the creation of three-dimensional models from a set of images. It is the reverse process of obtaining 2D images from 3D scenes. The essence of an image is a projection from a 3D scene onto a 2D plane, during which process the depth is lost. The 3D point corresponding to a specific image point is constrained to be on the line of sight. From a single image, it is impossible to determine which point on this line corresponds to the image point. If two images are available, then the position of a 3D point can be found as the intersection of the two projection rays. This process is referred to as triangulation. The key for this process is the relations between multiple views which convey the information that corresponding sets of points must contain some structure and that this structure is related to the poses and the calibration of the camera.

Processing:

The task of converting multiple 2D images into 3D model consists of a series of processing steps:

Camera calibration consists of intrinsic and extrinsic parameters, without which at some level no arrangement of algorithms

can work. The dotted line between Calibration and Depth determination represents that the camera calibration is usually required for determining depth. Depth determination serves as the most challenging part in the whole process, as it calculates the 3D component missing from any given image – depth. The correspondence problem, finding matches between two images so the position of the matched elements can then be triangulated in 3D space is the key issue here.

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Figure 13 Scanning of braket

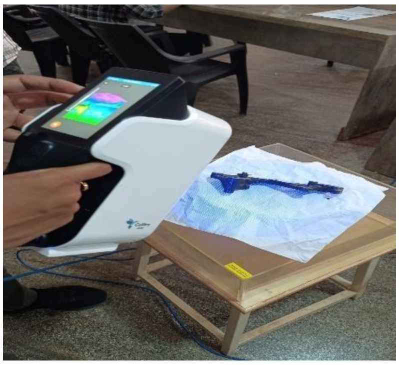

Figure 14 Scanner preview of scan

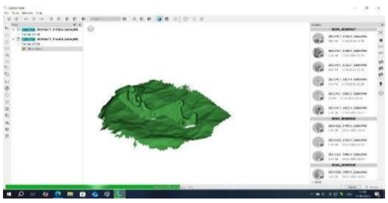

Figure 15 Calibry Nest preview

Figure 16 Model rendering of the scanned Data

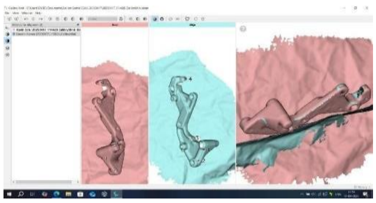

Figure 17 Merging of all the frames

3D PRINTING OF BRAKET

5.1 Introduction to 3d Printing

3D printing is an additive process whereby layers of material are built up to create a 3D part. This is the opposite of subtractive manufacturing processes, where a final design is cut from a larger block of material. As a result, 3D printing creates less material wastage. That is why "3D Printing" is also called additive manufacturing in contrast to traditional methods of production that are primarily subtractive in nature, also called as "subtractive manufacturing" or moulding/casting processes. Applications of 3D printing are emerging almost by the day, and, as this technology continues to penetrate more widely and deeply across industrial, maker and consumer sectors, this is only set to increase. Most reputable commentators on this technology sector agree that, as of today, we are only just beginning to see the true potential of 3D printing.

5.2 When was 3D Printing invented?

Building on Ralf Baker's work in the 1920s for making decorative articles (patent US423647A), Hideo Kodama's early work in laser cured resin rapid prototyping was completed in 1981. His invention was expanded upon over the next three decades, with the introduction of stereolithography in 1984. Chuck Hull of 3D Systems invented the first 3D printer in 1987, which used the stereolithography process. This was followed by developments such as selective laser sintering and selective laser melting, among others.

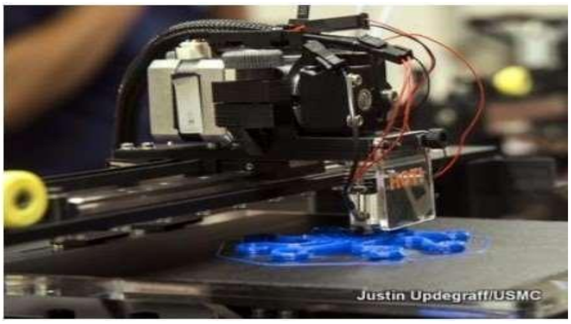

Figure 18 3D Printing Machine

5.2.1 Types of 3D Printing

3D printing has been categorized into seven groups by ISO/ASTM 52900 additive manufacturing - general principles - terminology. All forms of 3D printing fall into one of the following types:

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.311 ⁘ Peer-reviewed & Refereed journal ⁘ Vol. 12, Issue 5, May 2025

DOI: 10.17148/IARJSET.2025.125327

- Binder Jetting
- Direct Energy Deposition
- Material Extrusion
- Material Jetting
- Powder Bed Fusion
- Sheet Lamination
- VAT Polymerization

5.3 The 3d Basic Steps of 3d Printing:

3D printing has become synonymous with manufacturing. Research, in fact, indicates it's the most popular prototyping method used by manufacturing companies. Using a 3D printer, manufacturing companies can quickly build prototypes for testing and quality assurance purposes. While there are many different types of 3D printing processes, though, nearly all of them consist of three basic steps. So, what are the three basic steps of 3D printing exactly?

5.4 Modelling:

Before a manufacturing company can build an object with a 3D printer, it must design the model using computer software. Modeling is the first step of 3D printing. Manufacturing companies typically design object models using a special type of computer software known as a computer-aided design (CAD) package. Once complete, the object model is saved as a stereolithography (STL) or an additive manufacturing file (AMF) format. During the modeling step, manufacturing companies will check the model file for errors. Most CAD packages are able to detect errors that, if ignored, could cause defects in the printed object. Common errors found in model files include holes, self-intersections, manifold errors and faces.

5.5 Printing:

The second step of 3D printing involves printing, or building, the object. Assuming there are no errors in the STL or AMF file, the manufacturing company can upload it to the 3D printer. The 3D printer will use the instructions in the respective file to dictate where and how the material is deposited. Most 3D printers build objects by depositing layers of material onto a bed. The 3D printer will build the bottom layer first, after which it will build the next-highest layer. 3D printers may use different materials to build objects, though thermoplastic is the most common material used for this process. Thermoplastic pellets or beads are extruded out of the printer head, at which point they fall onto the bed where they form the printed object.

5.6 Finishing:

The third and final step of 3D any superficial imperfections while also creating a smoother surface finish. Alternatively, if supports were used to hold the object during printing, they'll have to be removed during this printing is finishing. As the name suggests, finishing involves making the final touches on the printed object. Solvents, for example, may be added to the printed object to eliminate third and final step.

5.7 Conclusion:

3D printing is typically performed in three steps. The first step involves designing the object model in a CAD package. The second step involves building the object with a 3D printer. The third step consists of finishing where the final touches are made.

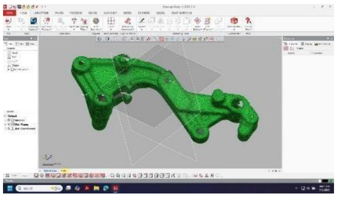

Figure 19 Modeling Of Braket

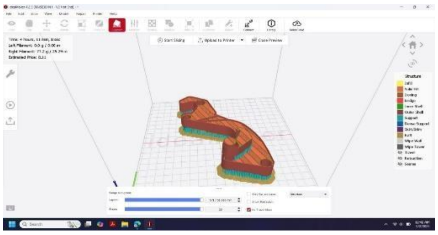

Figure 22 Finished Supports

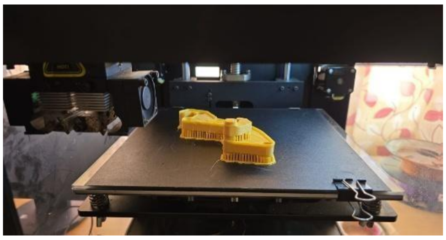

Figure 24 Finished Model

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.311 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 12, Issue 5, May 2025

DOI: 10.17148/IARJSET.2025.125327

RESULT AND DISCUSSION

REVERSE ENGINEERING PRINCIPLES TO A THREE-PISTON BRAKE CALIPER BRACKET

By analysing these factors, improvements can be made to the **three-piston brake caliper bracket** to optimize performance, durability, and compatibility with various braking systems. If you're exploring specific refinements or modifications.

generation

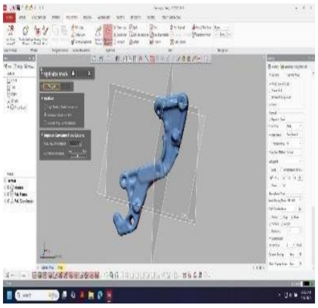

Figure 20 Optimal Meshing

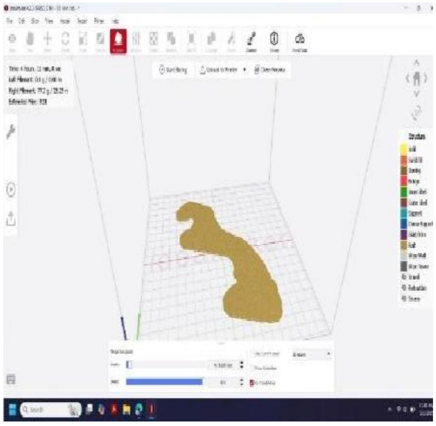

Figure 23 Printing of the Braket

Figure 25 Back View

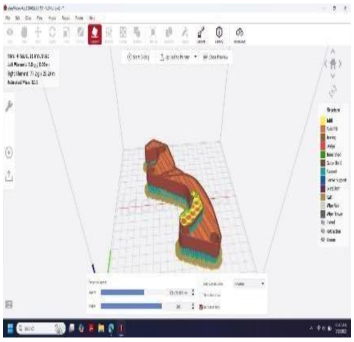

Figure 21 Construction of supports to the Model

Figure 27 Top View Of Braket

Figure 26 Front View

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

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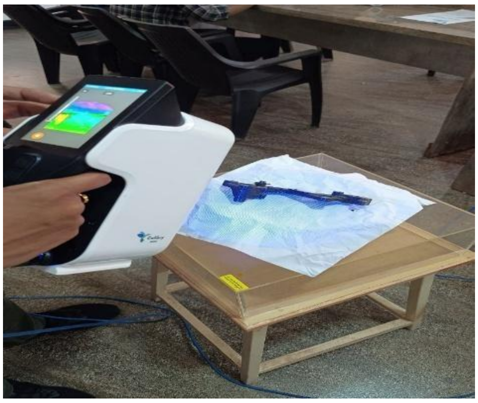

Figure 28 Side View Of Braket

Figure 29 Front View Of Braket

CONCLUSION

In conclusion, reverse engineering the **three-piston brake caliper bracket** provides key insights into its **design, material composition, structural properties, and manufacturing processes**. These findings can aid in **performance improvements, durability enhancements, and design optimizations** for specialized applications in both automotive and motorsport industries.

ACKNOWLEDGEMENT

We would like to express our sincere gratitude to our internal guide, **Mr. K. DAYAKAR,** Assistant Professor of Mechanical Engineering, GNIT for his valuable guidance, encouragement, and continuous support throughout the duration of this project.

We are also thankful to **Dr. B. VIJAYA KUMAR,** Professor & Head of Department, Department of Mechanical Engineering and COE of GNIT for his/her expert supervision and helpful suggestions, which contributed significantly to the successful completion of this project.

We wish to express our candid gratitude to Principal **Dr. KODUGANTI VANKATA RAO,** and the management for providing the required facilities to complete our project successfully.

We would also like to thank the faculty members of the **Mechanical Engineering** and the Lab Technicians for their assistance and cooperation during the practical work of our project.

We are grateful to our friends and well-wishers for their encouragement, collaboration, and useful feedback throughout the project journey.

Lastly, we sincerely thank our parents for their constant support, patience, and motivation, which helped us complete this project successfully.

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P. KARTHIK REDDY **21831A0309**

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