DESIGN OF A 7-CYLINDER RADIAL ENGINE USING CATIA

An Internship Project report submitted to AYLIN TECHNOLOGIES PRIVATE LIMITED in partial fulfilment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY in MECHANICAL ENGINEERING

Submitted by

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20761A0358

Under the guidance of

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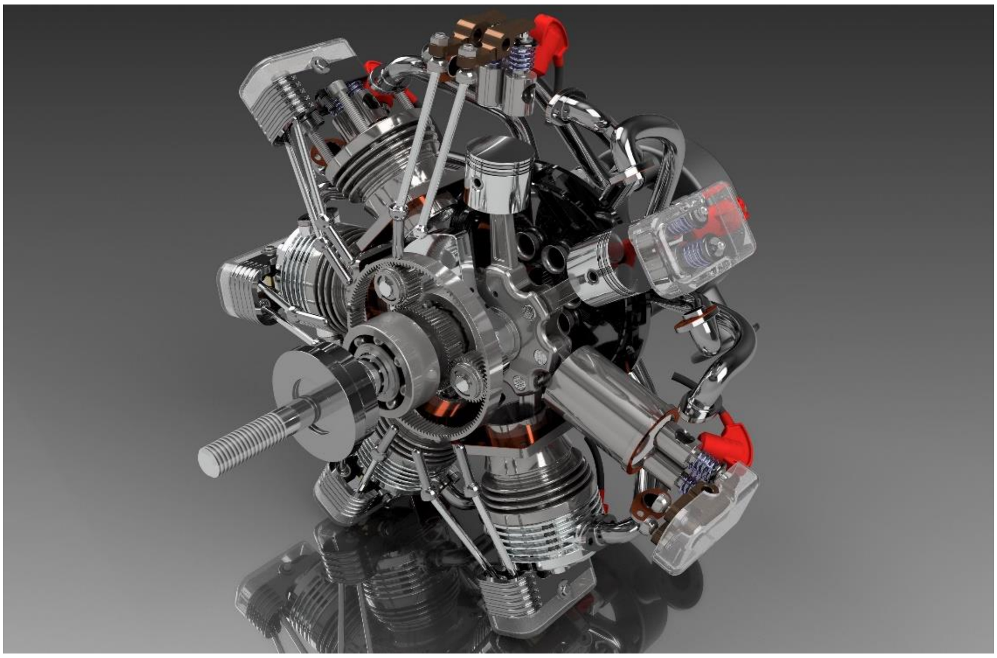

DEPARTMENT OF MECHANICAL ENGINEERING

LAKIREDDY BALI REDDY COLLEGE OF ENGINEERING

(AUTONOMOUS)

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This is to certify that the Internship Project work entitled "**DESIGN OF A 7-CYLINDER RADIAL ENGINE USING CATIA**" is a bonafide work done by **DOKKU SIRI VENKATA NAGA GOPI** (20761A0358), that is being submitted for the partial fulfillment of B. Tech degree in Mechanical Engineering from LAKIREDDY BALI REDDY COLLEGE OF ENGINEERING to AYLIN TECHNOLOGIES PRIVATE LIMITED during the academic year 2023-2024 and it has been found worthy of acceptance according to the requirement of their university.

Signature of the Supervisor

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The Satisfaction that accompanies that the successful completion of any task would be incomplete without the mention of the people whose cease less co-operation made it possible, whose constant guidance and encouragement crown all efforts with success.

I humbly express my thanks to the management **AYLIN TECHNOLOGIES PRIVATE LIMITED** for extending their support for providing us with an environment to complete our internship successfully.

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I am thankful to my friends who helped me sharing knowledge and by providing material to complete the internship in time.

DOKKU SIRI VENKATA NAGA GOPI.

(20761A0358)

DECLARATION

I am here by declaring that the project entitled "**DESIGN OF A 7-CYLINDER RADIAL ENGINE USING CATIA**" work done by me. I certify that the work contained in the report is original and has been done by me under the guidance of my supervisor. The work has not been submitted to any other institute in preparing for any degree or diploma. I have followed the guidelines provided by the institute in preparing the report. I have conformed to the norms and guidelines given in the Ethical Code of Conduct of the institute. Whenever I have used materials (data, theoretical analysis, figures and text) from other sources, we have given due credit to them by citing them in the text of the report and giving their details in the references. Further, we have taken permission from the copyright's owner of the sources, whenever necessary.

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ABSTRACT

Abstract:

The project focuses on the conceptualization, design, and analysis of a 7-cylinder radial engine using CATIA, a leading computer-aided design (CAD) software. Radial engines have historical significance and unique engineering challenges, making them intriguing subjects for study. The primary objectives of this project are to create a comprehensive 3D model of the radial engine, simulate its operational dynamics, and evaluate its performance characteristics.

The project begins with an in-depth review of radial engine theory, including combustion processes, thermodynamics, and mechanical principles. The design and operation of radial engines differ from traditional engines due to their arrangement of cylinders around a central hub. Leveraging CATIA's robust modelling capabilities, a detailed 3D representation of the 7-cylinder radial engine is developed, encompassing components such as cylinders, pistons, crankshafts, connecting rods, and a central hub. Special attention is given to the precise arrangement and alignment of components to ensure accurate depiction.

A 7-cylinder radial engine is a type of internal combustion engine widely used in aviation and industrial applications. It features a central crankshaft from which seven cylinders radiate like spokes on a wheel. This arrangement allows for efficient power delivery and balanced operation, as the cylinders' firing sequence is evenly spaced. The radial configuration provides several advantages, including simplified cooling due to the exposed cylinders, compact size, and relatively straightforward maintenance. These engines have been historically significant in aircraft design, powering various military and civilian planes during the early to mid-20th century. While newer engine designs have largely replaced the radial layout in modern aviation, the 7-cylinder radial engine remains an iconic symbol of early aviation's pioneering spirit and engineering ingenuity.

The outcomes of this project offer a holistic understanding of radial engine design principles, CAD modelling techniques, and performance analysis using advanced simulations. The insights gained can be applied to refine the design of radial engines for various applications, including aviation, automotive, and stationary power generation. The project underscores the utility of CATIA as a powerful tool for intricate engineering design and analysis and contributes to the broader field of internal combustion engine research.

Key words:

- CATIA
- Radial engine
- 7-cylinder
- CAD modelling

CONTENTS

CHAPTER – I

1. INTRODUCTION

The radial engine is a reciprocating type internal combustion engine configuration in which the cylinders "radiate" outward from a central crankcase like the spokes of a wheel. It resembles a stylized star when viewed from the front, and is called a "star engine" in some other languages. The radial configuration was commonly used for aircraft engines before gas turbine engines became predominant.

1.1. ENGINE OPERATION:

Since the axes of the cylinders are coplanar, the connecting rods cannot all be directly attached to the crankshaft unless mechanically complex forked connecting rods are used, none of which have been successful. Instead, the pistons are connected to the crankshaft with a master-and-articulating-rod assembly. One piston, the uppermost one in the animation, has a master rod with a direct attachment to the crankshaft. The remaining pistons pin their connecting rods' attachments to rings around the edge of the master rod. Extra "rows" of radial cylinders can be added in order to increase the capacity of the engine without adding to its diameter.

Four-stroke radials have an odd number of cylinders per row, so that a consistent every-other-piston firing order can be maintained, providing smooth operation. For example, on a five-cylinder engine the firing order is 1, 3, 5, 2, 4, and back to cylinder 1. Moreover, this always leaves a one-piston gap between the piston on its combustion stroke and the piston on compression. The active stroke directly helps compress the next cylinder to fire, making the motion more uniform. If an even number of cylinders were used, an equally timed firing cycle would not be feasible. The prototype radial Zoche aero-diesels (below) have an even number of cylinders, either four or eight; but this is not problematic, because they are two-stroke engines, with twice the number of power strokes as a four-stroke engine per crankshaft rotation.

As with most four-strokes, the crankshaft takes two revolutions to complete the four strokes of each piston (intake, compression, combustion, exhaust). The camshaft ring is geared to spin slower and in the opposite direction to the crankshaft. Its cam lobes are placed in two rows; one for the intake valves and one for the exhaust valves. The radial engine normally uses fewer cam lobes than other types. For example, in the engine in the animated illustration, four cam lobes serve all 10 valves across the five cylinders, whereas 10 would be required for a typical inline engine with the same number of cylinders and valves.

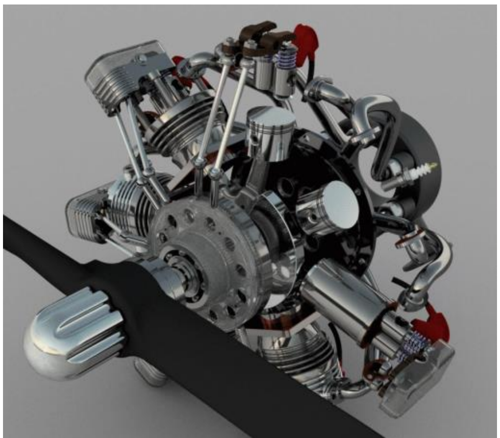


Fig- 1: Engine Operation of 7-Cylinder Radial Engine

Most radial engines use overhead poppet valves driven by pushrods and lifters on a cam plate which is concentric with the crankshaft, with a few smaller radials, like the Kinner B-5 and Russian Shvetsov M-11, using individual camshafts within the crankcase for each cylinder. A few engines use sleeve valves such as the 14-cylinder Bristol Hercules and the 18-cylinder Bristol Centaurus, which are quieter and smoother running but require much tighter manufacturing tolerances.

1.2. HISTORY:

1.2.1. Aircraft:

The history of radial engines is marked by notable developments and innovations. C. M. Manly's 1901 creation of a water-cooled five-cylinder radial engine, derived from Stephen Balzer's rotary engine, generated 52 hp at 950 rpm for Langley's Aerodrome aircraft. In 1903-1904, Jacob Ellehammer applied motorcycle construction experience to craft the world's first air-cooled radial engine, leading to a more powerful five-cylinder model by 1907. Alessandro Anzani's pre-1914 radial engines ranged from 3 to 20 cylinders, including a 20-cylinder engine with four rows of five cylinders. The Salmson 9Z series, a successful water-cooled nine-cylinder radial design for World War I aircraft, offered high power-to-weight ratios and reliability. The radial engine, initially overshadowed by the rotary engine, gained prominence due to its efficient cooling and the pioneering efforts of inventors like Charles Lawrance, whose J-1 engine demonstrated exceptional endurance. Wright's J-5 Whirlwind, claimed as the first reliable aircraft engine, played a crucial role in aviation history, powering significant aircraft like Charles Lindbergh's Spirit of St. Louis. Pratt & Whitney's radial engines, including the R-1830 Twin Wasp, set the standard for performance, with the Twin Wasp being the most prolific aviation piston engine. The UK's Bristol Aeroplane Company and other nations also contributed to the radial engine's evolution, leading to its widespread use in various iconic aircraft, such as the Vought F4U Corsair and Boeing B-29 Superfortress.

Fig- 2: Pratt & Whitney R-1340 radial mounted in Sikorsky H-19 helicopter

1.2.2. Tanks:


Fig- 3: Continental radial, 1944

In the years leading up to World War II, as the need for armored vehicles was realized, designers were faced with the problem of how to power the vehicles, and turned to using aircraft engines, among them radial types. The radial aircraft engines provided greater power-to-weight ratios and were more reliable than conventional inline vehicle engines available at the time. This reliance had a downside though: if the engines were mounted vertically, as in the M3 Lee and M4 Sherman, their comparatively large diameter gave the tank a higher silhouette than designs using inline engines.

The Continental R-670, a 7-cylinder radial aero engine which first flew in 1931, became a widely used tank powerplant, being installed in the M1 Combat Car, M2 Light Tank, M3 Stuart, M3 Lee, and LVT-2 Water Buffalo.

The Guiberson T-1020, a 9-cylinder radial diesel aero engine, was used in the M1A1E1, while the Continental R975 saw service in the M4 Sherman, M7 Priest, M18 Hellcat tank destroyer, and the M44 self-propelled howitzer.

1.2.3. Modern Radials:


Fig- 4: Four-stroke aircraft radial engine Scarlett mini-5

A number of companies continue to build radials today. Vedeneyev produces the M-14P radial of 360–450 hp (270–340 kW) as used on Yakovlev and Sukhoi aerobatic aircraft. The M-14P is also used by builders of homebuilt aircraft, such as the Culp Special, and Culp Sopwith Pup, Pitts S12 "Monster" and the Murphy "Moose". 110 hp (82 kW) 7-cylinder and 150 hp (110 kW) 9-cylinder engines are available from Australia's Rotec Aero sport. HCI Aviation offers the R180 5-cylinder (75 hp (56 kW)) and R220 7-cylinder (110 hp (82 kW)), available "ready to fly" and as a build-it-yourself kit. Verner Motor of the Czech Republic builds several radial engines ranging in power from 25 to 150 hp (19 to 112 kW). Miniature radial engines for model airplanes are available from O. S. Engines, Saito Seisakusho of Japan, and Shijiazhuang of China, and Evolution (designed by Wolfgang Seidel of Germany, and made in India) and Technopower in the US.

1.3. COMPARISON WITH INLINE ENGINES:

Liquid cooling systems are generally more vulnerable to battle damage. Even minor shrapnel damage can easily result in a loss of coolant and consequent engine overheating, while an air-cooled radial engine may be largely unaffected by minor damage. Radials have shorter and stiffer crankshafts, a single-bank radial engine needing only two crankshaft bearings as opposed to the seven required for a liquid-cooled, six-cylinder, inline engine of similar stiffness.

Fig- 5: The 1935 Monaco-Trossi race car, a rare example of automobile use

While a single-bank radial permits all cylinders to be cooled equally, the same is not true for multi-row engines where the rear cylinders can be affected by the heat coming off the front row, and air flow being masked.

A potential disadvantage of radial engines is that having the cylinders exposed to the airflow increases drag considerably. The answer was the addition of specially designed cowlings with baffles to force the air between the cylinders. The first effective drag-reducing cowling that didn't impair engine cooling was the British Townend ring or "drag ring" which formed a narrow band around the engine covering the cylinder heads, reducing drag. The National Advisory Committee for Aeronautics studied the problem, developing the NACA cowling which further reduced drag and improved cooling. Nearly all aircraft radial engines since have used NACA-type cowlings.

While inline liquid-cooled engines continued to be common in new designs until late in World War II, radial engines dominated afterwards until overtaken by jet engines, with the late-war Hawker Sea Fury and Grumman F8F Bearcat, two of the fastest production piston-engined aircraft ever built, using radial engines.

1.4. TYPES OF RADIAL ENGINE:

- Single-Row Radial Engine
- Double-Row Radial Engine
- Multi-Row Radial Engine
- Air-Cooled Radial Engine
- Water-Cooled Radial Engine
- Sleeve Valve Radial Engine
- Geared Radial Engine
- Supercharged Radial Engine
- Twin Radial Engine
- Wasp Radial Engine
- Cyclone Radial Engine
- Jupiter Radial Engine
- Duplex-Cyclone Radial Engine etc.

CHAPTER – II

2. 7–CYLINDER RADIAL ENGINE

The 7-cylinder radials were a family of air-cooled radial engines, designed and built by the Comet Engine Corporation at Madison, Wisconsin from around 1927. A 7-cylinder engine can be categorized as a single-row radial engine. In this configuration, the cylinders are arranged in a single circular row around the engine's crankshaft.

2.1. DESIGN AND DEVELOPMENT:

Comet designed the 7-cylinder radial series to take advantage of the boom in private aviation in the late 1920s; intending to replace the large number of relatively unreliable wartime surplus engines that flooded the market in the early 1920s.

First produced by the Aircraft Engine Corporation of Oakland, California, new interests acquired the California company and the Comet Engine Corporation was formed under the sponsorship of Air Investors Inc., the Crocker First Company of San Francisco and the Gisholt Machine Company.

Production transferred to workshops adjacent to the Gisholt Machine Company in Madison, which acted as production supervisor.

A Comet 7-E on display at the Hiller Aviation Museum, San Carlos, California.

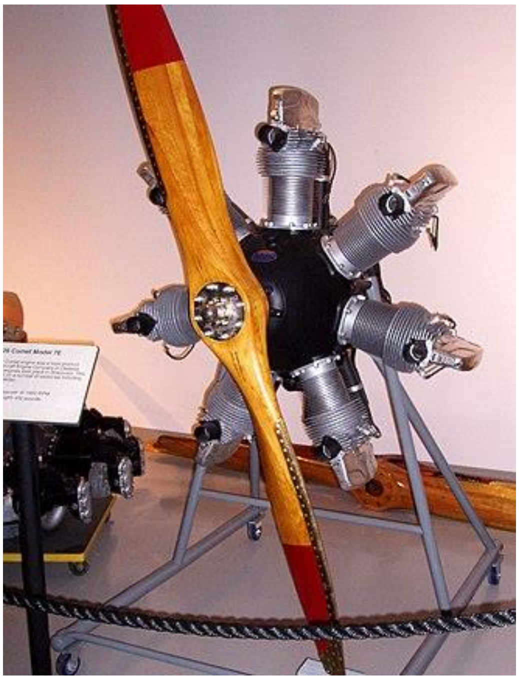


Fig- 6: A Comet 7-E on display at the Hiller Aviation Museum, San Carlos, California.

The Comet radial was fairly standard with steel finned cylinders, cast light alloy cylinder heads and two valves per head. The valves are operated by a single rocker arms and push-rods, to the rear of the cylinder, which are in turn operated positively by inner and outer cam tracks operating rollers on the pushrod.

Oil pumps and magnetos are driven by the camshaft drives as well as the Heywood air starter and tachometer.

The two-piece crankshaft, with counter-weights, is carefully forged from heat-treated chrome-vanadium alloy steel and drilled for lightness and lubricating oil flow. Master and slave connecting rods are forged and machined from the same material as the crank-shaft. The rear of the crankshaft carries an induction rotor to ensure even mixture distribution to the cylinders from the Stromberg carburettor.

The two-piece crankcase is split in the plane of the cylinder centres, with the forward half supporting the forward crank /prop-shaft bearing and the rear half housing the rear bearing, induction rotor, cam drives and accessories.

2.2. VARIANTS:

- **7-RA**
  From 1928 with Approved Type Certificate No.9, rated initially at 130 hp (97 kW) at 1,800 rpm.
- **7-D**
  After improvements rated at 150 hp (112 kW) at 1,800 rpm (maximum continuous) from 612 cu in (10.0 L).
- **7-E**
  From 1929 with Approved Type Certificate No.47, delivering 165 hp (123 kW) from the same 612 cu in (10.0 L).

2.3. APPLICATIONS:

- Adcox Student Prince
- Alexander Eaglerock Bullet C-4 (7-E option not installed)
- Alexander Eaglerock A-12 7-RA and some re-engined with 7-E
- Bach 3-CT-5 (2x 7-RA)
- Bach 3-CT-6 (2x 7-RA)
- Bird Wing Imperial (option)
- Briggs Briggster
- Cessna AC
- Curtiss Robin J-1 (7-D)
- Fairchild KR-34B (aka KR-34B-1) 7-RA
- Fairchild KR-34C (7-E)
- General Aristocrat 102-D proposed 7-RA
- Kreider-Reisner C-4 7-RA
- Kreider-Reisner C-4B 7-D
- Marine Water Sprite Marine Aircraft Co, Sausalito CA. - 7-E
- Maximum Safety M-2 7-RA
- Maximum Safety M-3 7-D
- Neilson Golden Bear
- Parks P-2 (option)
- Schroeder-Wentworth 1929 monoplane 7-RA
- Sierra BLW-1 7-RA
- Sierra BLW-2 7-RA
- Spartan C3-166 7-E
- Stearman C3L 7-RA
- Thaden T-2 7-D
- Timm C-165 Collegiate 7-E
- Timm K-100 Collegiate 7-RA
- Towle TA-1 7-D
- Towle WC Amphibion 7-D
- Travel Air 4-U conversion to 7-RA, 7-D and 7-E by O W Timm Aircraft Co.
- Triton Water Sprite, Triton Aircraft Co, Sausalito CA. 7-E

2.4. SPECIFICATIONS (VARIANT):

2.4.1. General characteristics:

- Type: 7-cylinder air-cooled radial piston engine
- Bore: 4.5 in (114 mm)
- Stroke: 5.5 in (140 mm)
- Displacement: 612 cu in (10.0 L)
- Dry weight: 395 lb (179.2 kg) without exhaust manifold or propeller hub

2.4.2. Performance:

- Power output: 130–150 hp (97–112 kW) at 1,800 rpm
- Specific fuel consumption: 0.55 lb/hp/h (0.093 kg/kW/ks)
- Oil consumption: 0.025 lb/hp/h (0.0042 kg/kW/ks)

CHAPTER – III

3. COMPONENTS OF 7-CYLINDER RADIAL ENGINE

A 7-cylinder radial engine, like other radial engine configurations, consists of several key components that work together to generate power and drive an aircraft's propeller. Here are the main components of a 7-cylinder radial engine:

3.1. CRANK CASE:

In a radial engine, the crankcase plays a crucial role in housing the crankshaft and connecting rods, which are essential components for converting the reciprocating motion of the pistons into rotational motion that drives the engine. The radial engine design is characterized by having cylinders arranged in a circular pattern around a central crankshaft.

In a 7-cylinder radial engine, the crankcase would be designed to accommodate seven cylinders spaced evenly around the centre. Each cylinder has its own piston and connecting rod that attaches to the crankshaft. The crankshaft extends from the centre of the crankcase and is supported by bearings that are integrated into the crankcase structure.

The crankcase not only provides the housing for the crankshaft and connecting rods but also serves as a structural component that helps maintain the alignment of the cylinders and supports various engine accessories and components such as the propeller hub, magnetos, and other systems.

3.2. CAM HOUSING:

In a radial engine, the cam housing is an integral part of the engine's design, particularly in engines that use a mechanical system for operating the valves. The cam housing contains the camshaft, which is responsible for controlling the opening and closing of the engine's intake and exhaust valves.

3.3. SUCTION HOUSING:

A suction housing typically refers to a component in a mechanical system, often found in pumps and other fluid-handling devices. It is designed to facilitate the process of drawing in fluids (such as liquids or gases) from a source, typically using suction or negative pressure.

3.4. CYLINDER:

n a 7-cylinder radial engine, the cylinder is the individual combustion chambers where the air and fuel mixture are ignited to produce power. Each cylinder contains a piston that moves up and down within the cylinder to convert the pressure from the combustion process into mechanical motion, which is then transferred to the crankshaft to power the engine.

3.5. CYLINDER HEAD:

The cylinder head is a crucial component in a radial engine, as well as in any internal combustion engine. It is located at the top of each cylinder and seals the combustion chamber, where the air and fuel mixture are ignited to produce power. In a 7-cylinder radial engine, there are seven individual cylinder heads, each associated with one cylinder.

3.6. CYLINDER LINER:

A cylinder liner, also known as a cylinder sleeve or barrel, is a component found within the cylinders of an internal combustion engine. It serves as a replaceable or repairable liner that provides several benefits, such as reducing friction, enhancing durability, and facilitating maintenance. Cylinder liners are particularly important in engines that experience significant wear and tear due to high-temperature and high-pressure combustion processes, such as those found in many radial engines.

In a 7-cylinder radial engine, each cylinder can have its own cylinder liner.

3.7. PISTON:

In a 7-cylinder radial engine, each cylinder is equipped with a piston. Pistons are essential components that play a crucial role in the engine's operation by converting the energy generated from the combustion of air and fuel into mechanical motion.

3.8. PISTON RING:

Piston rings are essential components in internal combustion engines, including 7-cylinder radial engines. These rings are positioned around the outer diameter of the piston and play a critical role in ensuring efficient engine operation. Piston rings provide a tight cylinder space. They work at high temperature and variable loads. The main requirements about them are to have high elasticity, durability and low coefficient of friction with the cylinder walls.

3.9. MASTER ROD AND SLAVE ROD:

Master rod and slave rod in a 7-cylinder radial engine are the connecting rods that connects piston and crankshaft. The connecting rod is a crucial component that connects the piston to the crankshaft and converts the linear motion of the piston into rotational motion of the crankshaft. Each piston in an internal combustion engine, including a 7-cylinder radial engine, is attached to a slave rod. And all the 7 slave rods are connected to the master rod which is attached to the crank shaft.

3.10. CRANK SHAFT:

The crankshaft is a central component in an internal combustion engine, including a 7-cylinder radial engine. It is responsible for converting the reciprocating motion of the pistons, which move up and down in the cylinders, into rotational motion that drives the engine and powers external systems such as propellers. In case of 7-cylinder radial engine, the piston movements are radial, as they are attached to the master rod whose movement is radial due to the connection of crankshaft with master rod at its centre.

3.11. CAM DISK:

In a radial engine, the terms "cam disk" generally refer to components related to the engine's valve actuation system, specifically the camshaft and its associated parts. The cam disk is responsible for controlling the timing of the intake and exhaust valves in each cylinder.

3.12. EPICYCLIC GEAR SYSYTEM:

Epicyclic gear systems are a type of gear mechanism where gears are arranged in a way that allows one gear to rotate around another gear, creating complex and versatile gear ratios. This type of gear system is used in various applications, including some engines and transmissions.

There are 3 types of gears associated within this gear system. They are:

3.12.1. Sun Wheel (Sun Gear): The sun wheel, also known as the sun gear, is a central gear in an epicyclic gear system. It is typically located in the centre of the gear arrangement and is surrounded by other gears. The sun gear is driven by an input force, and its rotation causes the other gears in the system to move in various ways.

3.12.2. Planetary Wheel (Planet Gear): The planetary wheels, or planet gears, are gears that rotate around the sun gear. They are typically mounted on a carrier, which allows them to move in a circular path around the sun gear. The planet gears engage with both the sun gear and an internal gear, creating complex interactions that result in different gear ratios and motion.

3.12.3. Internal Gear (Ring Gear): The internal gear, also known as the ring gear, is the outermost gear in the epicyclic gear system. It surrounds the planetary wheels and engages with their teeth. The internal gear can be fixed in place or allowed to rotate, depending on the specific design of the gear system.

In an epicyclic gear system, the arrangement of the sun gear, planetary wheels, and internal gear creates various gear ratios and motion possibilities. By controlling the rotation and engagement of these components, different output speeds and torque values can be achieved. Epicyclic gear systems are commonly used in applications where multiple gear ratios, compact size, and versatile motion control are required, such as in some automotive transmissions.

And there are so many minor parts included in 7-radial engine, like:

- Spark Plug
- Ignition Plug
- Rocker Arm System
- Valve Group
- Keys
- Cover Disc
- Cylinder Head Gasket
- Cylinder Base Gasket
- Piston Shaft
- Mounting ring
- Suspension Pin
- Intake Pipe
- Ball Bearings
- Washers etc.

And there a lot more minor parts included in the design of &-cylinder radial engine.

There are some additional parts where I added them to the 7-cylinder radial engine.

- Exhaust Gas Collector
- Propeller
- Nose

CHAPTER – IV

4. PART DESIGN PROCEDURE FOR COMPONENTS

4.1. PART DESIGN PROCEDURE:

To design any part under part design module, we have to follow certain steps.

- Start the CATIA V5R20 installed on the desktop.
- Go to the “Start” menu and click on “Part Design” under the tab of “Mechanical Design”.
- A pop-up window will appear on screen asking to enter the part name to be designed.

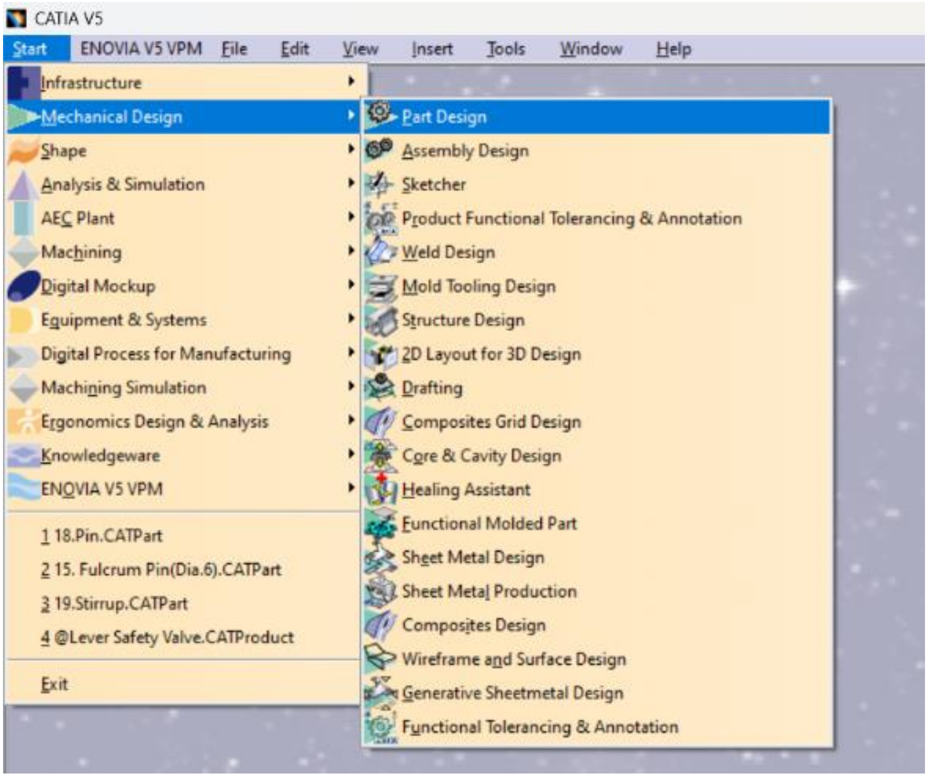


Fig- 7: Part Design from Start Menu

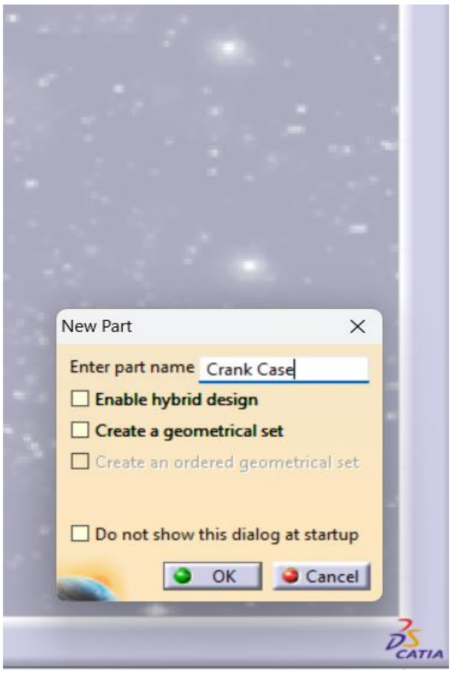


Fig- 8: Pop-up window to enter part name

- The screen will be directed to the 3D “Part Design” module where actions like creating a 3D product from a sketch and material addition and removal operations can be done through a numerous command.

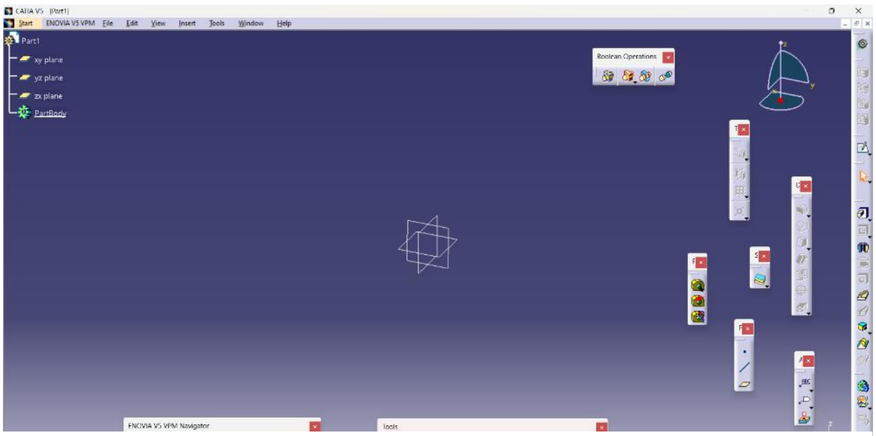


Fig- 9: 3D Part Design Module

- Create an “Axis Based System” by hiding the “Plane Based System” and create a point on the origin of the “Axis Based System” by clicking right button of mouse under “Origin” and select “Create a point” option.

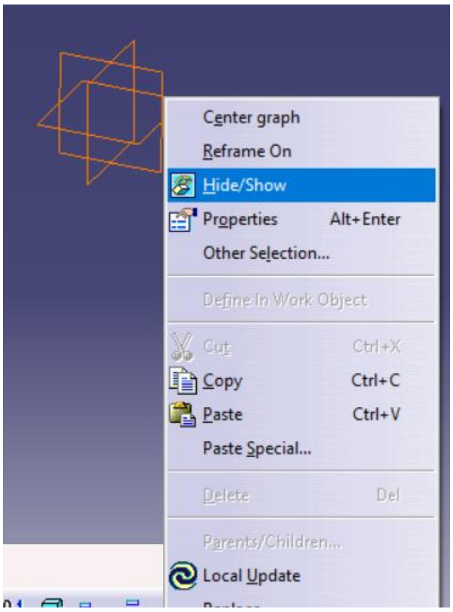


Fig- 10: Hiding Plane Based System

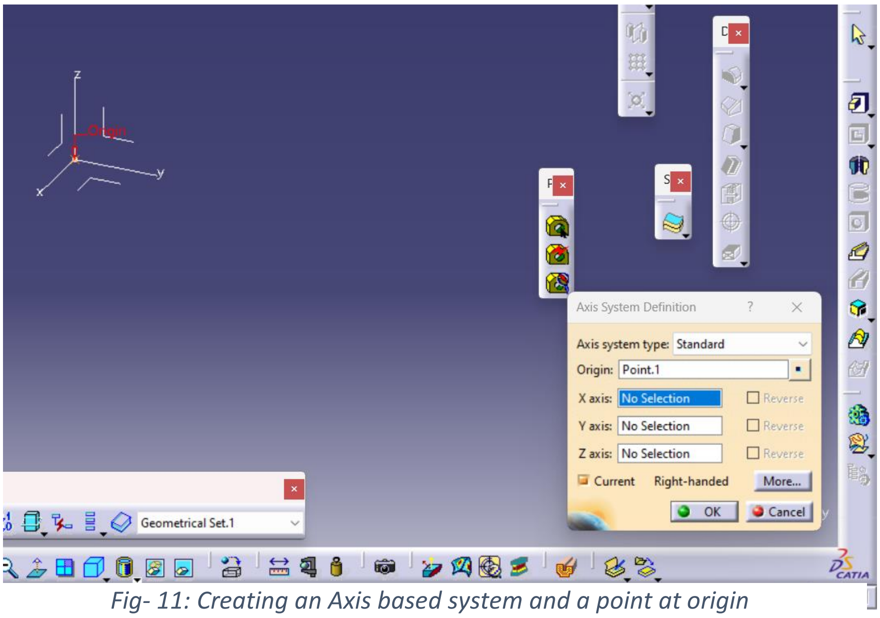


Fig- 11: Creating an Axis based system and a point at origin

- Insert a “Body” from the “Insert” Tool Bar from top.

- Now go to the “Sketcher Workbench” by clicking on “Sketch” (or) “Positioned Sketch” commands under right side Docking Area of CATIA Interface and select a plane.

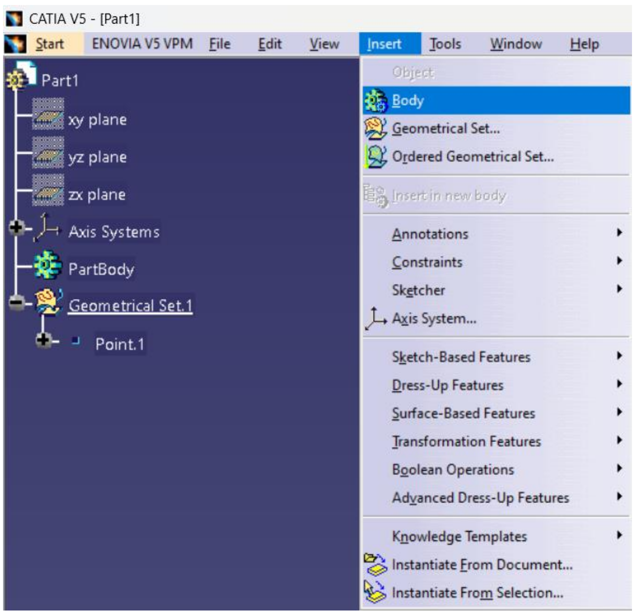


Fig- 12: Inserting a Body

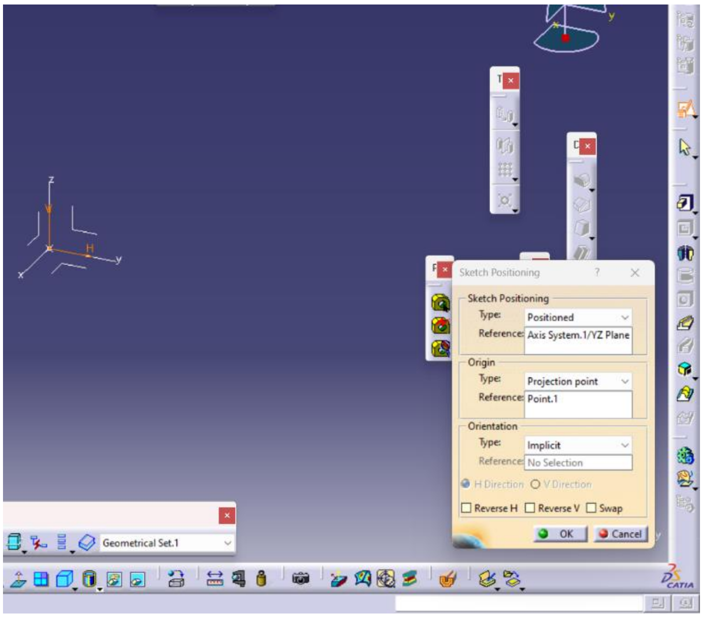


Fig- 13: Position Sketching

- The screen will be directed to the “Sketcher” module where we can draw all sort of diagrams. Now, create a required sketcher of the body using sketch-based features and give constraints to all drawings using “Constraint” tool bar in the sketcher. Make sure all the constraints are “Iso-constrained” and all the profiles are “Closed”, by clicking “Sketch solving status” and “Sketch Analysis”.

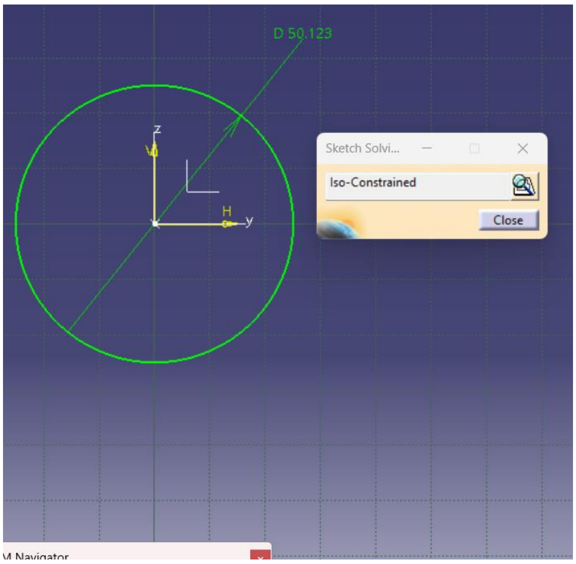


Fig- 14: Sketch solving Status

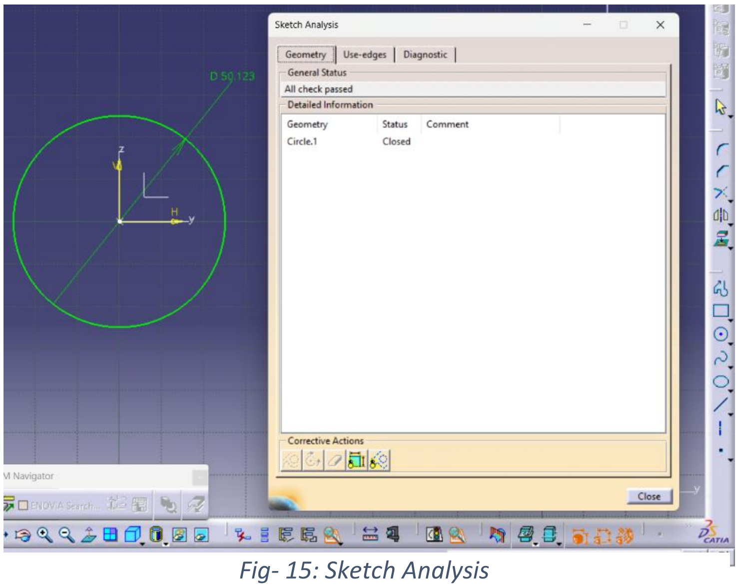


Fig- 15: Sketch Analysis

- Click on “Exit Workbench” on top-left side of Docking area to create a 3D solid body of the sketch that is created in “Sketcher” module, using several commands.

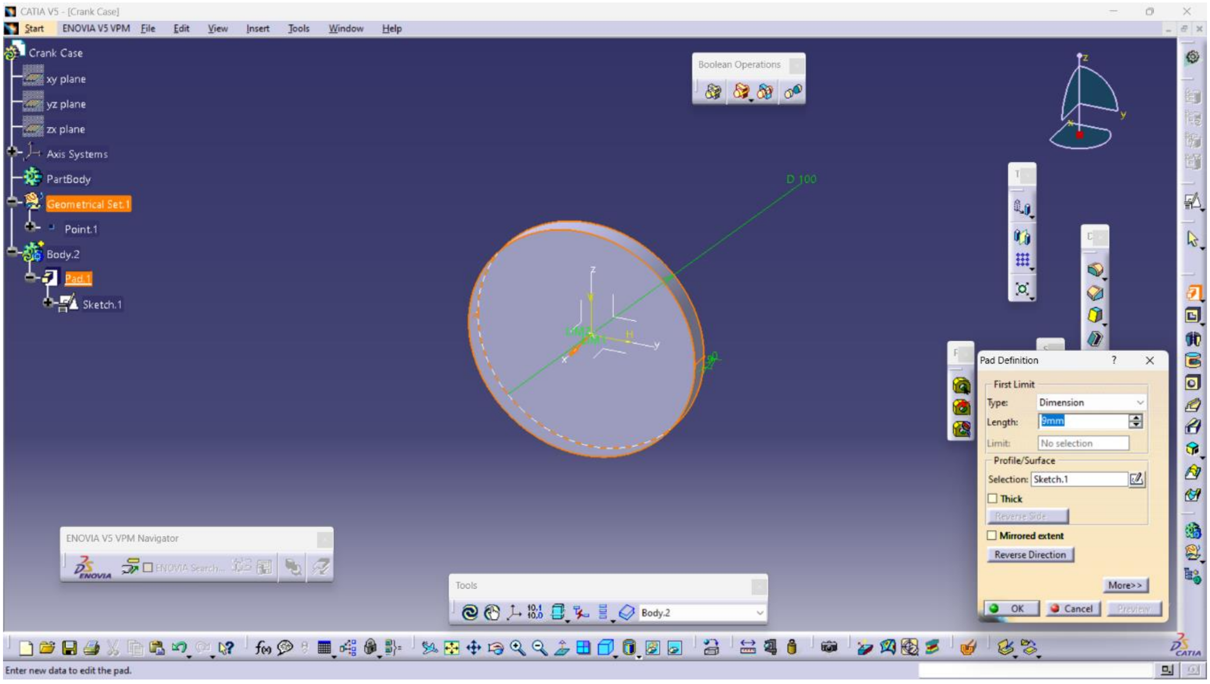


Fig- 16: Creating a 3D body using "Pad" command in Part Design module

- Likewise, if there are any bodies needed to be added or removed from the main body, insert a new “Body”. Before adding a “Body”, click on “Define in Work Object” for the main body by clicking right-side button of the mouse. And create a new sketch and exit the workbench and create a solid body and add (or) remove bodies using “Boolean Operations (Add (or) Remove)”. There are several other “Boolean Operations” like “Union trim”, “Assemble”, “Intersection” and “Remove Lump” which can be used based up on different applications.

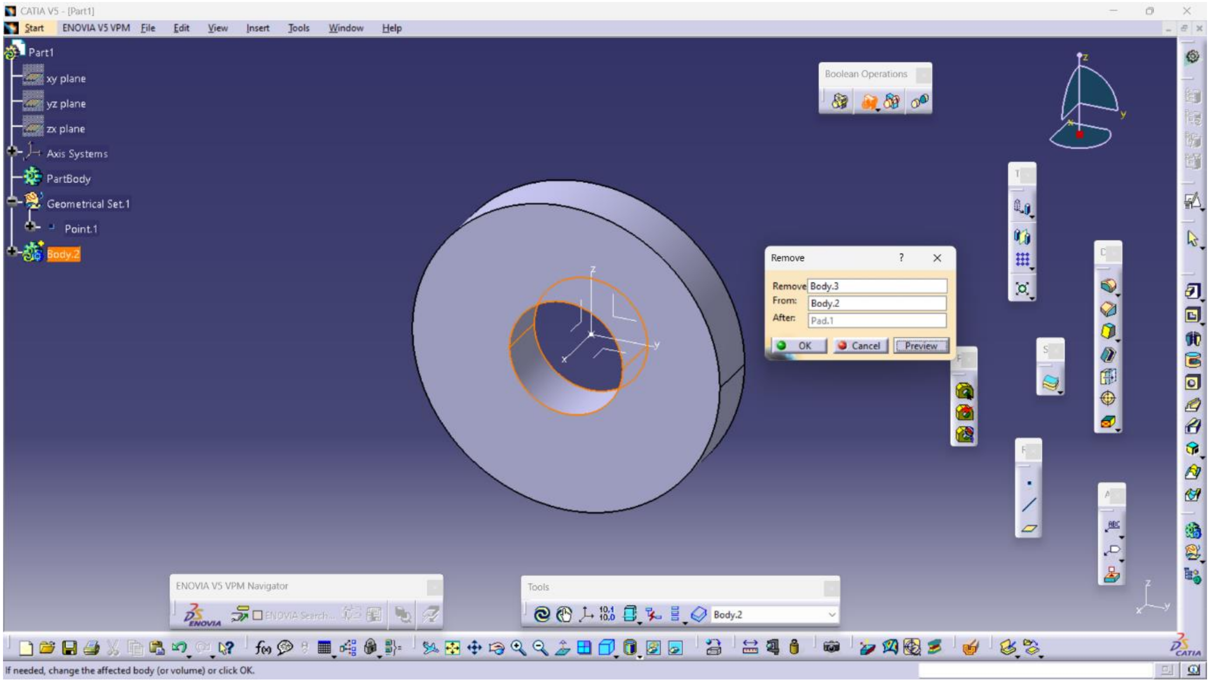


Fig- 17: Removing a body using "Remove" Boolean operation

- Additional operations like “Fillet”, “Chamfer” is used to make softer edges of the body at the end of the design of part body.
- Likewise, the part bodies are designed using various commands based on the application.

4.2. DESIGN OF PARTS OF 7-CYLINDER RADIAL ENGINE:

4.2.1. Crank Case:

- In Part Design, select a plane on “Axis based system” and go to “Sketcher” by using “Positioned Sketch” after inserting a “Body”.
- Draw two circles of 100 mm and 85 mm diameters and exit the workbench and give it a pad value of 12.5 mm.
- Insert a new body and draw and enter the sketcher module. Draw a heptagon of side 43.388 mm and exit the workbench and give it a pad value of 40 mm.
- Add these two bodies using a Boolean Operations, “Add”.

- Insert a new body and select body2 for the position sketch and enter the sketcher workbench and draw two circles according to the blueprint given and give it a pad of 9mm and give it a "Circular Pattern" with 7 instances under "Complete Crown" Option. Add this body to main Body using "Add" Boolean Operation.

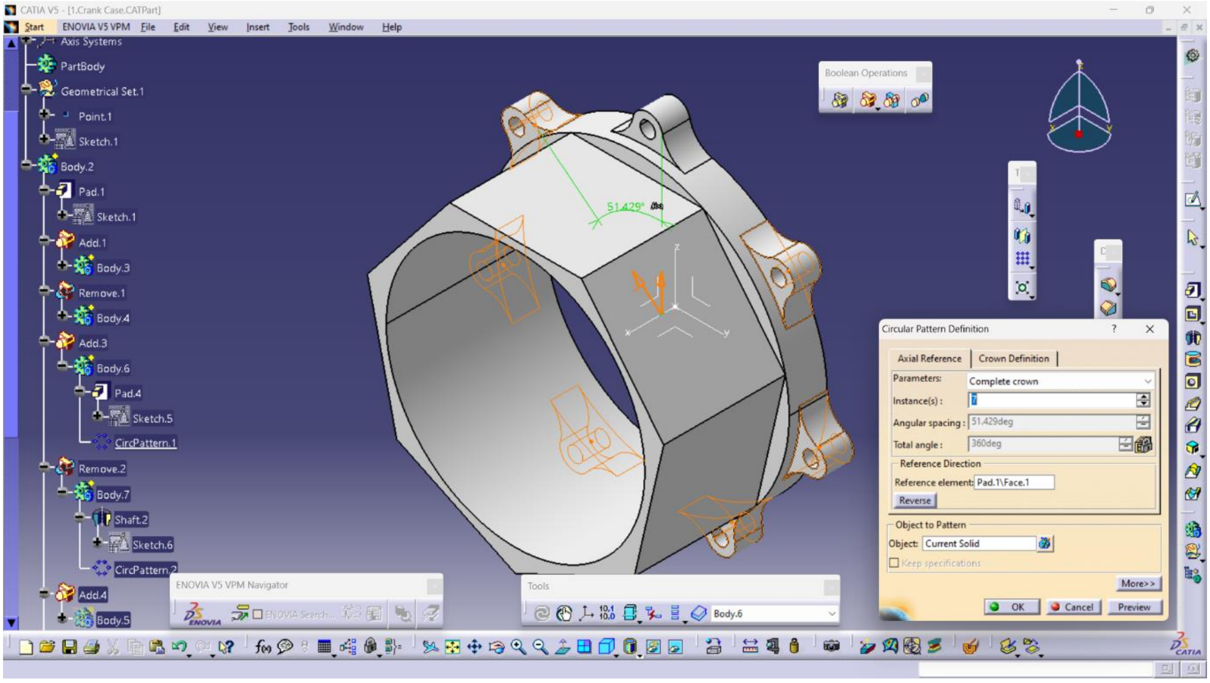


Fig- 18: Circular Pattern of a 3D Solid Body

- Likewise, insert another body, select body2 for sketching and draw required diagram according to blueprint and give it a shaft in Part design module. And remove it from body2.
- And there are a lot more steps to do like in the below figures given.

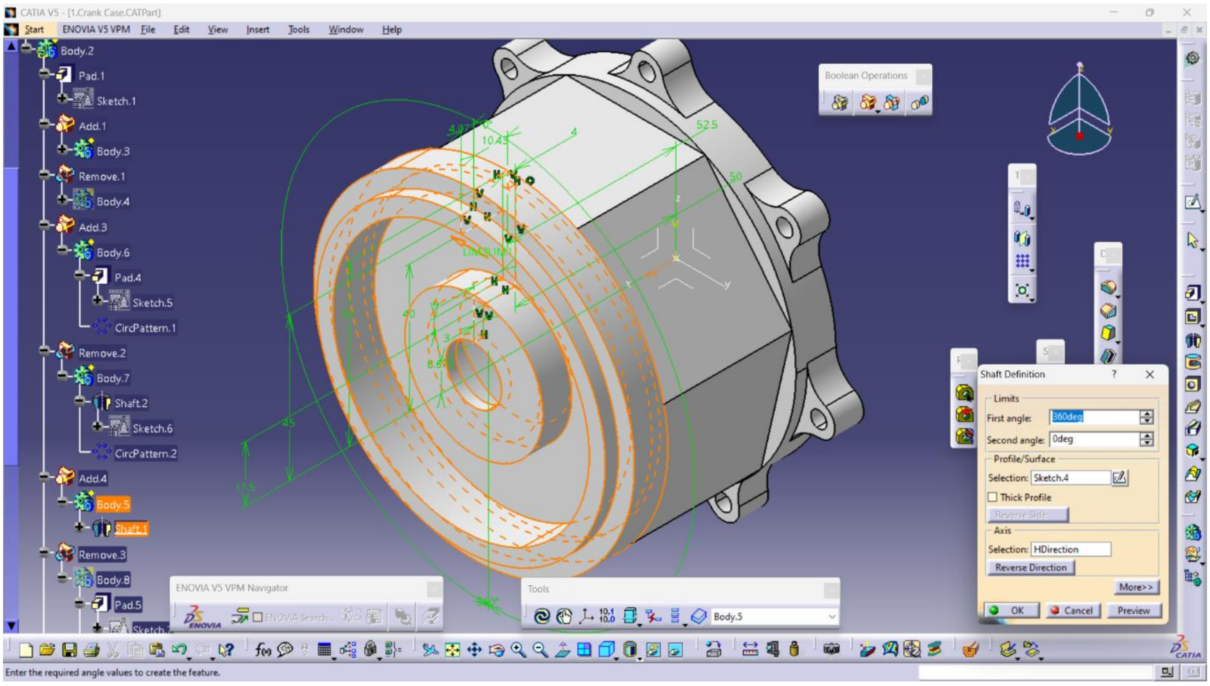


Fig- 19: Shafting the sketched diagram

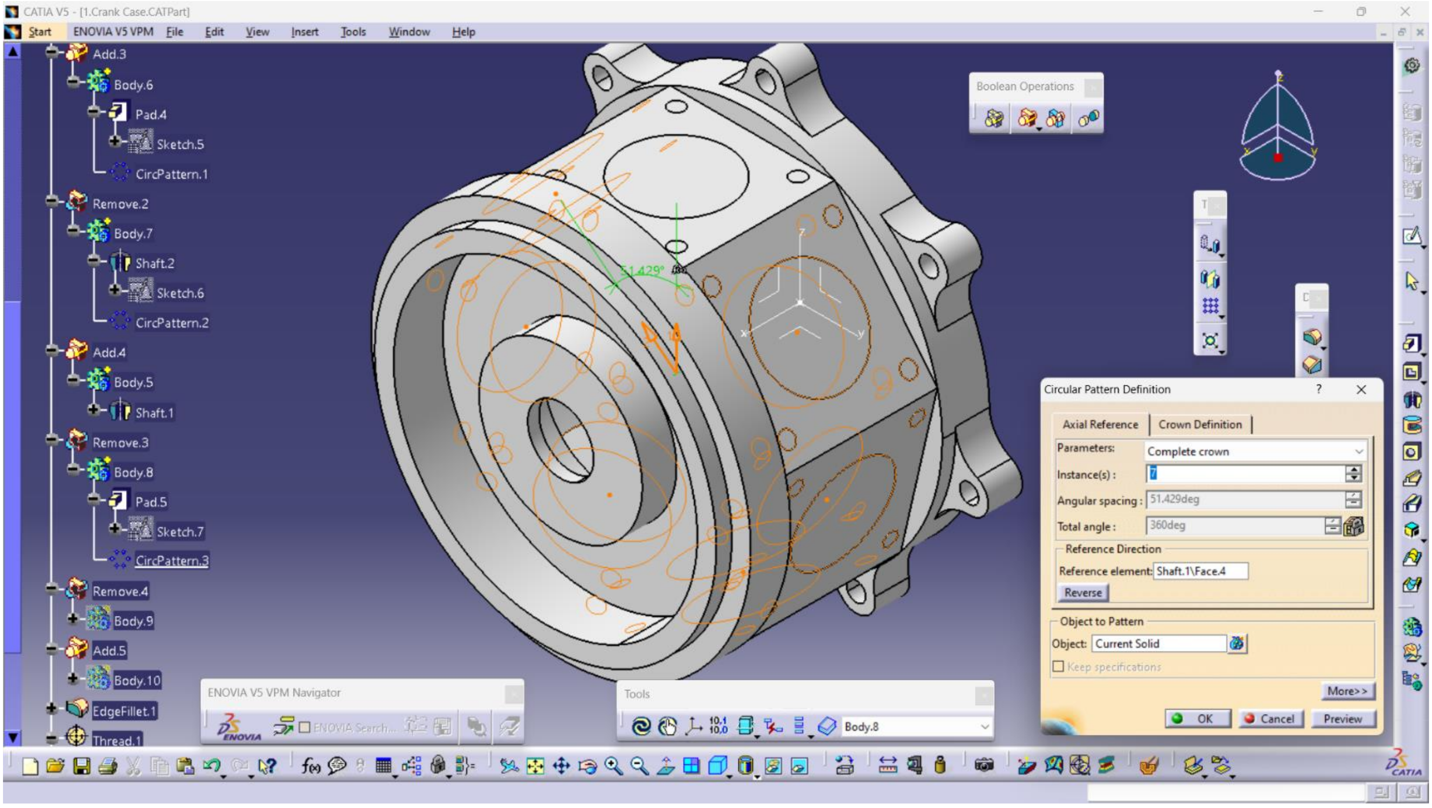


Fig- 20: Circular Pattern for a 3D body

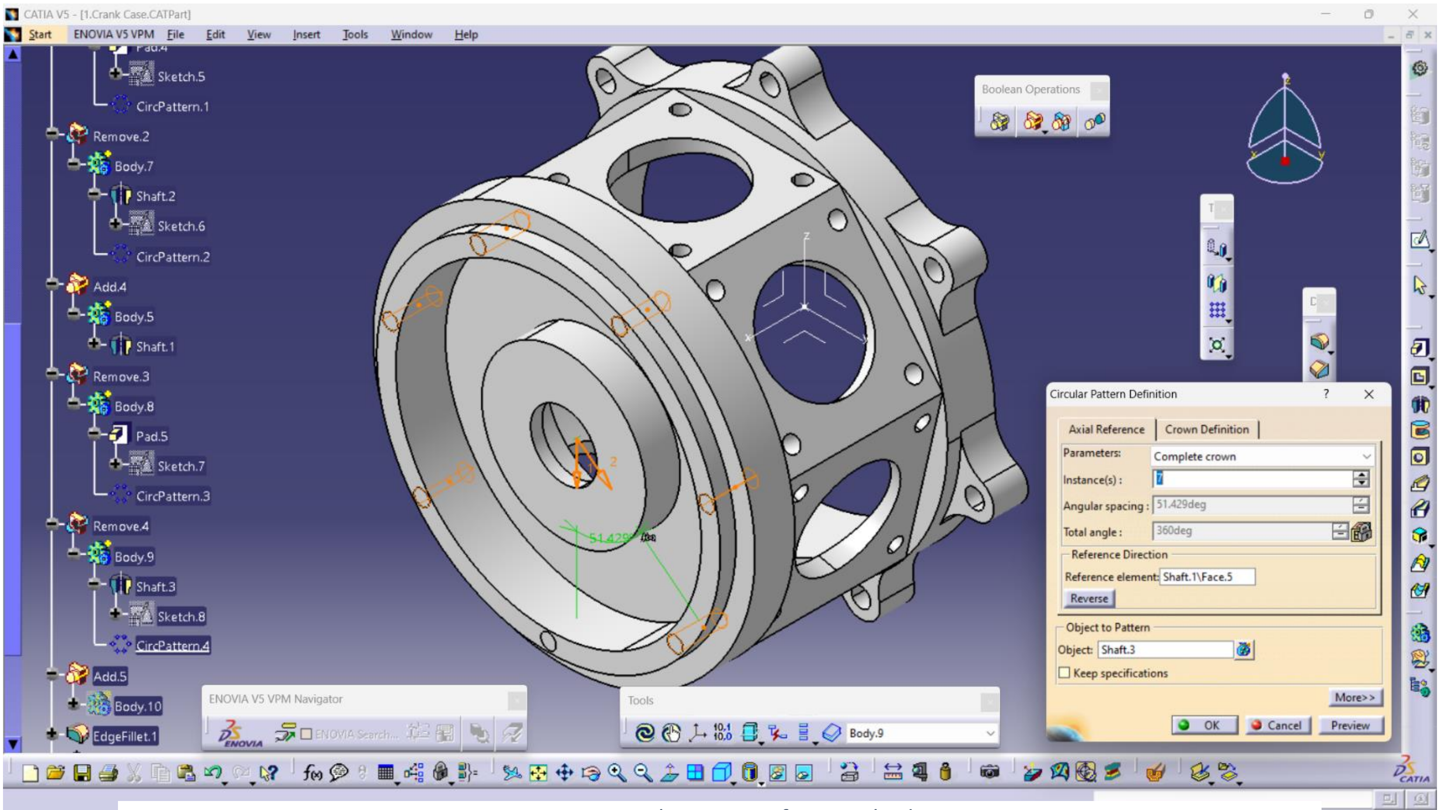


Fig- 21: Circular Pattern for a 3D body

- Afterall these operations, give "Fillets" and "Chamfers" to the required edges.

4.2.2. Cam Housing:

- In Part Design, insert a Body and go to sketcher workbench and draw the required sketch based on sectional view from blueprint and exit the workbench and give it a "Shaft".

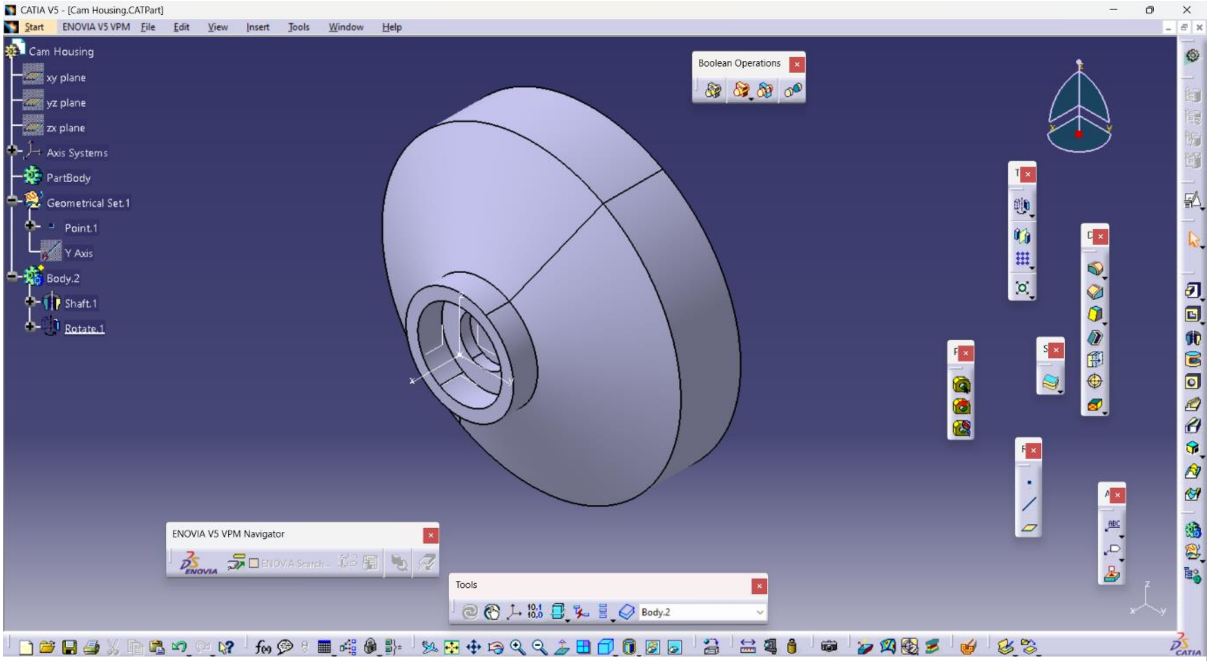


Fig- 10: Shafting the sketched diagram

- Insert a "Body" and select "Body2" for sketching reference and draw the required sketch from the blueprint and give it a "Pad" of 14.79 mm and trim it from "Body2" using "Union Trim" Boolean operation.

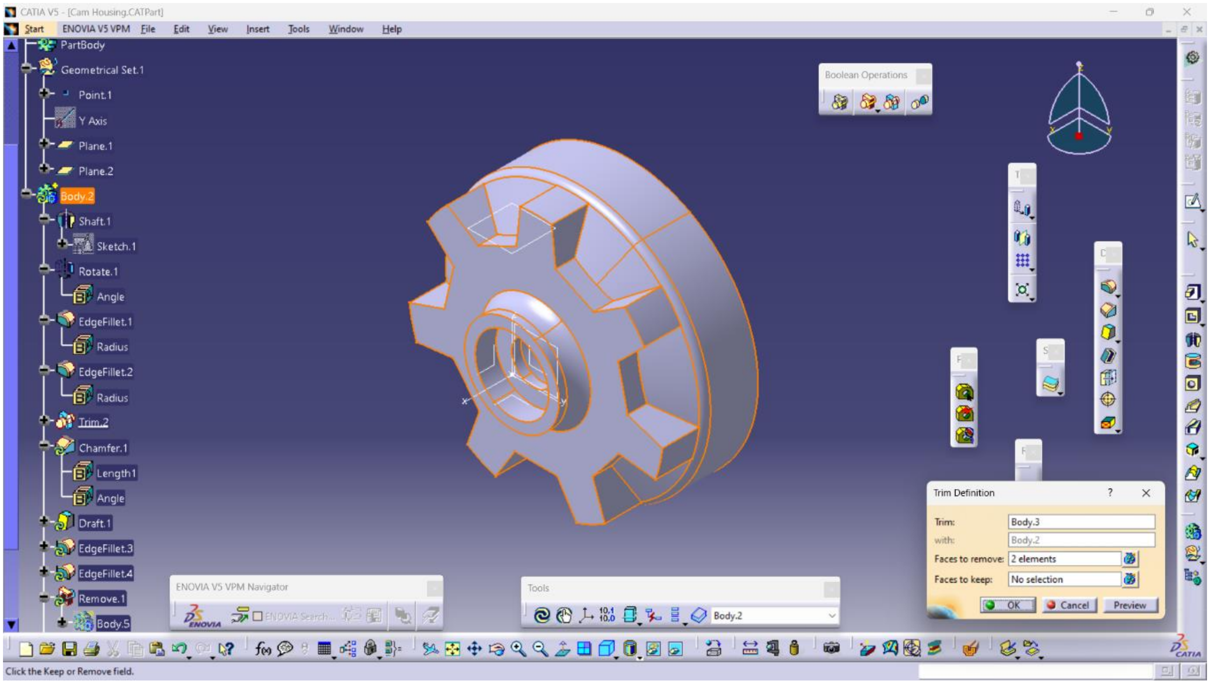


Fig- 11: Trimming the secondary body from main body using Union Trim Boolean Operation

- Insert a new body and select back of "Body2" and enter "Sketcher". Draw the stepped cylinder diagram of required dimensions from blueprint then, exit the workbench give it a "Shaft" and make a "Circular Pattern" of 7 instances under "Complete Crown" option. Remove this "Body4" from "Body2" using "Remove" Boolean operation.

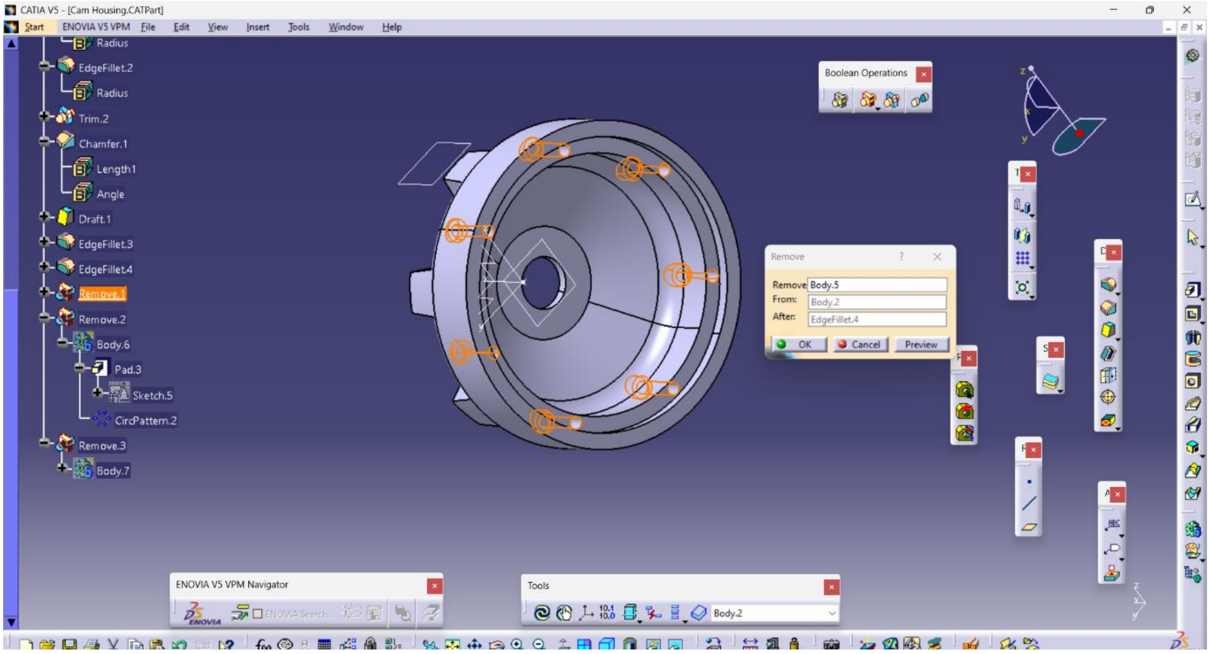


Fig- 12: Removing Body4 from Body2 using "Remove" Boolean operation

- Insert a new body, select "Body2" top and enter "Sketcher" using "Positioned Sketch" and draw two circles of diameters 5 mm each at a distance of 9.21 mm for first circle and 7 mm for second circle respectively from the centre axis. Exit the workbench and give a "Pad" of 15 mm and create 7 instances of it using "Circular Pattern" under "Complete Crown Option". Remove "Body5" from "Body2" using "Remove" Boolean operation.

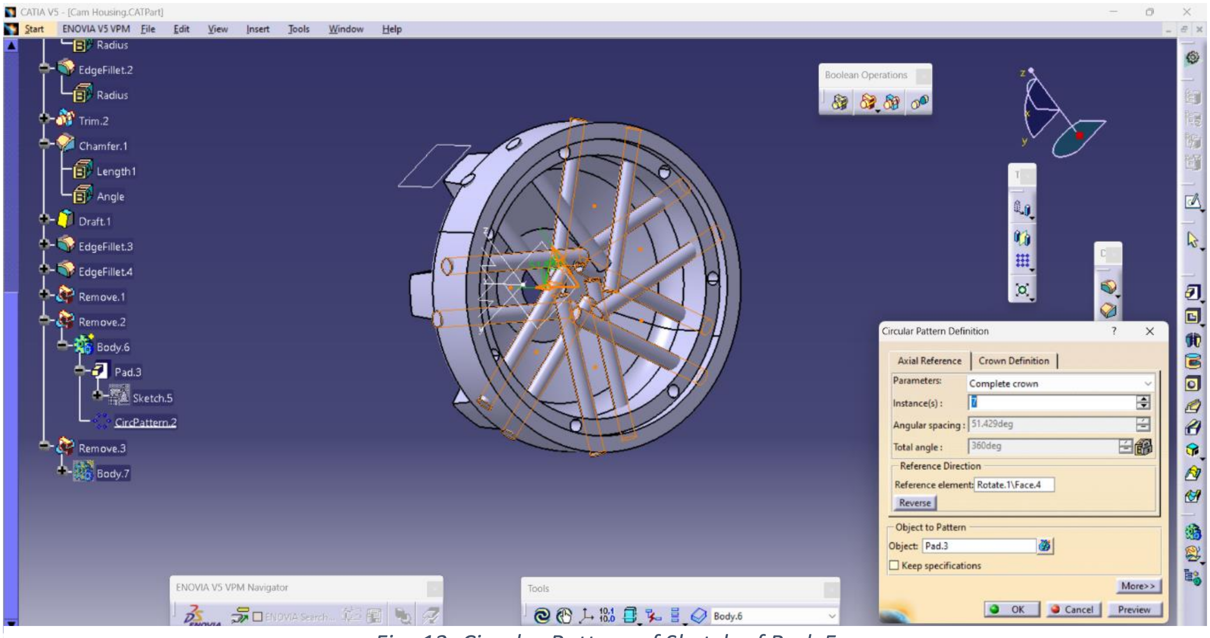


Fig- 13: Circular Pattern of Sketch of Body5

- At last, give smooth edges for the body using “Fillet” and “Chamfer” at required positions.

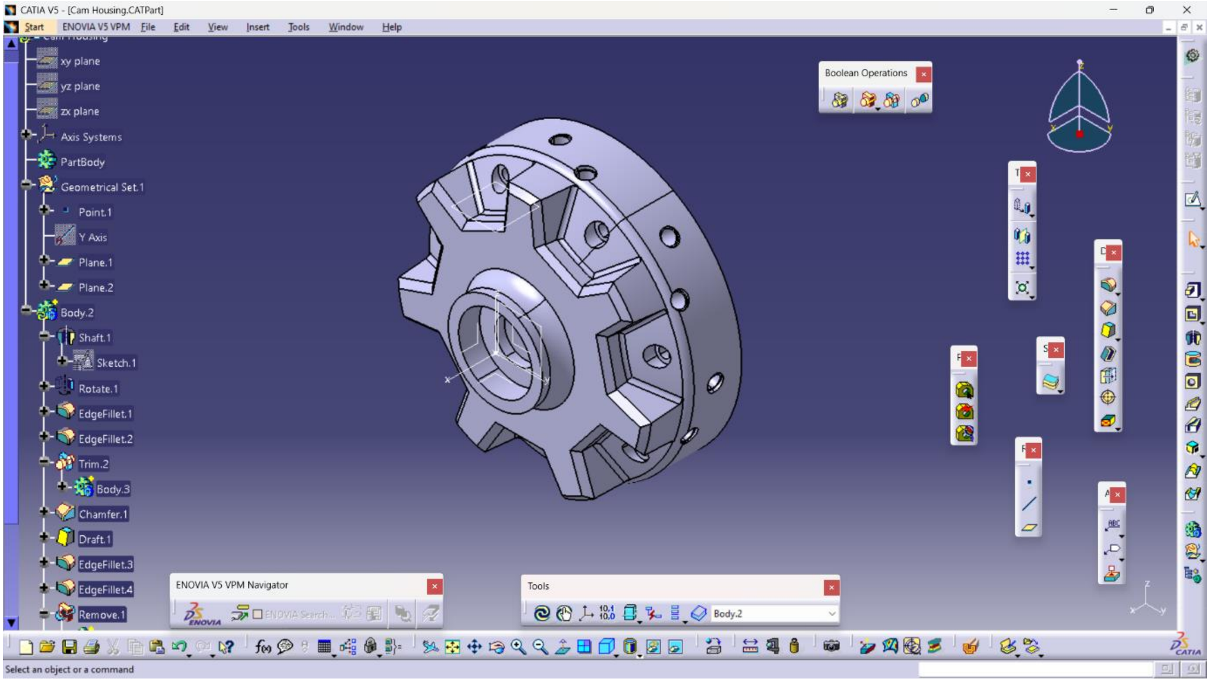


Fig- 14: Final Design of Cam Housing

4.2.3. Suction Housing:

- In Part Design, insert a Body, go to the “Sketcher” workbench by clicking on “Positioned Sketch” and a plane. Draw the sketch of sectional view of the Suction Housing given in the blueprint using “Sketch based features”. Exit the workbench and give it a “Shaft”. It is “Body2”.

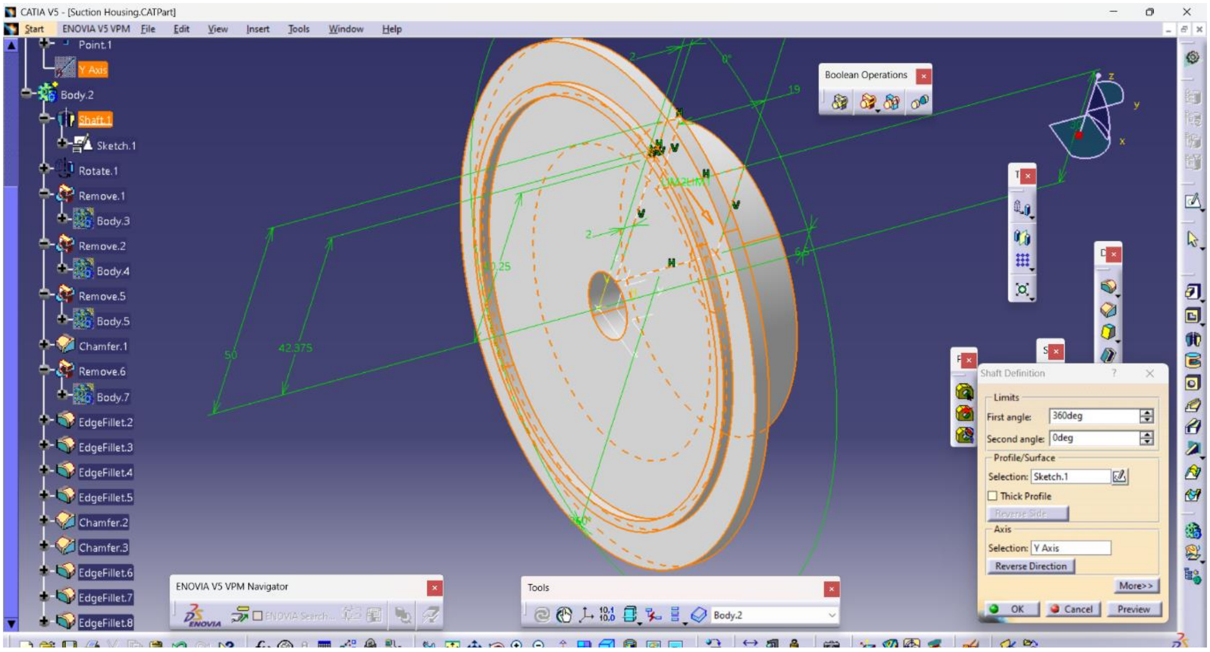


Fig- 15: Creating a 3D solid body using "Shaft" command of Sketch1

- Insert a new body, go to the “Sketcher” by selecting the back of “Body2” and “Positioned Sketch”. Draw the semi-circle of diameter 10 mm at a distance of 30 mm from the Horizontal plane. Exit the Workbench and give it a “Pad” value of 19 mm and make 7 instances using “Circular Pattern” under “Complete Crown” option. This 3D body is “Body3”. Remove “Body3” from “Body2” using “Remove” Boolean operation.

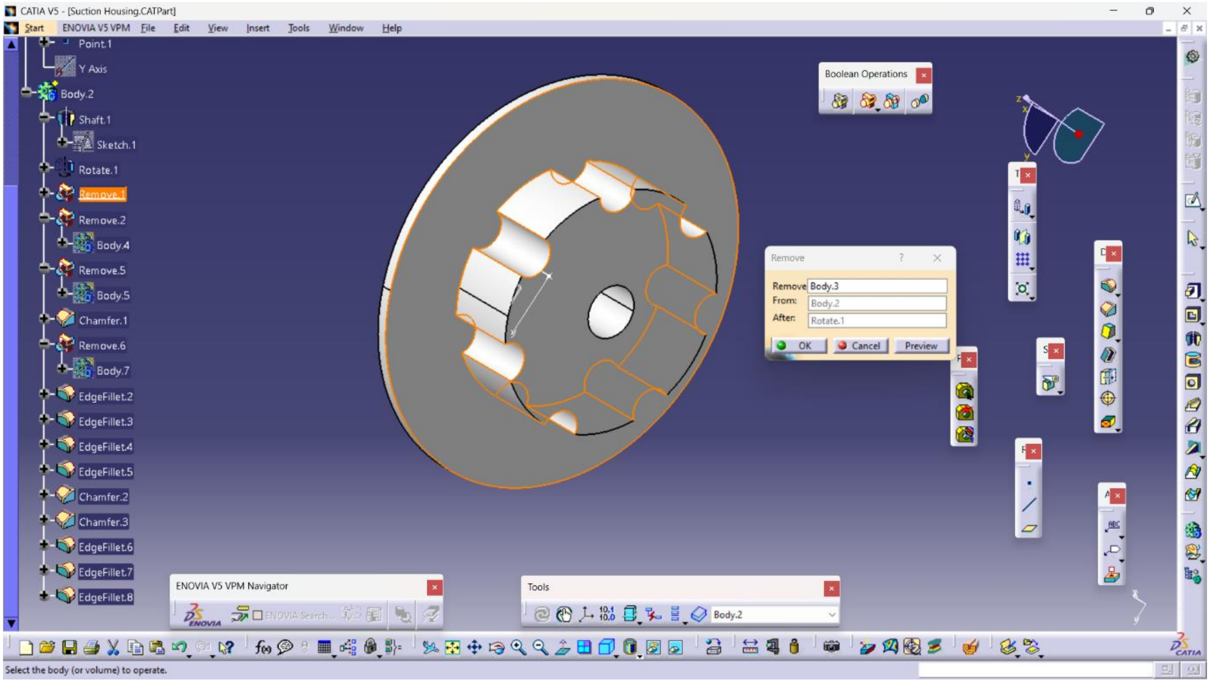


Fig- 16: Removing Body3 from Body2 using Remove command

- Insert a new body and create a new sketch of stepped cylinder bar of radii 2.5mm and 1.25mm on with respect to “Body2”. Give it a “Shaft” and remove “Body4” from “Body2” using “Remove” command.

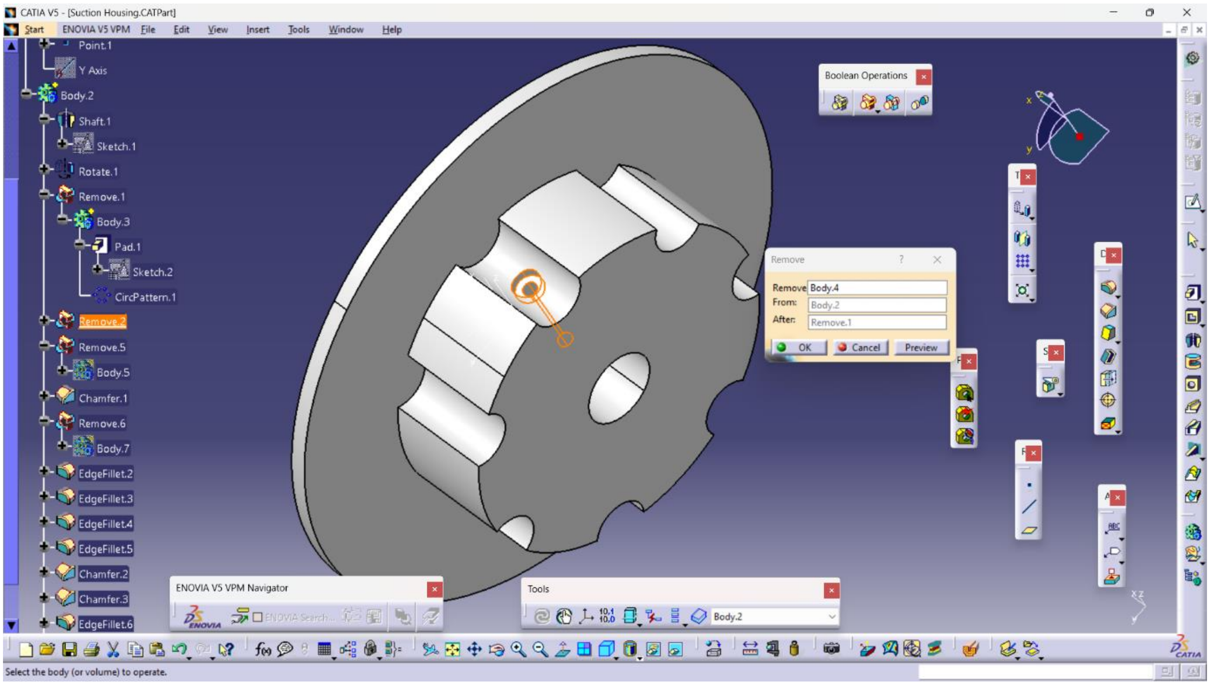


Fig- 17: Removing Body4 from Body2 using Remove command

- Insert a new body, create a new sketch of stepped cylinder of radii 4.5mm and 3.5mm with respect to Body2. Exit the workbench and give it a shaft and circular instances of 7. This will be “Body5”. Repeat this process from inserting a body to shafting, perpendicular to “Body5”. That will form a “Body6”. Now add “Body6” to “Body5”. At last, remove “Body5” from Body2” using “Remove” command.

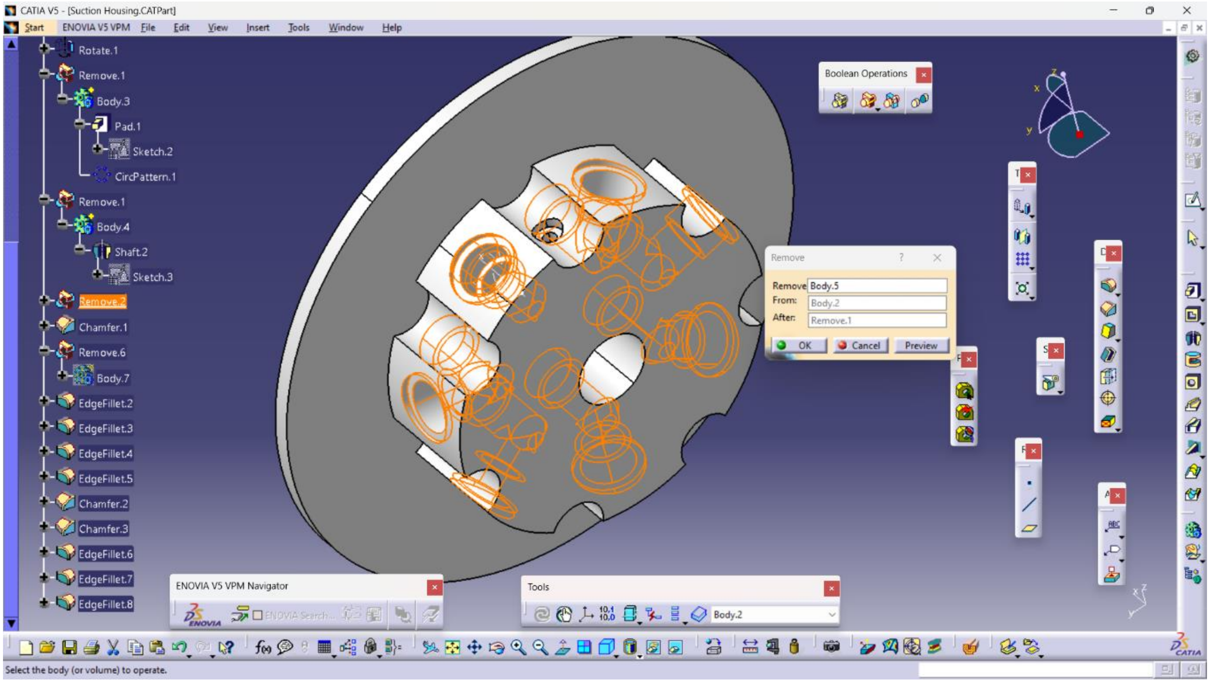


Fig- 18: Removing Body5 from Body2 using Remove Command

- Insert a body (Body7), and create a sketch of circle of diameter 4mm and 46mm from Horizontal axis on front view of “Body2”. Create 7 instances using “Circular Pattern” and remove “Body7” from “Body2” using “Remove Command.

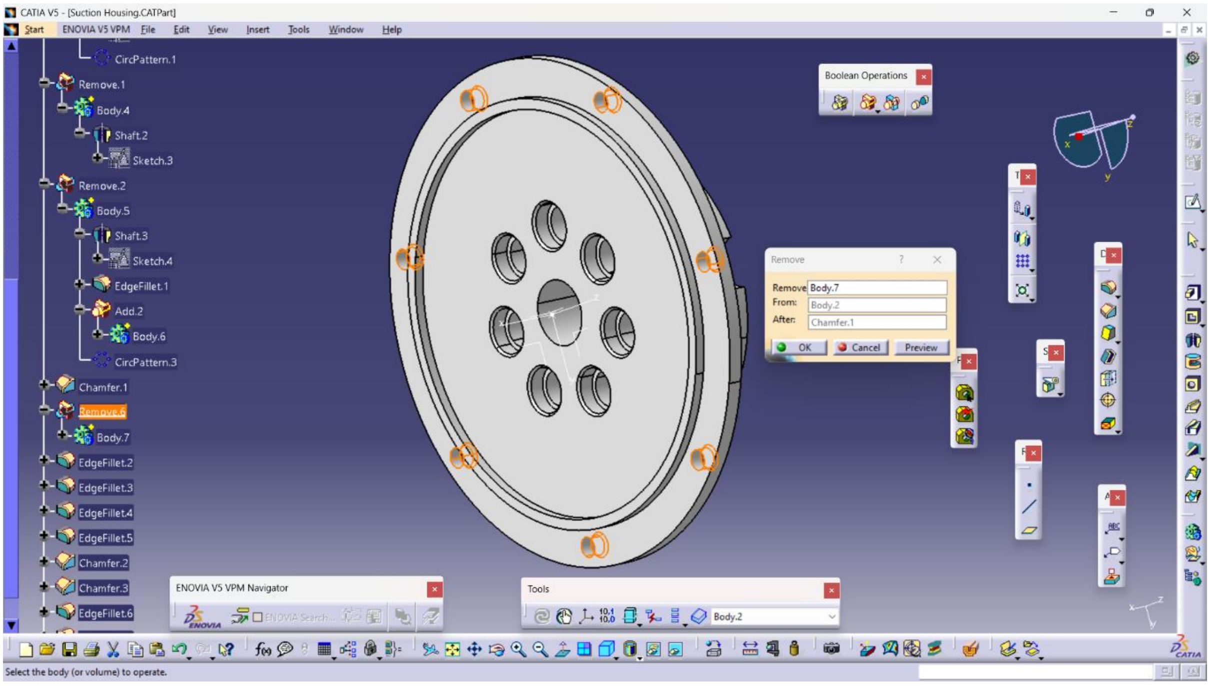


Fig- 19: Removing Body7 from Body2 using Remove command

- Give “Body2” necessary edge fillets and chamfers at sharp edges.

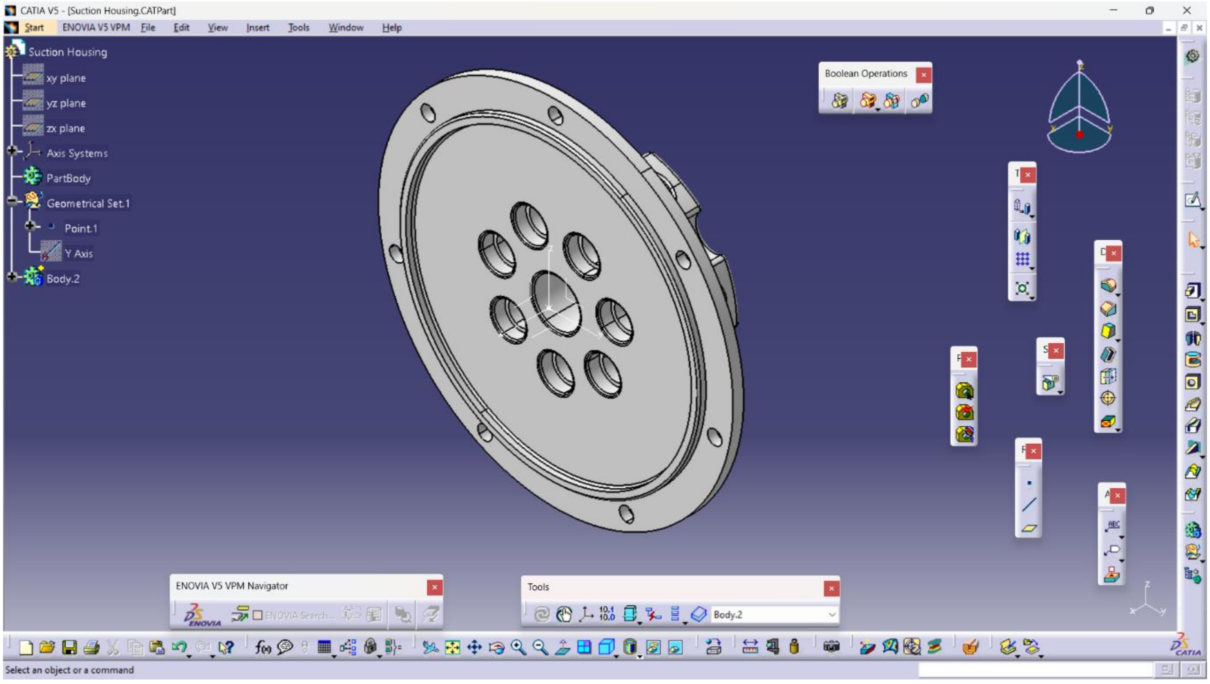


Fig- 20: Final Design of Suction Housing

4.2.4. Cylinder:

- In Part Design, insert a new body and go to “Sketcher”. Create a Sketch of square of dimensions 40x40 mm and a circle of diameter 27mm and exit the workbench and create a 3D solid body (Body2) using “Pad” of 3.8mm.

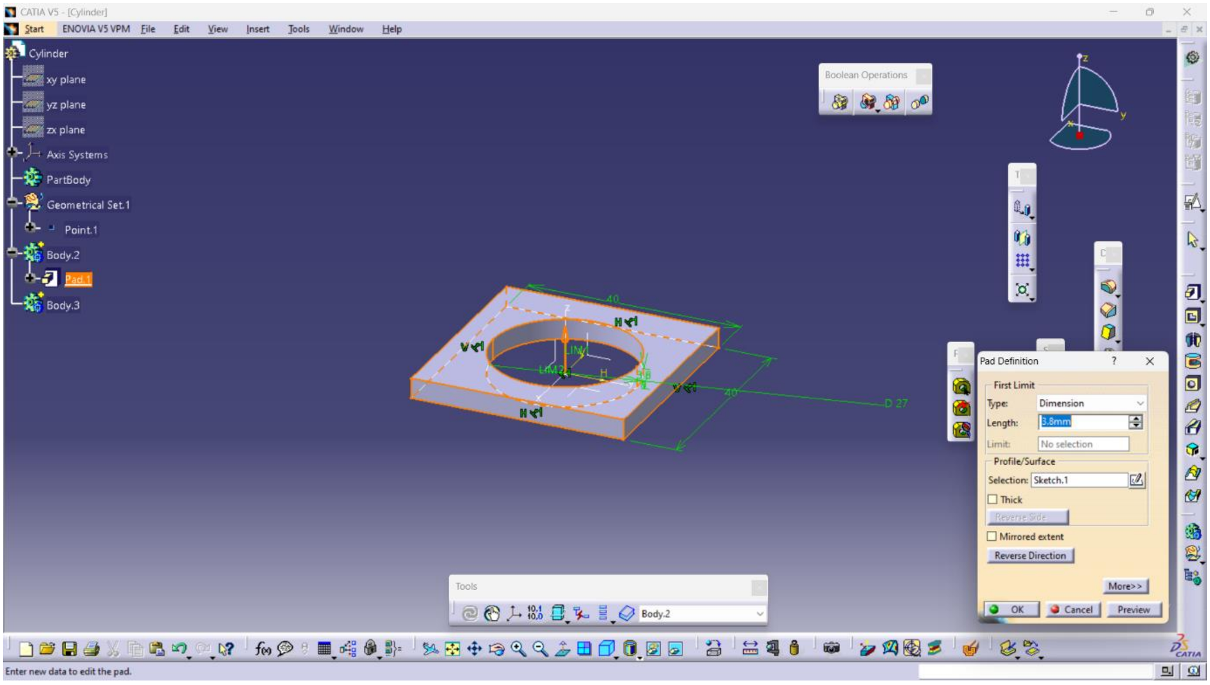


Fig- 21: Creating a solid body using Pad Command

- Insert a body (Body3), create a sketch of given sectional view in the blueprint and exit the workbench and create a solid body using "Shaft" command and add "Body3" to "Body2" using "Add" command.

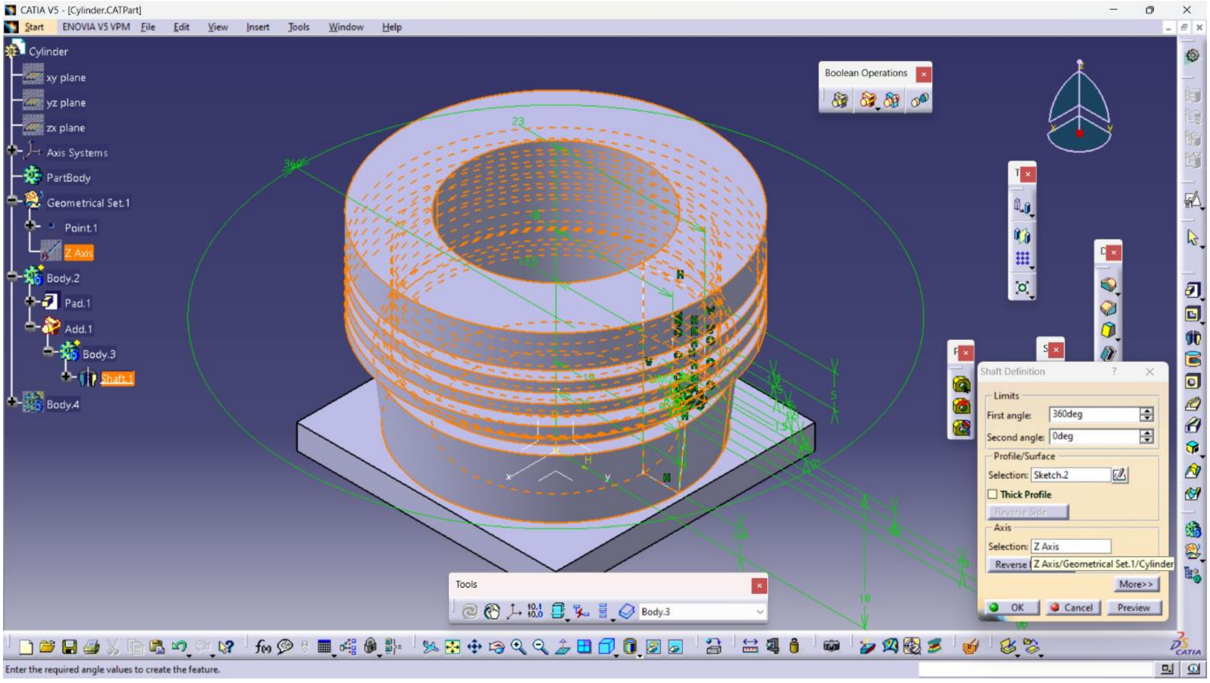


Fig- 22: Creating a solid body using Shaft command

- Create holes on "Body2" by inserting bodies and remove them using "Remove" command as shown in Blueprint of Cylinder and give necessary edge fillets and chamfers at sharp edges.

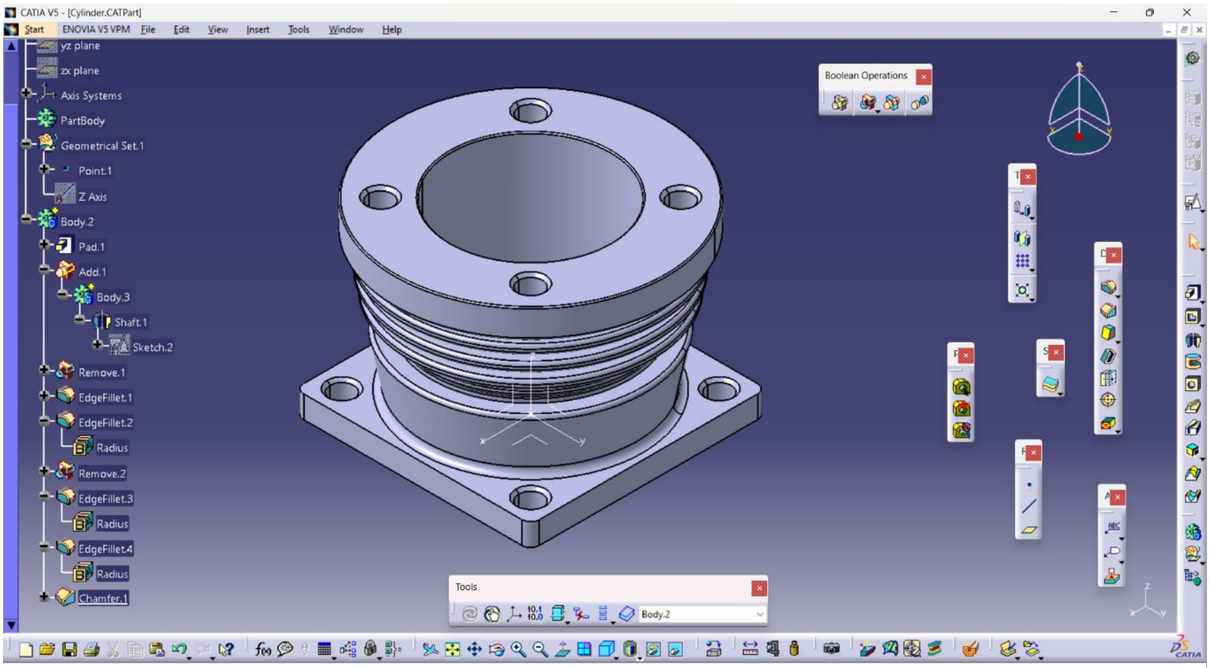


Fig- 23: Final Design of Cylinder

4.2.5. Cylinder Head:

- In Part Design, insert a body (Body2), create a sketch of sectional view as mentioned in the blueprint of Cylinder head and exit the workbench and create a solid body using “Shaft” command.

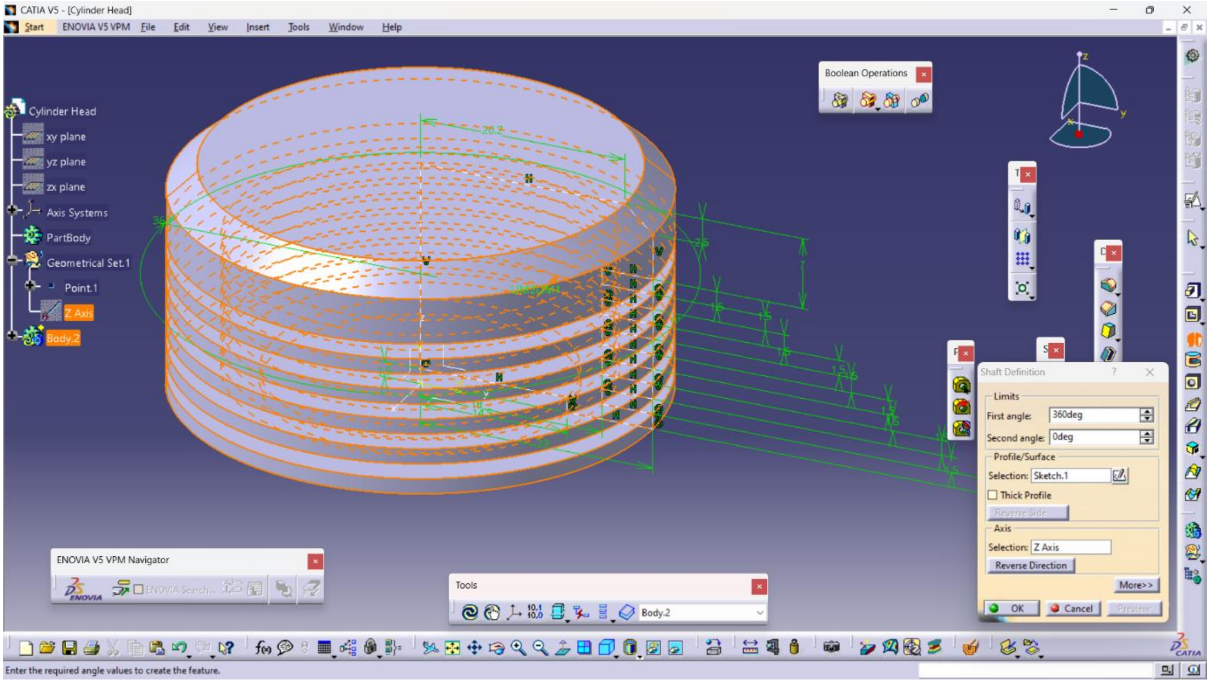


Fig- 24: Creating a solid body from Sketch1 using Shaft command

- Insert a new body (Body3) and create a new sketch of stepped cylinder of radii 5.5mm and 2.5mm at bottom view of “Body2”. Exit the workbench and create solid body using “Shaft” and transform one instance of it at a distance of 12mm using “Rectangular Pattern”. Remove “Body3” from “Body2” using “Remove” command.

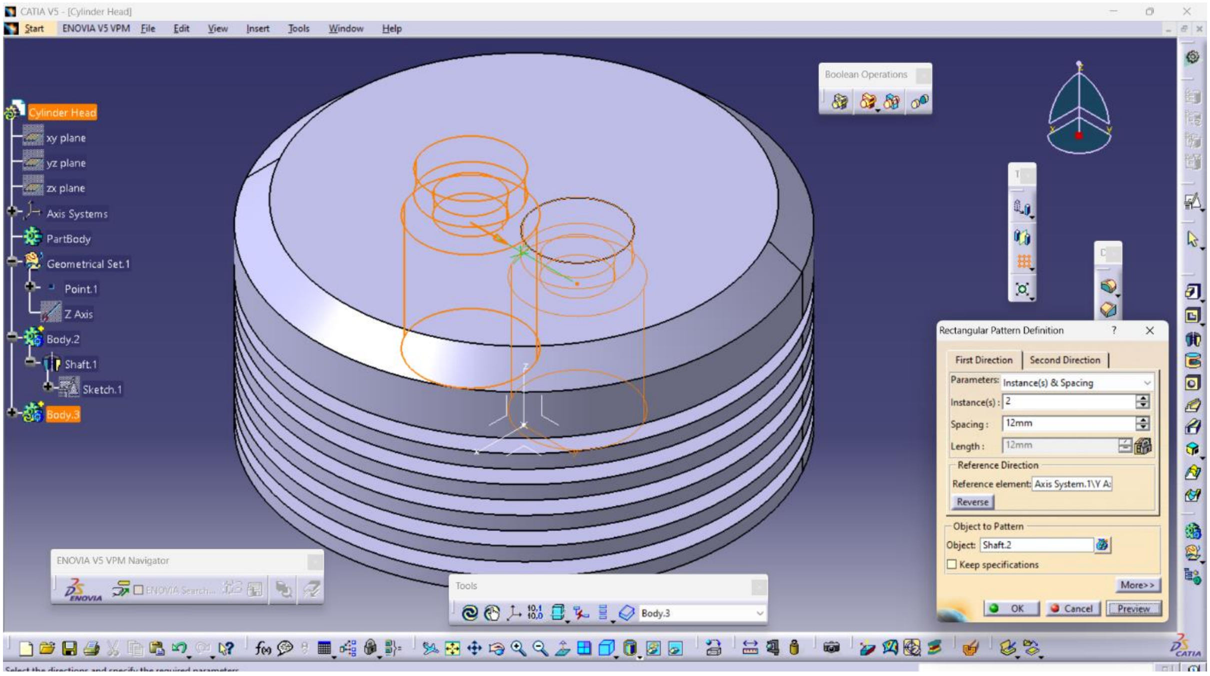


Fig- 25: Transforming a Body3 element using Rectangular Pattern

- Insert a new body (Body4) and create a new sketch as given in blueprint pf cylinder head on bottom view of “Body2”. Exit the workbench and create a solid body using “Pad” command of 3mm. Remove “Body4” from Body2” using “Remove” command.

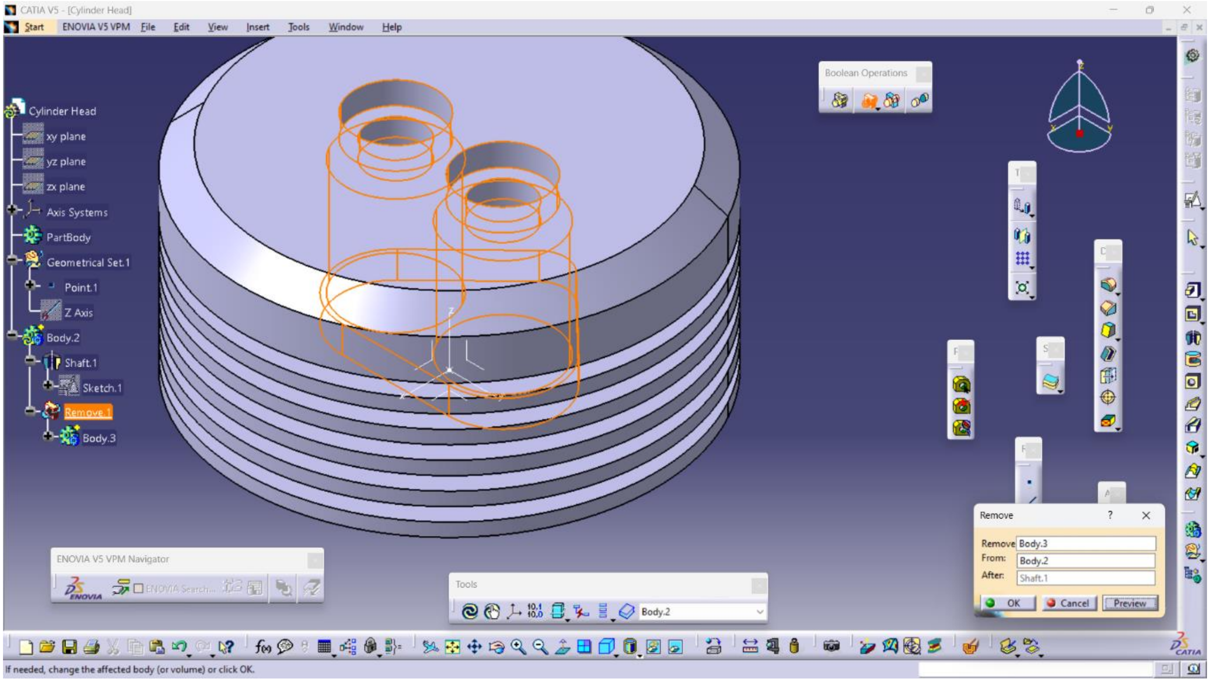


Fig- 26: Removing Body4 from Body2 using Remove Command

- Insert a new body (Body5), create a sketch of rectangle of dimensions 20x12 mm on side view of “Body2”. Exit the workbench and create a solid body using “Pad” of 19mm. Transform the right-side element to left side by using “Mirror” command and trim the “Body5” from “Body2” using “Union Trim” command.

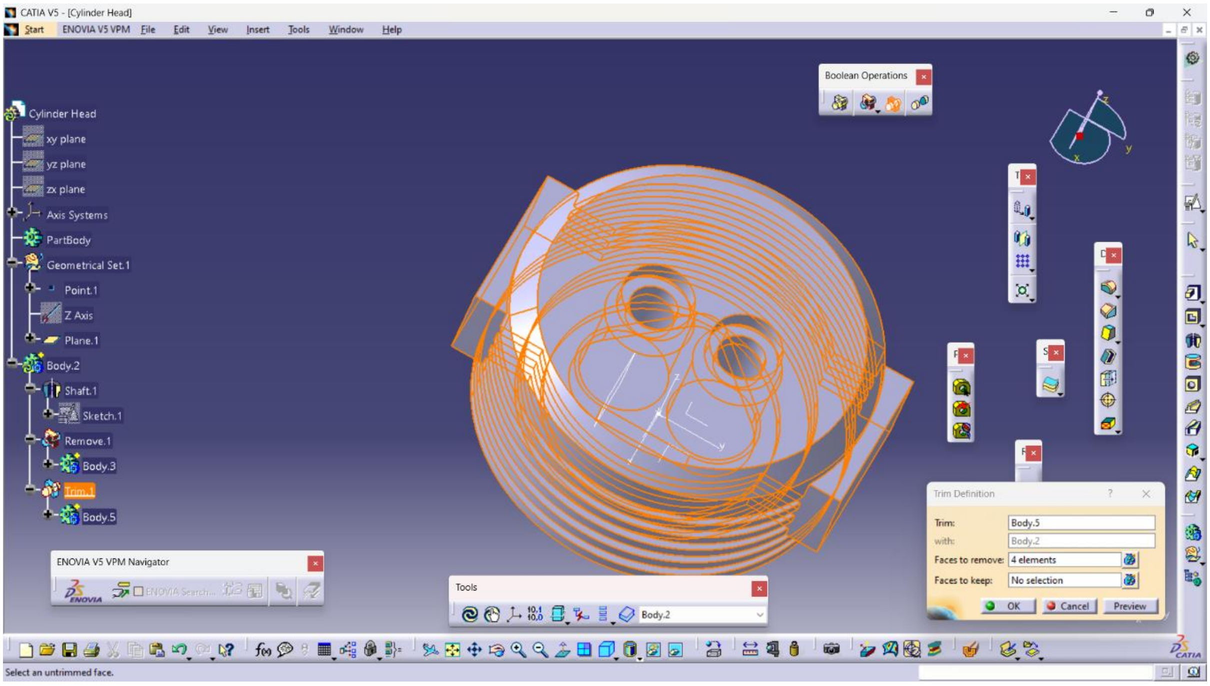


Fig- 27: Trimming Body5 from Body2 using Union Trim of Boolean operation

- Insert a new body, create a new sketch of 2 identical circles of diameter 3mm separated by a distance of 14mm and stepped cylinder of radii 4mm and 3.5mm on the side view of "Body2". Exit the workbench and create a solid body for 2 identical circles using "Pad" of 10mm and use "Shaft" command for stepped cylinder. Transform them by using Mirror command on to the other side view of Body2. Remove those bodies from "Body2" using "Remove" command.

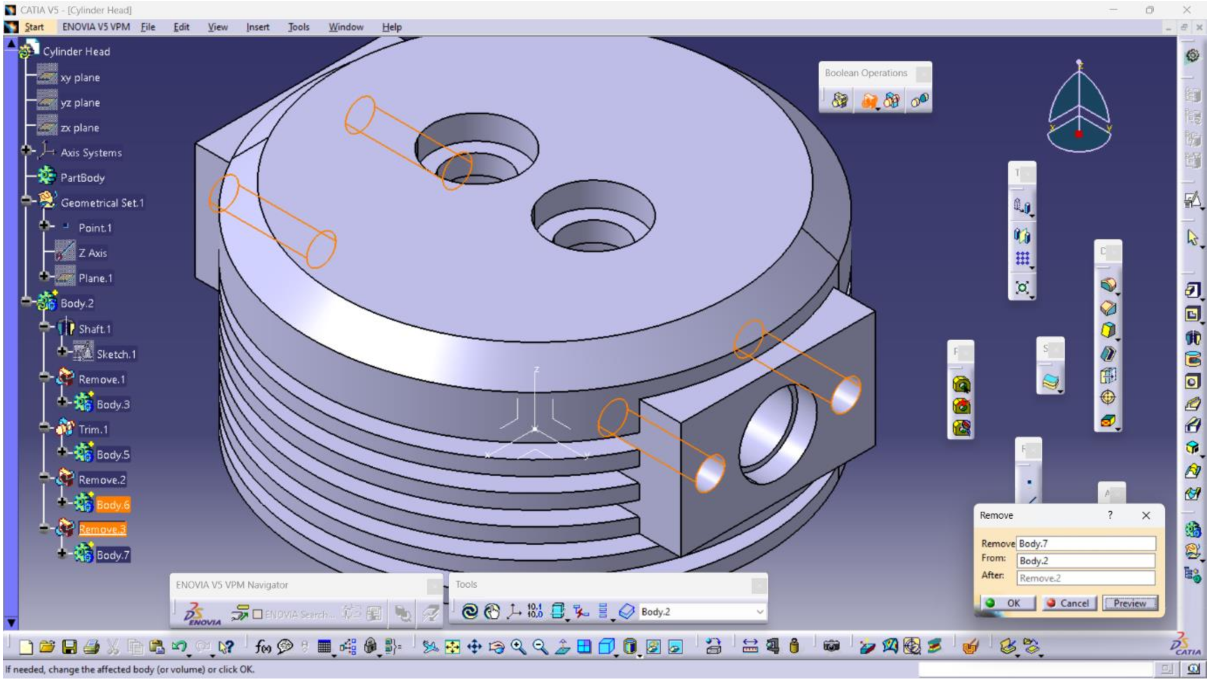


Fig- 28: Removing Bodies from "Body2" using Remove command

- Insert a new body (Body8), create a new sketch of stepped cylinder of radii 6.005mm and 2.5mm inclined to the plane as shown in blueprint of cylinder head, at xz plane. Exit the workbench and create a solid body using "Shaft" command and remove it from "Body2" using "Remove" command.

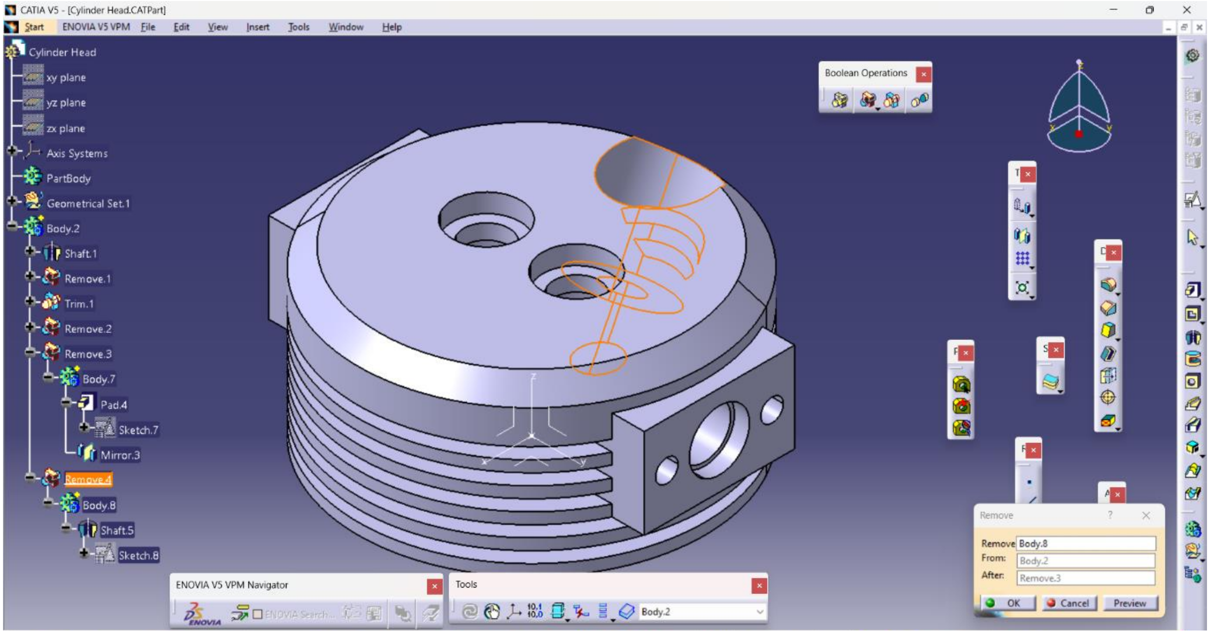


Fig- 29: Removing Body8 from Body2 using Remove command

- Insert a new body (Body9), create a sketch of stepped cylinder od radii 4mm ad 3.5mm on top view of "Body2". Exit the workbench and create a solid body using "Shaft" command. Create 4 instances of body element using "Rectangular Pattern" through two directions (x & y) at a distance of 25.46mm. Remove "Body9" from "Body2" using "Remove' Command.

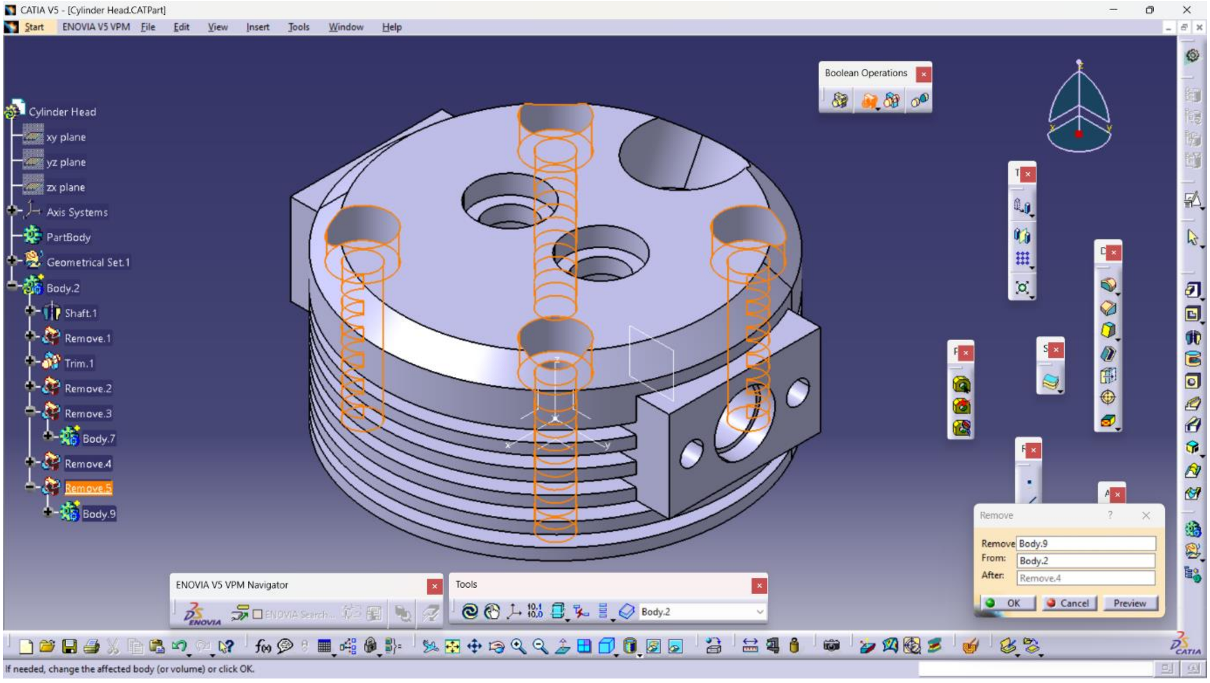


Fig- 30: Removing Body9 from Body2 using Remove Command

- Create a design as shown in blueprint of cylinder head, by inserting a body and removing it from Body2. And give "Body2" necessary edge fillets and chamfers at sharp edges.

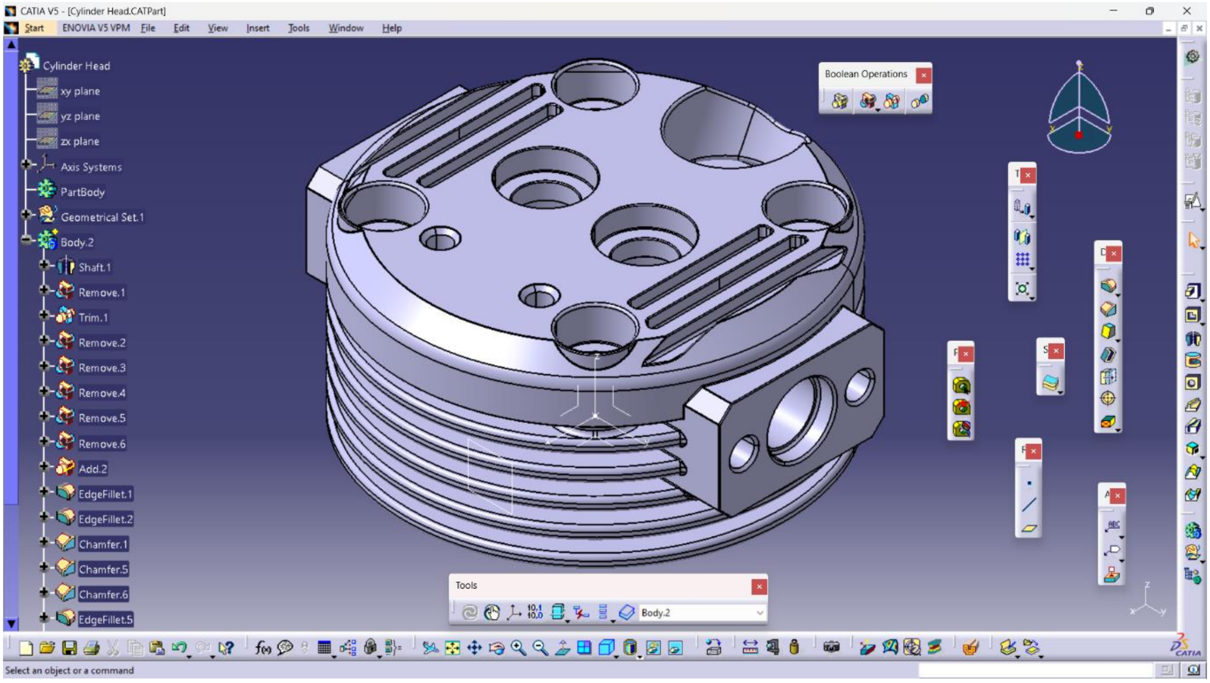


Fig- 31: Final Design of Cylinder Head

4.2.6. Cylinder Liner:

- In Part Design, insert a body (Body2), and go to “Sketcher” workbench using “Positioned Sketch” on ZY plane. Create a “Sketch1” of inverted “L” shape of radii 14.5mm and 12mm from the centre and a height of 40mm and 37.5mm respectively, using sketch-based features. Exit the workbench and create a solid “Body1” using “Shaft” command.

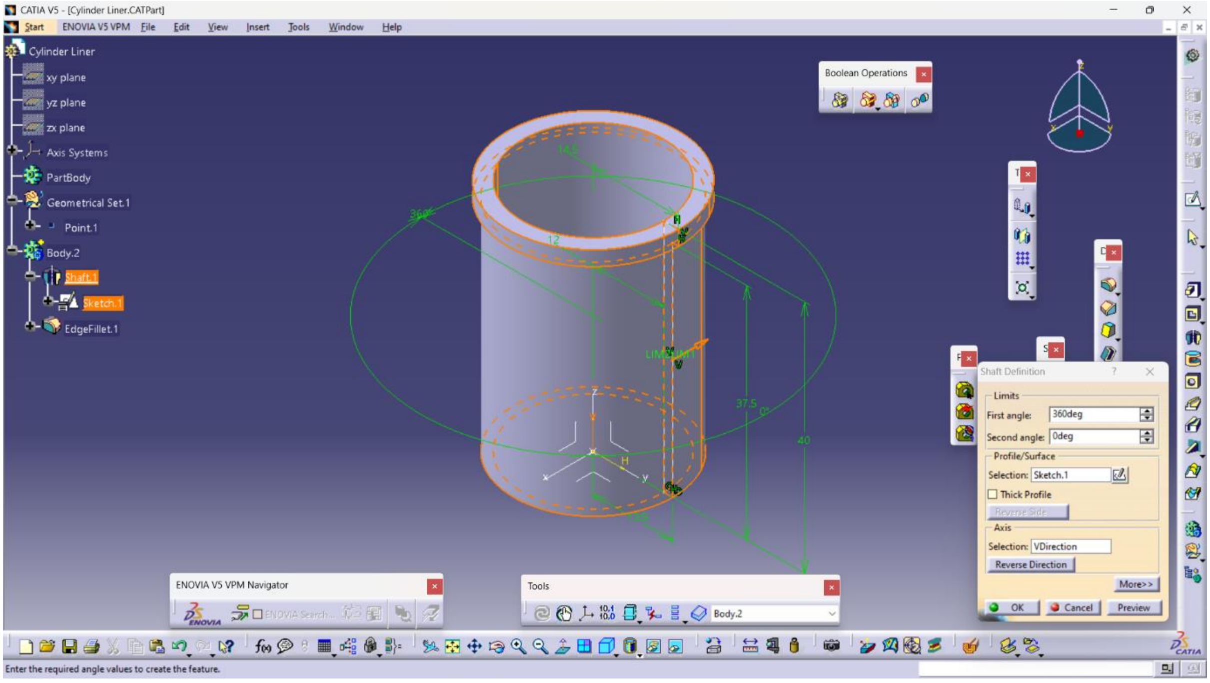


Fig- 32: Creating a solid body from Sketch1 using Shaft command

- Give the “Body2”, necessary edge fillets and chamfer at sharp edges.

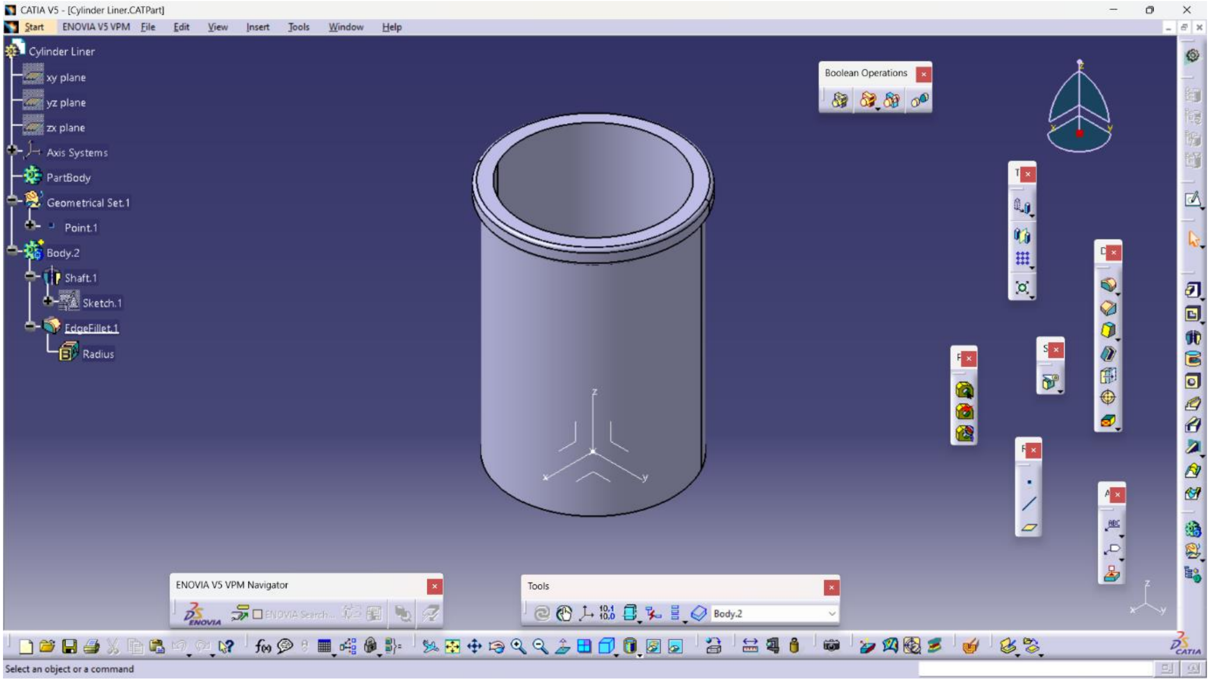


Fig- 33: Final Design of Cylinder Head

4.2.7. Piston:

- In Part Design, insert a new body (Body2), and go to the "Sketcher" using "Positioned sketch" on ZY plane. Create a "Sketch1" of sectional view of piston given in blueprint. Exit the workbench and create a solid "Body2", using "Shaft" command.

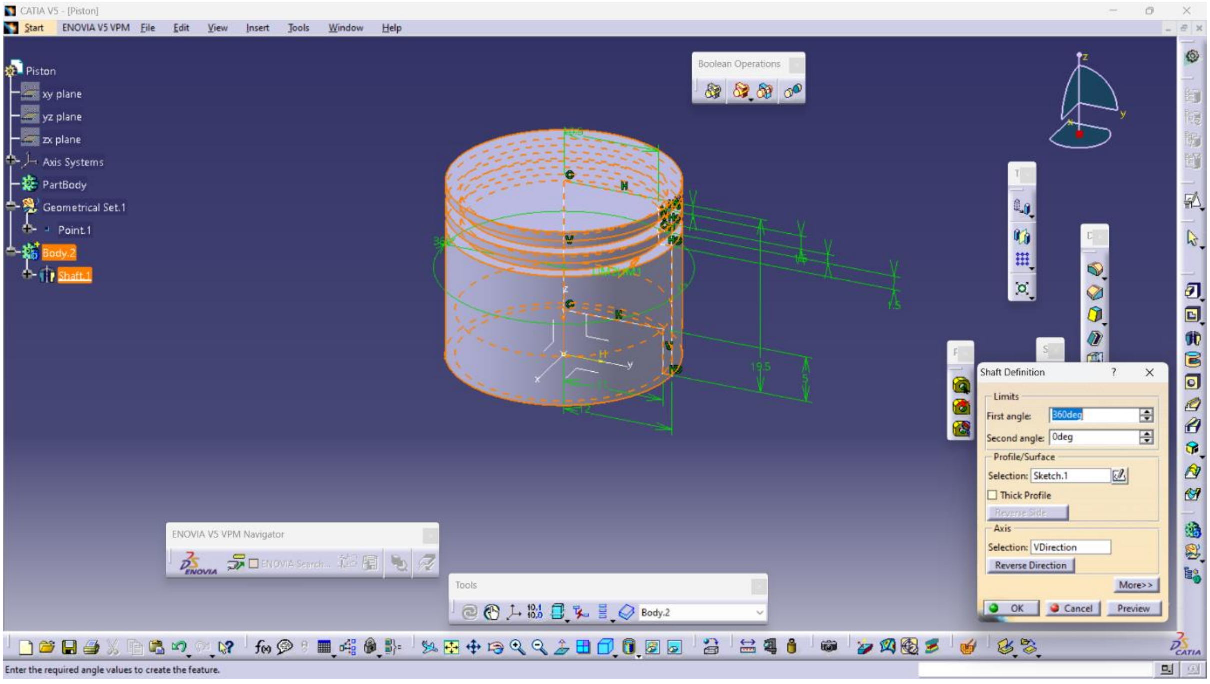


Fig- 34: Creating a solid body of Sketch1 using Shaft Command

- Insert a new body (Body3), and create a new "Sketch2" of circle of diameter 6.26mm at a distance of 10mm from origin, on ZY plane. Exit the workbench and create a solid "Body3" using "Pad" command of 12mm under "Mirror Extend" option. Remove "Body3" from "Body2" using "Remove" command.

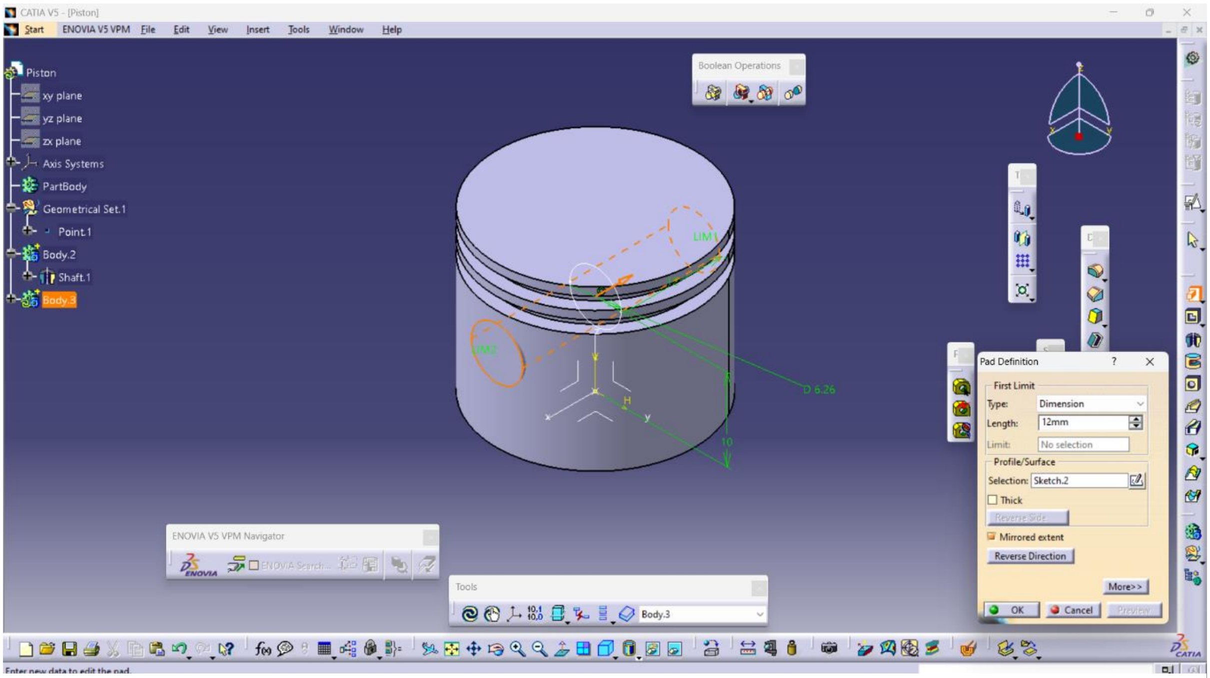


Fig- 35: Creating a solid Body3 from Sketch2 using Pad command

- Insert a new body (Body4), and create a new “Sketch3” of an elongated hole of 5mm radius and 21mm long and two identical circles of diameter 2.5mm separated by a distance of 16mm vertically, on bottom view of “Body2”. Exit the workbench and create a solid “Body4” using “Multi-Pad” command of 10mm “Mirror extend” for elongates hole and 5mm each for two identical circles. Remove “Body4” from “Body2” using “Remove” command.

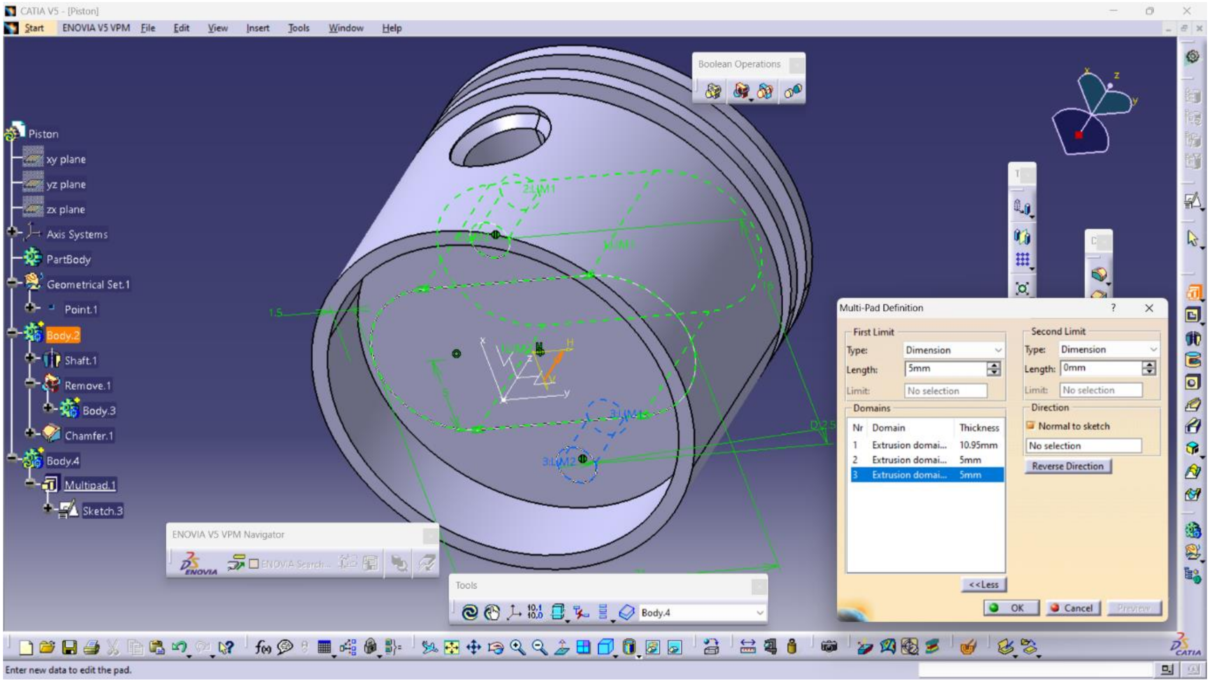


Fig- 36: Creating solid "Body4" of Sketch3 using Multi-Pad definition

- Give all necessary edge fillets and chamfers the “Body2” at sharp edges.

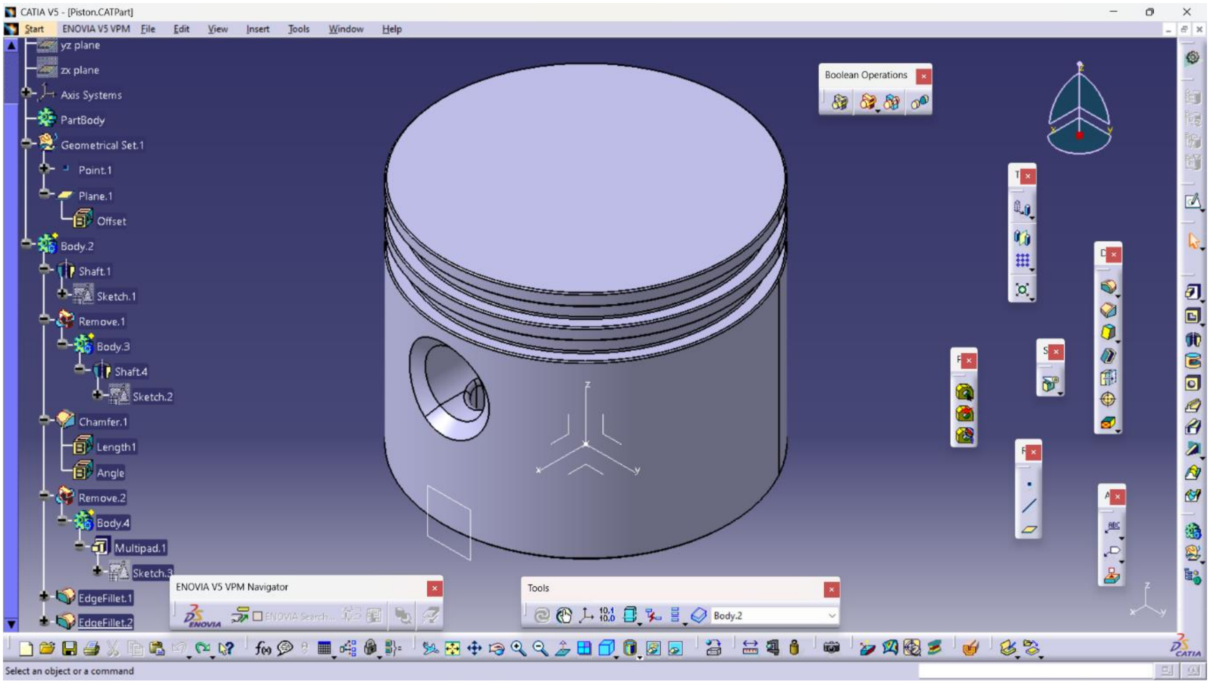


Fig- 37: Final Design of Piston

4.2.8. Piston Ring:

- In Part Design, insert a new body (Body2), and create a “Sketch1” of two concentric circles of diameters 24mm and 21mm on XY plane. Exit the workbench and create a solid “Body2” using “Pad” command of 1mm.

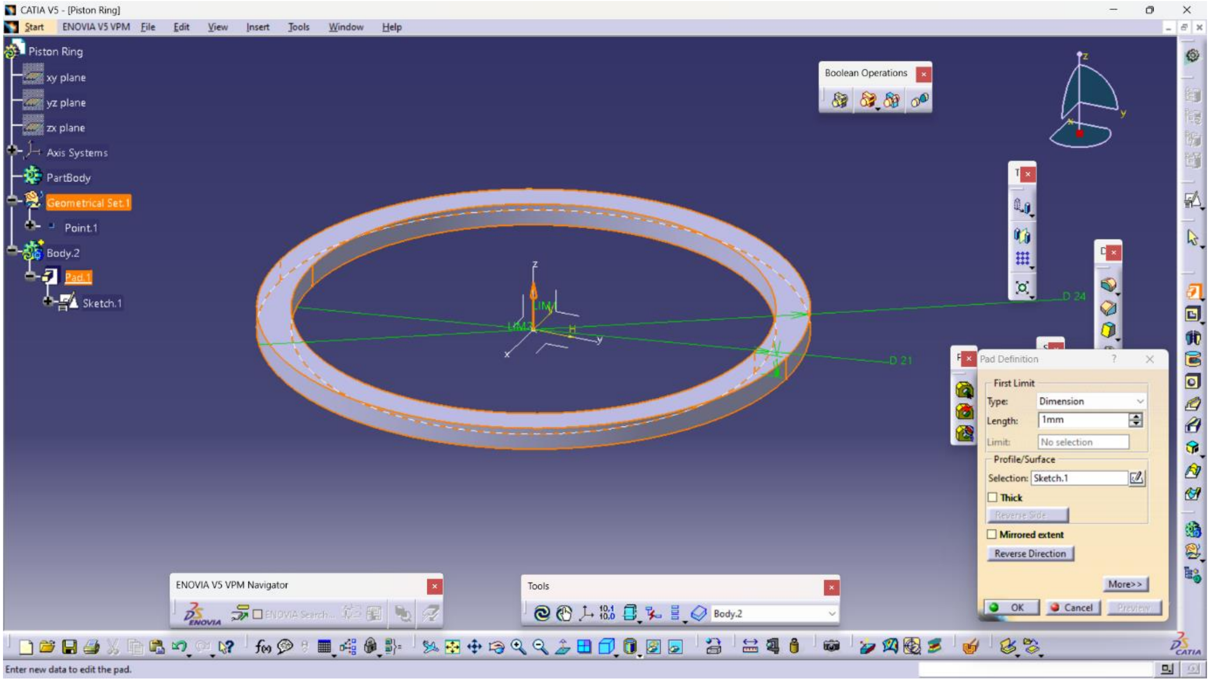


Fig- 38: Creating a solid Body2 of Skecth1 using Pad Command

- Insert a new body (Body3), and create a new “Sketch2” of parallelogram of 0.5x3.757mm at an angle of 45 degrees from horizontal axis, on ZX plane. Exit the workbench and create solid “Body3” using “Pad” command of 12 mm and remove “Body4” from “Body2” using “Remove” command.

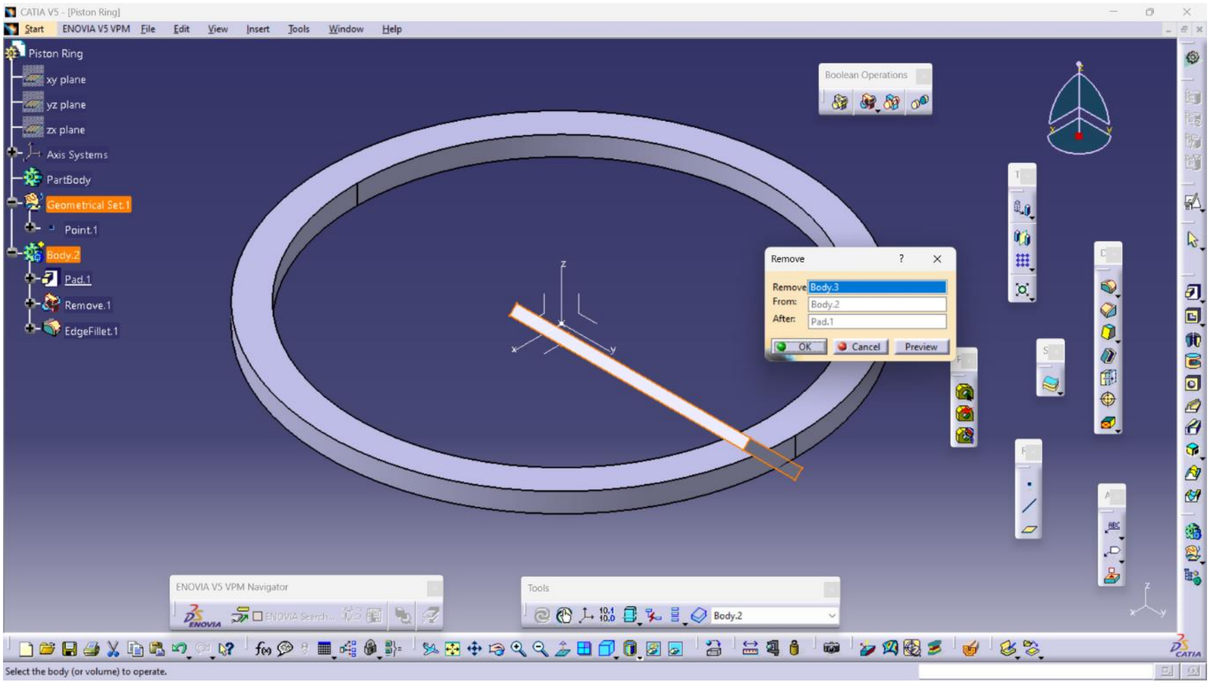


Fig- 39: Creating solid Body3 of Sketch2 using Pad command

- Give “Body2” all necessary edge fillets and chamfers at sharp edges.

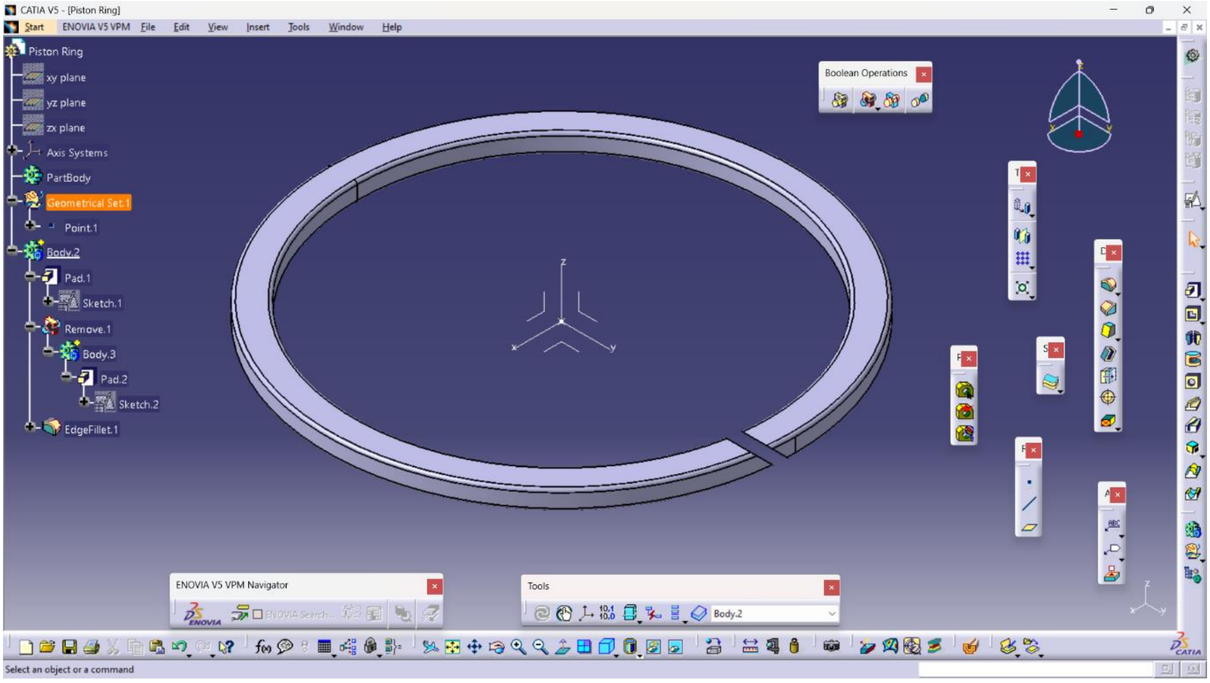


Fig- 40: Final Design of Piston Ring

4.2.9. Master Rod and Slave Rod:

a) Master Rod:

- In Part Design, insert a new body (Body2), and create a “Sketch1” of two series of concentric circles of 28mm & 52mm and 5mm & 10 mm separated by 60mm from their centres, on ZY plane. Make the design for bigger concentric circles using lines and arcs as shown in blueprint of Master rod. Exit the workbench and create a solid “Body2” using “Pad” definition of 3.5mm under “Mirror extend” option.

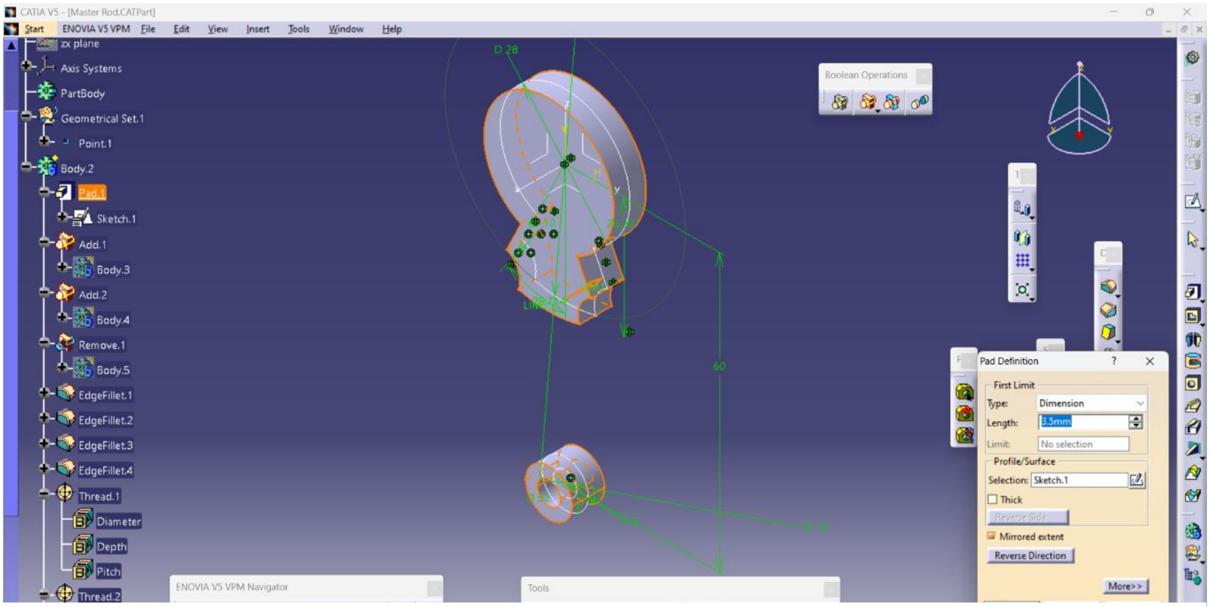


Fig- 41: Creating solid Body2 of Sketch1 using Pad command

Enter new data to edit the pad.

- Insert a new body (Body3), and create a new “Sketch2” on ZY plane. In “Sketch2”, connect the gap between Concentric circles of “Body2” using 2 random lines of length 29mm and 29mm. Close the profile using their corresponding circles by “Projecting” the sketches. Now, use mirror command on two lines. Trim excess profiles. Exit the workbench and create a solid “Body3” using “Multi-Pad” command of 5mm for longer profile and 3.5mm for shorter profile. Add “Body3” to “Body2” using “Add” command.

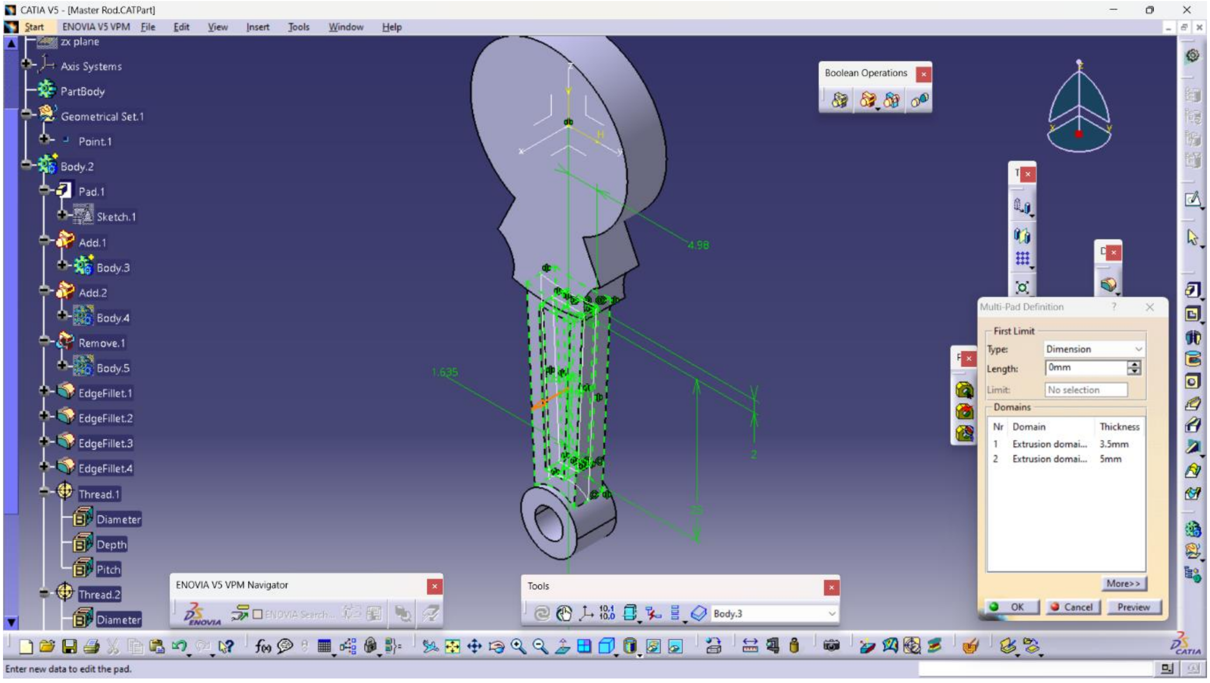


Fig- 42: Creating solid Body3 using Multi-Pad Definition

- Insert a new body (Body4), and create a new “Sketch3” on front view of “Body2”. “Sketch3” consists of a circle of diameter 52mm trimmed using 7 semi-circle of radius 5mm. Exit the workbench and create a solid “Body4” using “Pad” definition of 3mm. Create an instance of this body element using “Rectangular Pattern” at distance of 10mm. Add “Body4” to “Body2” using “Add” command.

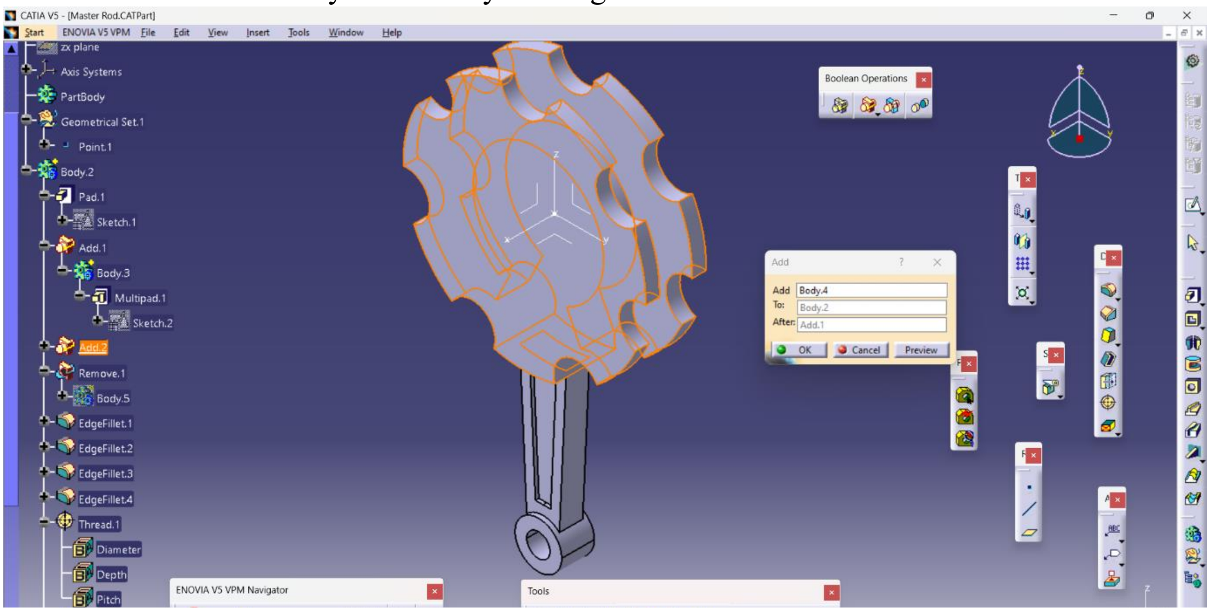


Fig- 43: Adding Body4 to Body 2 using Add command

Select the body (or volume) to operate.

- Insert a new body (Body5), and create a new “Sketch4” of circle of diameter 22mm and 6 identical circles of diameter 6mm in a circular pattern around 22mm circle, with a distance of 20 mm from origin and 2 identical circles of 3mm at a distance of 16mm from the origin. Exit the workbench and create a solid “Body5” using “Pad” definition of 13 mm. Remove “Body5” from “Body2” using “Remove” command.

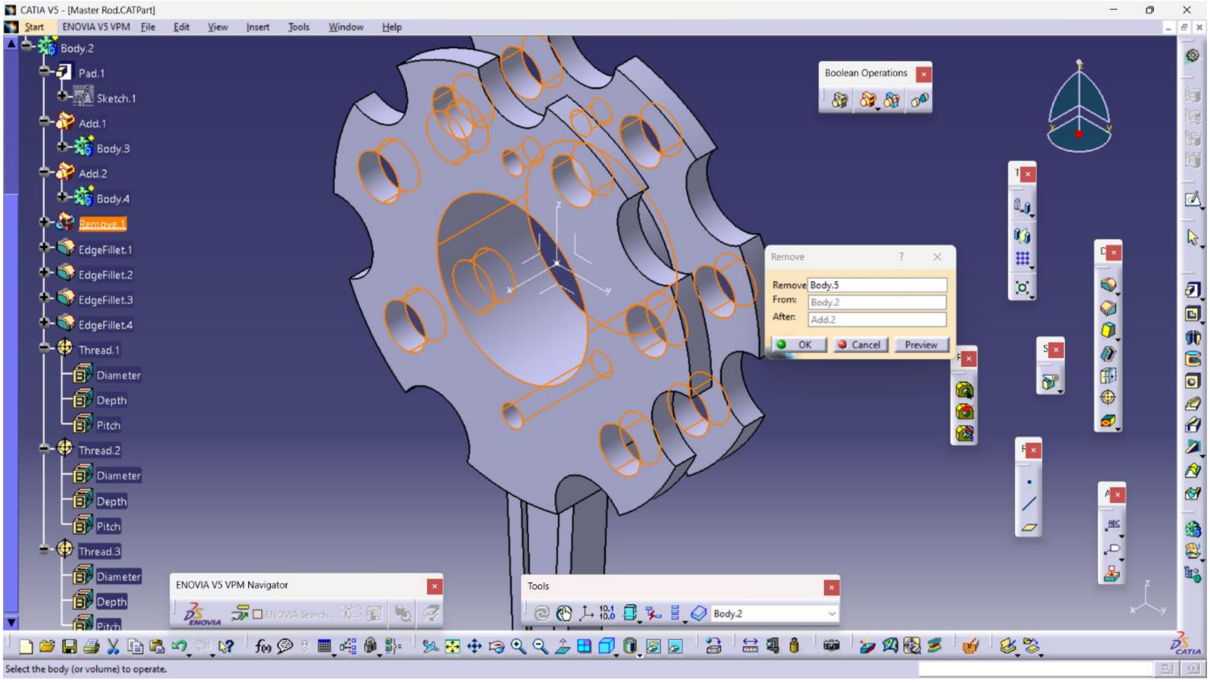


Fig- 44: Removing Body5 from Body2 using Remove command

- Give all necessary edge fillets and chamfers at sharp edges of “Body2”.

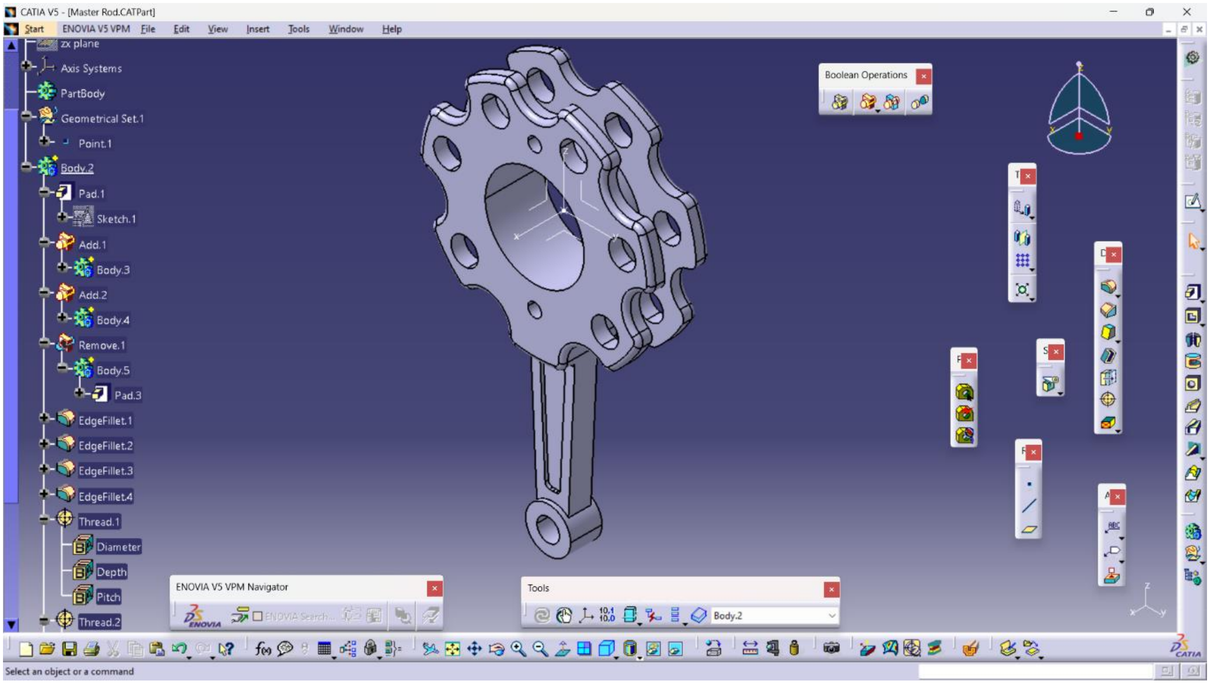


Fig- 45: Final Design of Master Rod

b) Slave Rod:

- In Part Design, insert a body (Body.2), create a sketch (Sketch.1) of 2 sets of concentric circles of diameters 5mm & 10.5mm and 6mm & 10.5mm respectively separated by a distance of 40mm from their centres, on ZY plane. Exit the workbench and create solid body (Body2) using “Pad” definition of 3.5mm under “Mirror extend” option.

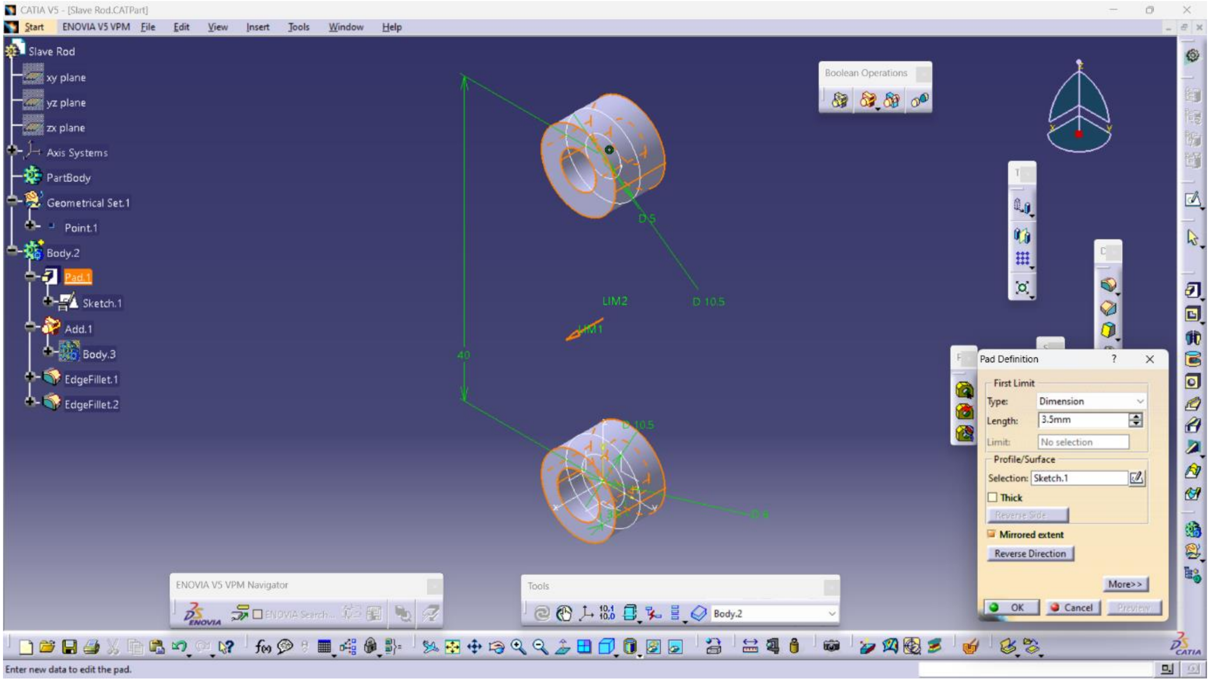


Fig- 46: Creating solid Body2 from Sketch1 using Pad command

- Insert a new body (Body3), and create a new “Sketch2” on ZY plane. In “Sketch2”, connect the gap between Concentric circles of “Body2” using 2 random straight lines at distance of 3.75mm and 2.25mm from vertical plane. Close the profile using their corresponding circles by “Projecting” the sketches. Now, use mirror command on two lines. Trim excess profiles. Exit the workbench and create a solid “Body3” using “Multi-Pad” command of 5mm for longer profile and 4mm for shorter profile under “Mirror extend” option. Add “Body3” to “Body2” using “Add” command. Give all necessary edge fillets and chamfers at sharp edges of “Body2”.

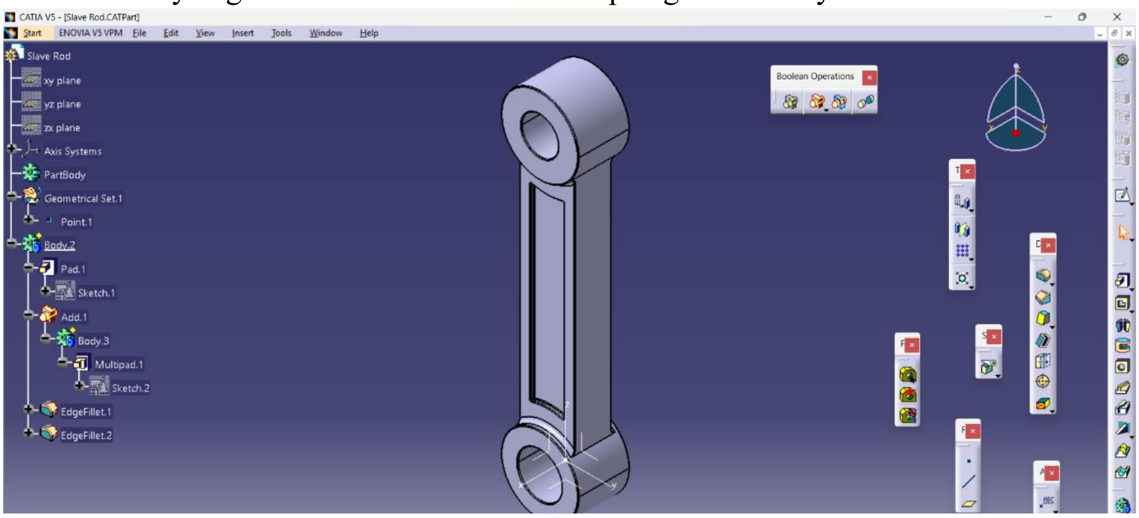
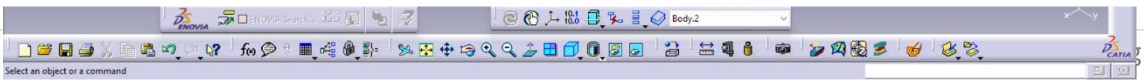


Fig- 47: Final Design of Slave Rod



4.2.10. Crank Shaft:

- In Part Design, insert a body (Body.2) and create a sketch (Sketch.1) of stepped half bar diagram of wide 5mm,6mm,7.5mm,5mm,7.5mm,8.5mm,11mm of lengths 57mm, 8mm,6.25mm,1.25mm,28.5mm,12mm,2.9mm respectively, on ZY plane. Exit the workbench and create a solid body (Body2) using “Shaft” command.

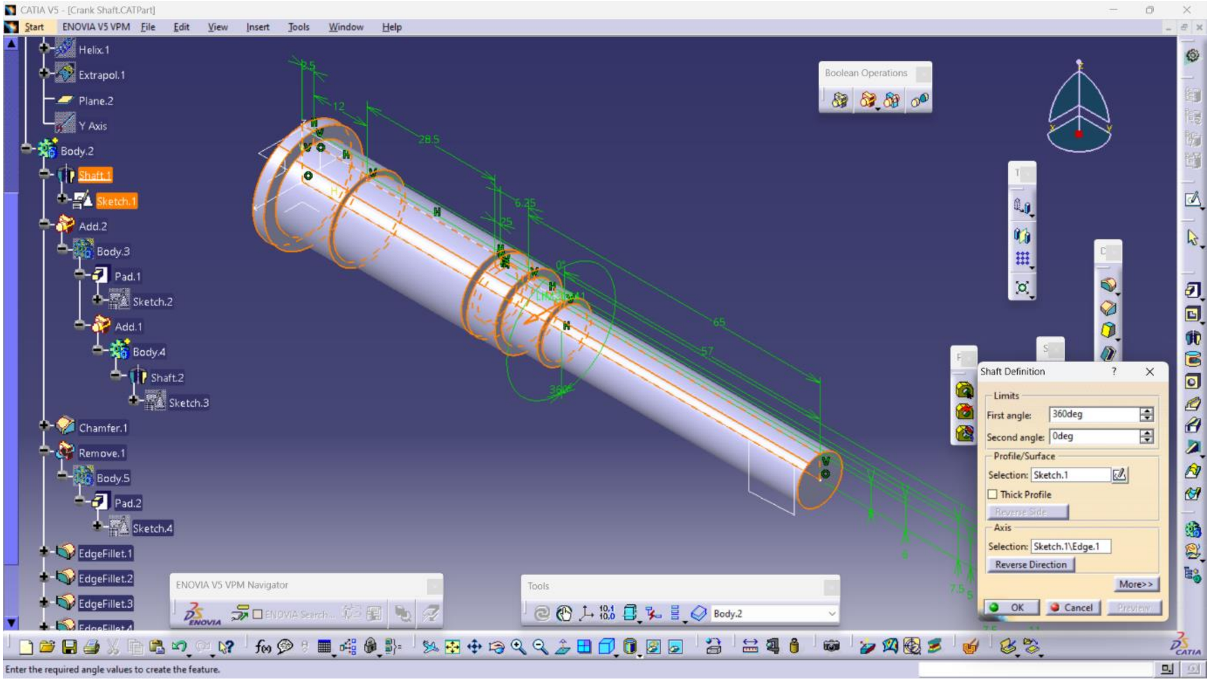


Fig- 48: Creating a solid Body2 using Shaft command

- Insert two bodies (Body3, Body4) one after other and create sketches (Sketch2, Sketch4) of required diagram from blueprint of crank shaft on ZY plane. Exit the workbench and create a solid body “Body3” using “Pad” definition of 7mm and “Body4” using “Shaft” command. Add “Body4” to “Body3” and add “Body3” to “Body2” using “Add” command.

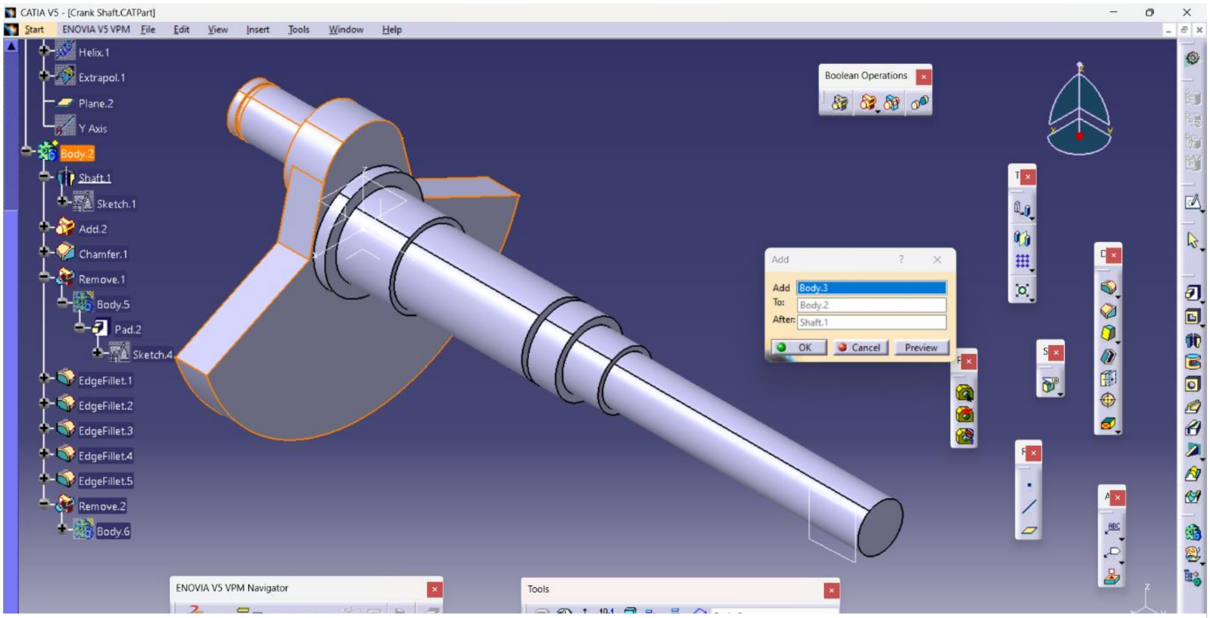


Fig- 49: Adding Body3 to Body2 using Add command

- Insert a new body (Body5) and create a sketch (Sketch4) of elongated hole of radius 5mm and length of 8mm with 19.5 mm distance from origin, on a plane which is 5.5mm from XY plane. Exit the workbench and create solid body "Body5" using "Pad" definition of 2mm. Remove "Body5" from "Body2" using "Remove" command.

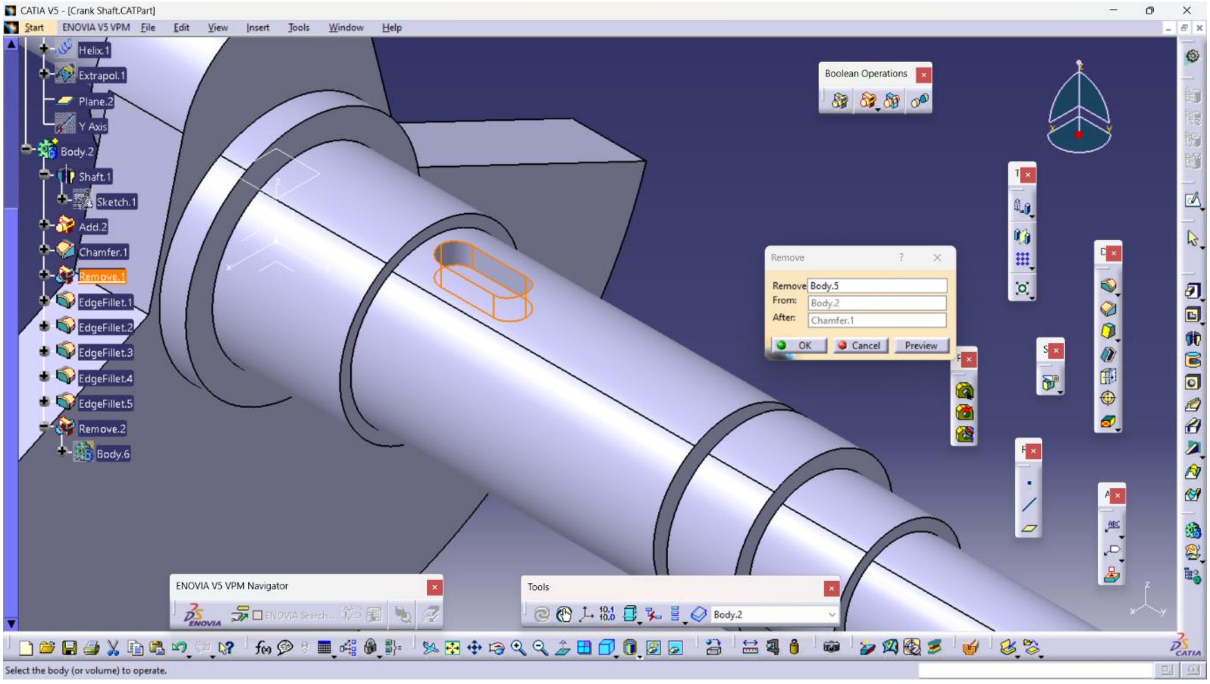


Fig- 50: Removing Body5 from Body2 using Remove command

- Insert a new body (Body6) and create a threading on 10 mm diameter shaft of "Body2" as given below:
  1. Create a point (Point.2) on 10mm diameter shaft of "Body2" at the sharp edge.
  2. Go to the "Generative Shape Design" module and create a helix (Helix.1) of Pitch 1.5mm height of 5mm from the "Point.2". Now, extrapolate (Extrapoalte.1) the helical curve 10mm, using "Extrapolate" command.
  3.Redirect back to the "Part Design" module and insert a plane (Plane.2) on "Helix.1" and "Extrapolate.1). Create a sketch of circle of diameter 0.75mm on "Plane.2".
  4. Exit to the workbench and create a solid body using "Rib" command. Remove "Body6" from "Body2" using "Remove' command.
- Give all necessary edge fillets and chamfers for "Body2" at sharp edges.

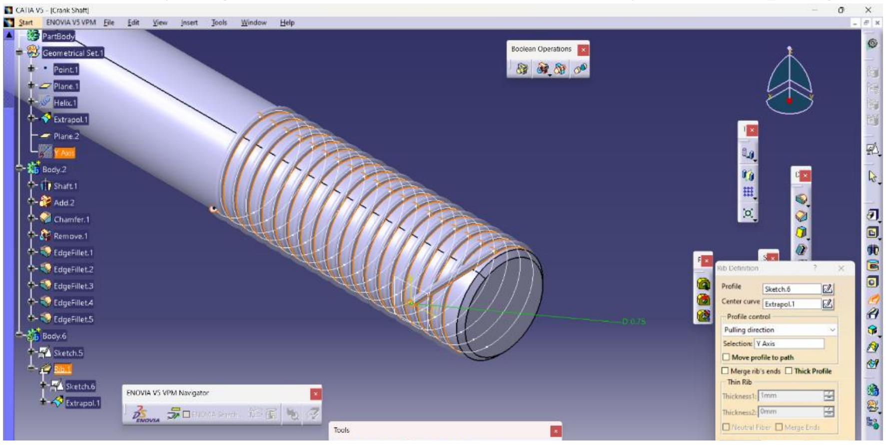


Fig- 51: Creating a solid body of Helix from the sketch using Rib command

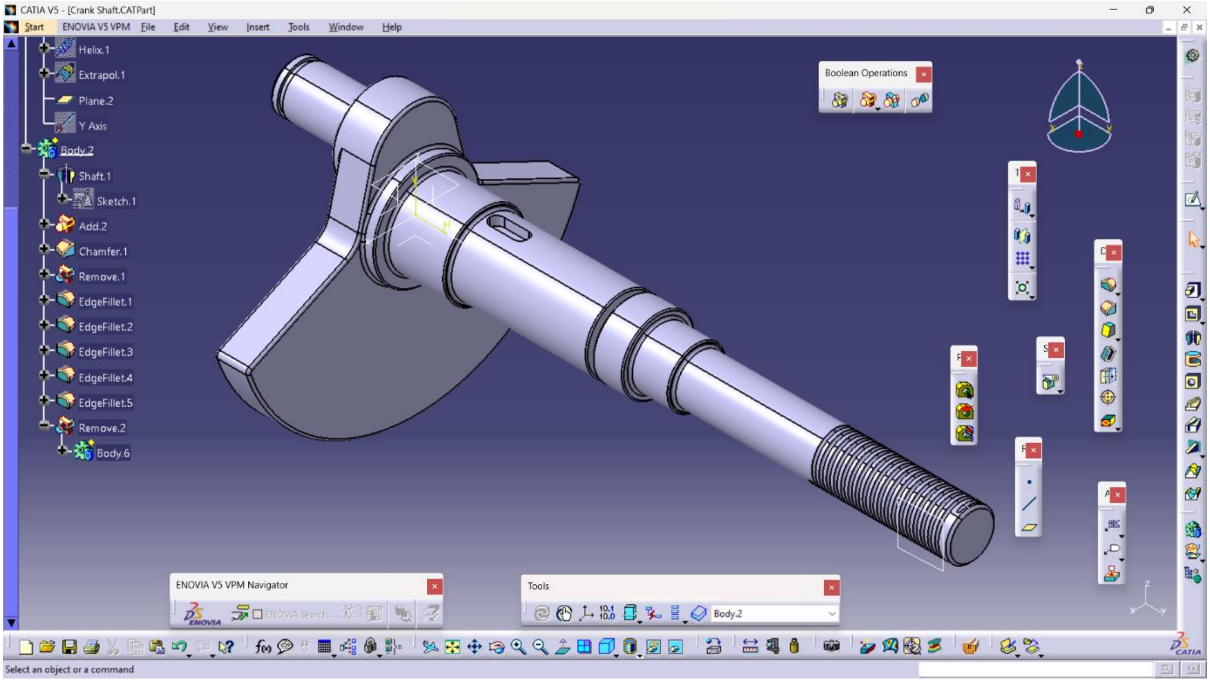


Fig- 52: Final Design of Crank Shaft

4.2.10. Epicyclic Gears:

a) Sun Wheel Gear:

- In Part Design, insert a body (Body2) and create sketch (Sketch1) of circle of diameter 31.75mm on ZY plane. Exit the workbench and create a solid body (Body2) from Sketch1 using "Pad" definition of 3.5mm under "Mirror Extend".

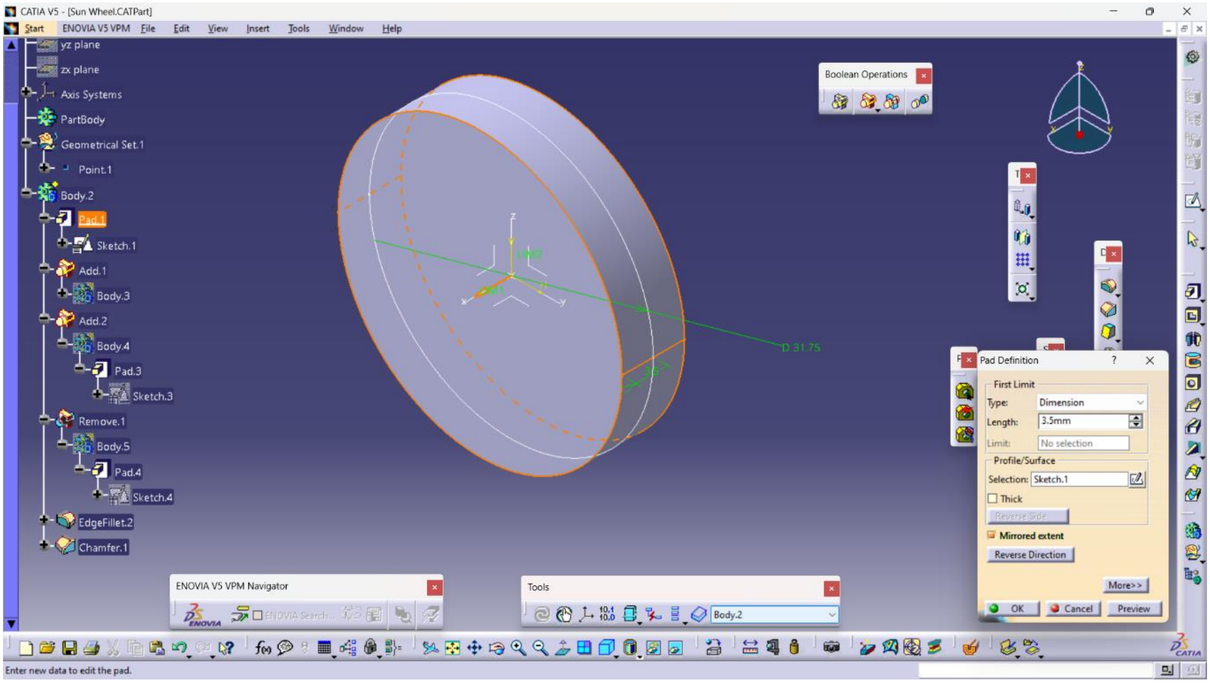


Fig- 53: Creating a solid body from Sketch1 using Pad command

- Insert a new body (Body3) and create a sketch (Sketch2) on front view surface of "Body2". The specifications to create a sketch of Sun wheel gear are given as, Module(m)=0.5, Number of teeth(z)=66. Pitch Circle(d)=33mm. To create the "Sketch2", calculations are done as follows:

1. Circular Pitch, P = π x m = π x 0.5 = 1.5708mm.
2. Addendum, a = m = 0.5mm.
3. Dedendum, b = 1.25 x m = 1.25 x 0.5 = 0.625mm.
4. Outer radius, OD = d + 2a = 33 + 2x0.5 = 34mm
5. Root radius, RD = d – 2b = 33 – 2x0.625 = 31.75mm
6. Angle between axis of teeth = 360/z = 360/66 = 5.4545 degrees
7. Thickness of teeth, s = (π x m)/2 = (π x 0.5)/2 = 0.7854mm
8. Radius of teeth, R = d/5 = 33/5 = 6.6mm
9. Fillet on tooth of gear is to be 0.25 to 0.3 multiple of module(m).

With the above calculations, the Sun wheel gear can be designed.

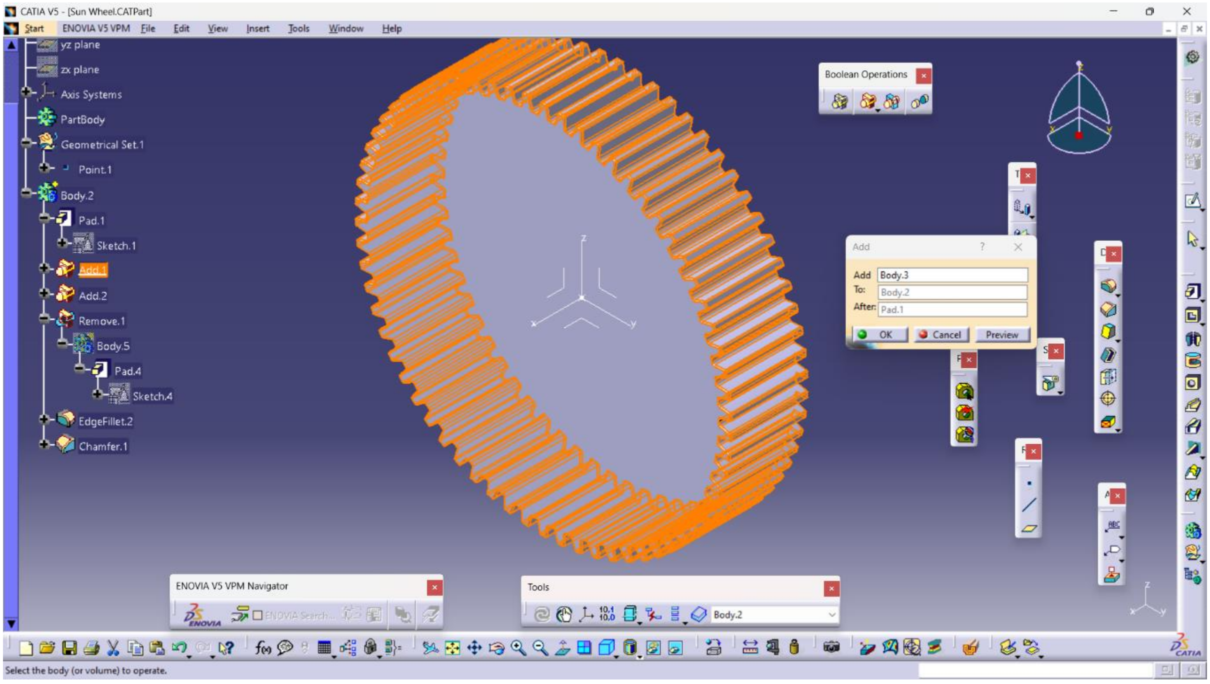


Fig- 54: Adding Body 3 to Body2 using Add command

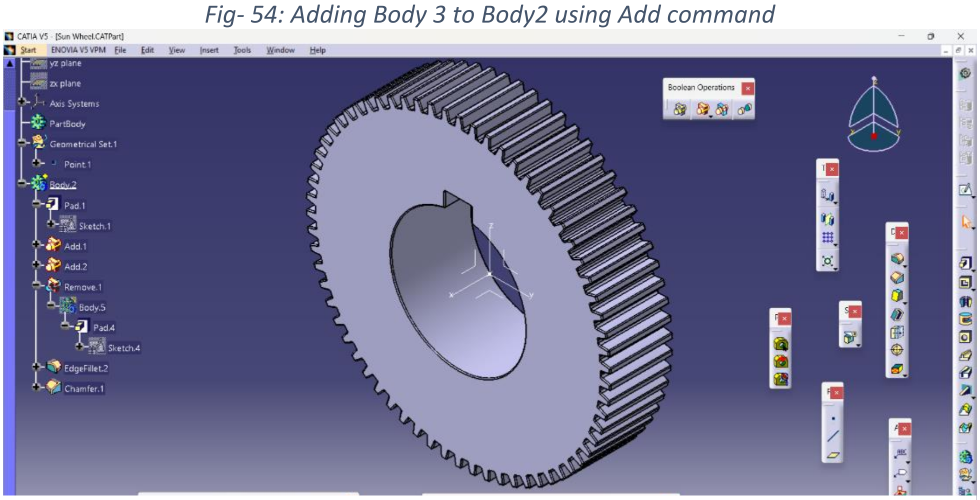


Fig- 55: Final Design of Sun wheel gear

b) Planetary Wheel Gear:

- The specifications of Planetary wheel gear are as given:
  Module(m)=0.5, Number of teeth(z)=33, Pitch circle(d)=16.5mm
- Likewise in Sun wheel gear the procedure for design of Planetary gear is same.

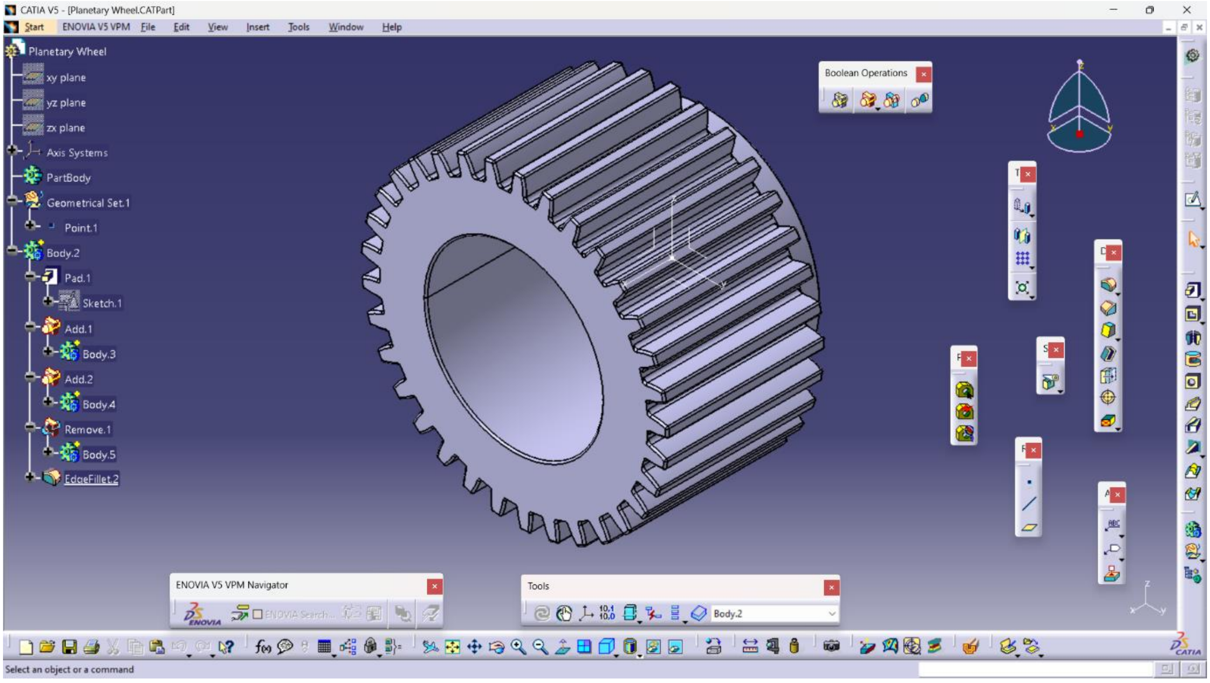


Fig- 56: Final Design of Planetary Wheel Gear

c) Internal Gear:

- The specifications of Internal gear are as given:
  Module(m)=0.5, Number of teeth(z)=132, Pitch circle(d)=66mm
- Likewise in Sun wheel gear the procedure for design of Planetary gear is almost same but instead of adding the teeth to base circle, removing of teeth is done from the main body.

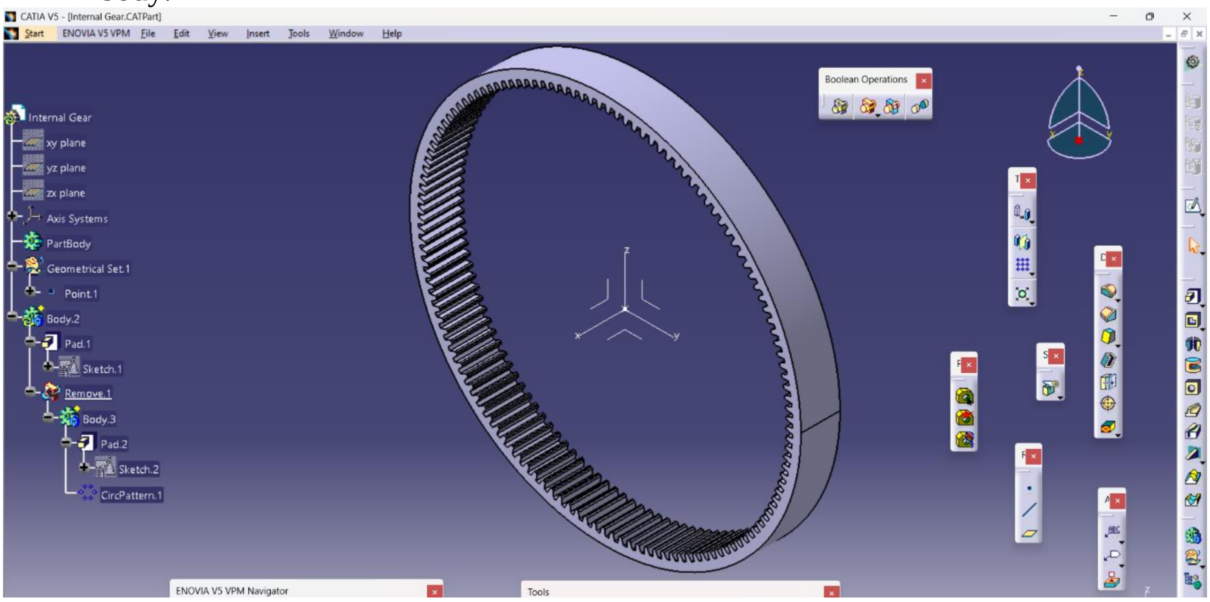


Fig- 57: Final Design of Internal Gear

Select an object or a command

The Part designs of main components of 7-Cylinder radial engine are finished. And a lot part designs for minor parts are done.

CHAPTER – V

5. ASSEMBLY DESIGN PROCEDURE FOR COMPONENTS IN CATIA

5.1. ASSEMBLY DESIGN PROCEDURE IN CATIA:

To assemble parts that are designed under part design module, we have to follow certain steps:

- Go to the "Start" menu and click on "Assembly Design" under the tab of "Mechanical Design".
- Click on "Existing Component With Positioning" under "Insert" Toolbar to insert an existing designed component from computer.

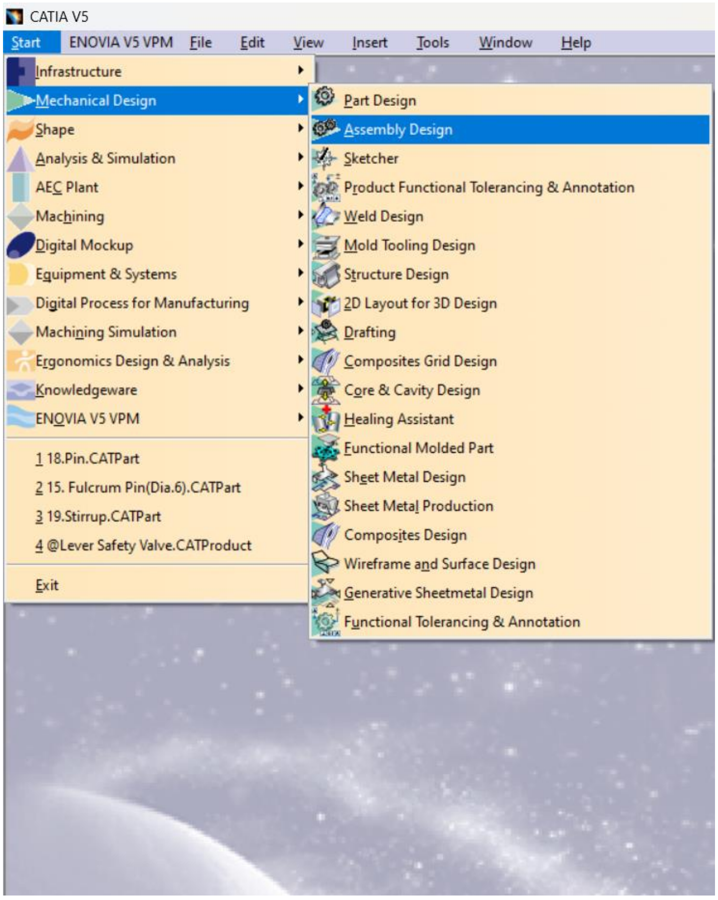


Fig-70: Assembly Design from Start menu

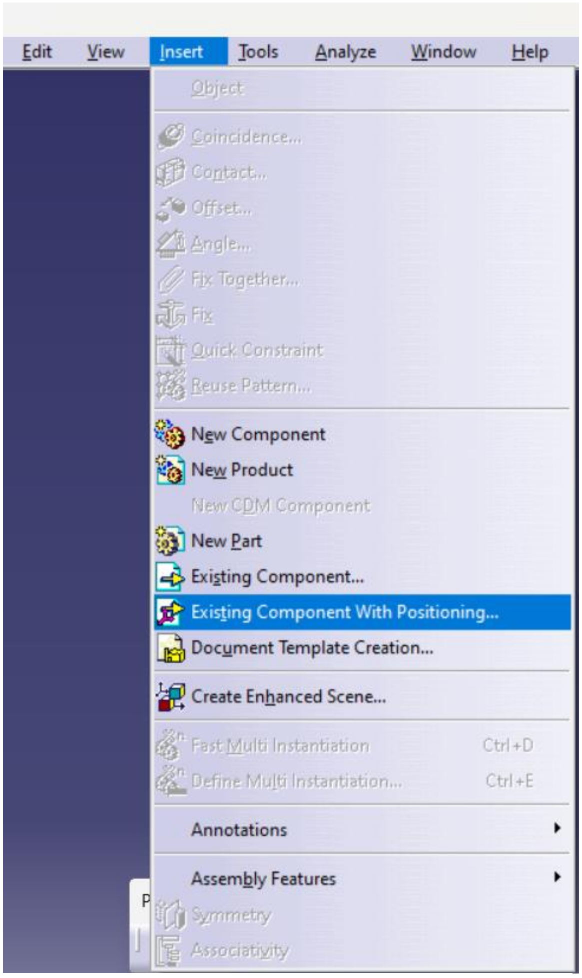


Fig- 71: Inserting an existing component with position

- Fix the First(or) main component using "Fix Component" command from left side under Docking area.
- The components can be moved in the required direction by using "Manipulation" command and the distance between components are given by using "Offset" command.
- Using the "Coincidence Constraint" make the axes of components to be coincident.
- Using the "Contact Constraint" the contacts between the components are made.
- Likewise, the commands are used to do the required task on the components. And there a lot of commands to design an assemble of a Product.

5.2. ASSEMBLY OF COMPONENTS OF 7-CYLINDER RADIAL ENGINE:

The assembly of 7-Cylinder radial engine is done using “Top to Bottom Approach” Method.

5.2.1. Piston Assembly:

Firstly, import the required components for the assembly of Piston. The components included are: Piston, Piston Ring, Piston Shaft and DIN EN ISO 4029 - M2,5 x 2,5.1. By using the Assembly based features like “Fix Component”, “Manipulate”, “Coincidence Constraint”, “Angle Constraint” and “Offset Constraint” the assembly of Piston is done.

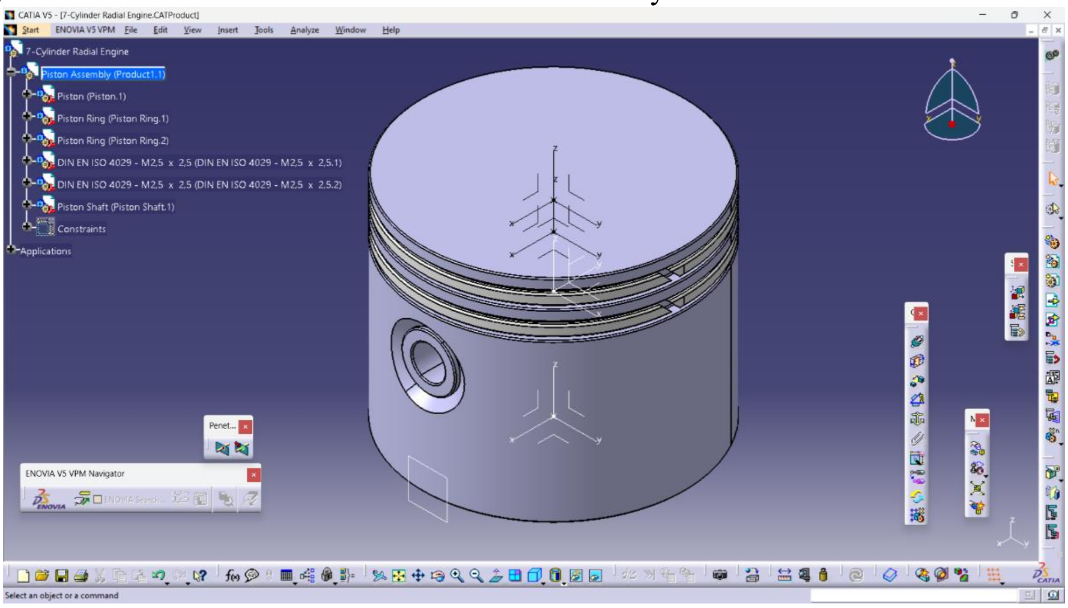


Fig- 58: Piston Assembly

5.2.2. Crank Shaft Assembly:

Firstly, import the required components for the assembly of Crank Shaft. The components included are: Crank Shaft, Roller Bearing DIN 617 SKF NA 4900 RS, Master Rod, Cover Disc, Washer (DIN 6799-9), Two sets Nut DIN 920 M3x3, Key, Sun Wheel, Washer (DIN 6799-10). By using the Assembly based features like “Fix Component”, “Manipulate”, “Coincidence Constraint”, “Angle Constraint” and “Offset Constraint” the assembly of Crank Shaft is done.

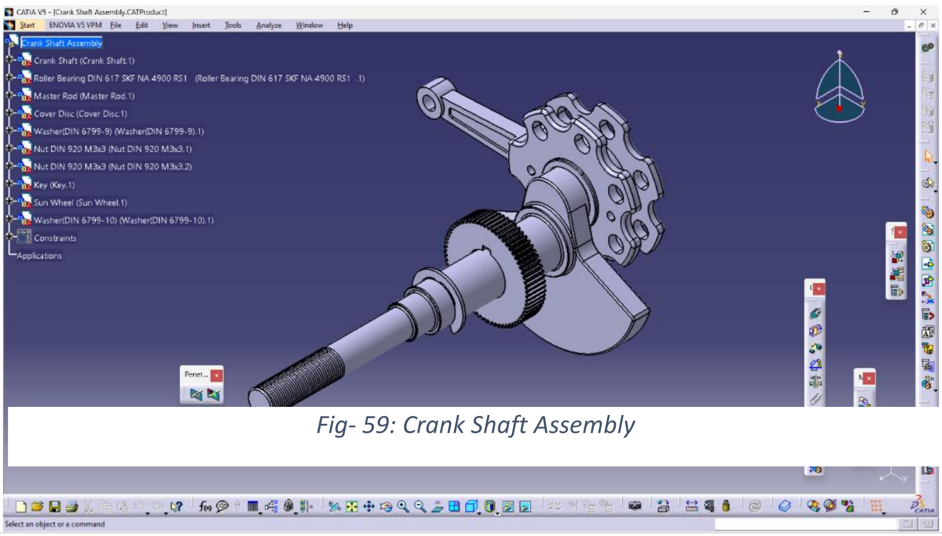


Fig- 59: Crank Shaft Assembly

5.2.3. Cylinder Assembly:

Firstly, import the required components for the assembly of Cylinder. The components included are: Cylinder, Cylinder Liner, Cylinder Head Gasket, Cylinder Head, 2 sets of Valve group, Ignition Plug, Spark Plug, 4 sets of Nut ISO 4762 - M4 x 25ISO, Rocker Arm Bracket Cover, Rocker Arm, Rocker Arm Axis, 2 sets of Rocker Arm Bearing Block, 2 sets of Rocker Arm Link, 2 sets of Nut ISO 7046-1 - M3 x 8 - 4.8 - Z – ISO, 2 sets of DIN 6799 - 3,2 4, 2 sets ISO 4036 - M3, Cylinder Base Gasket and 2 sets of Flange Gasket. By using the Assembly based features like “Fix Component”, “Manipulate”, “Coincidence Constraint”, “Angle Constraint”, “Offset Constraint” and “Reused Rectangular Pattern”, the assembly of Cylinder is done.

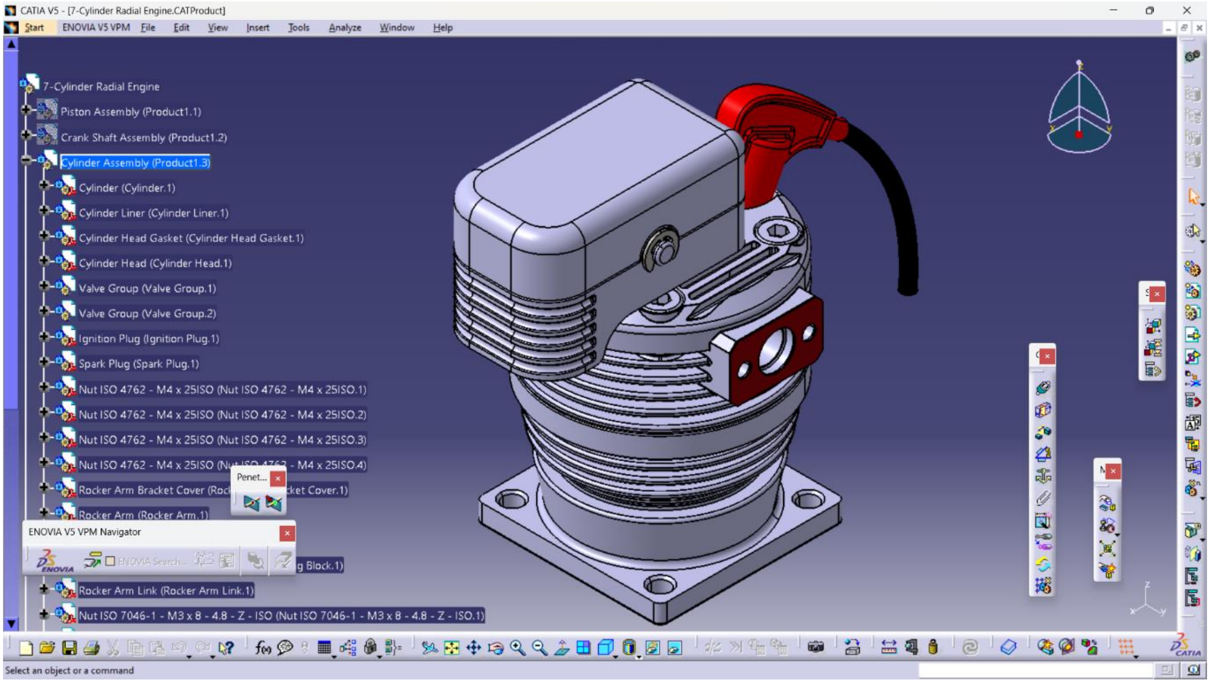


Fig- 60: Cylinder Assembly

5.2.4. Crank Case Assembly:

Firstly, import the required components for the assembly of Crank Case. The components included are:

- Crank Case
- Suction Housing
- Suction Housing Pin
- Ball Bearing (DIN 625 T1 - 16003 - 17 x 35 x 8)
- DIN EN ISO 4762 - M4 x 6
- Mounting Ring, Suspension Pin
- ISO 10511 - M5

By using the Assembly based features like “Fix Component”, “Manipulate”, “Coincidence Constraint”, “Angle Constraint”, “Offset Constraint” and “Reused Rectangular Pattern”, the assembly of Crank Case is done.

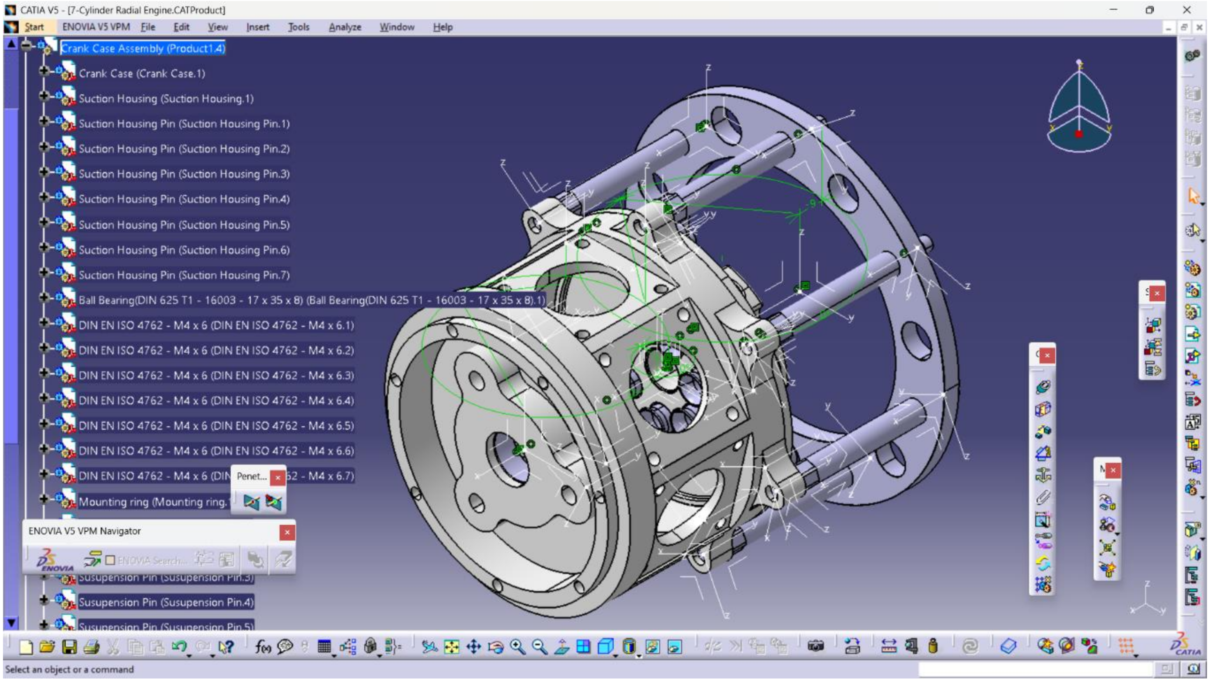


Fig- 61: Crank Case Assembly

5.2.5. Overall Cylinder Assembly:

Overall Cylinder Assembly consists of 7 Cylinders. The cylinders are arranged in such a way that they are mounted directly on piston moving holes of Crank Case.

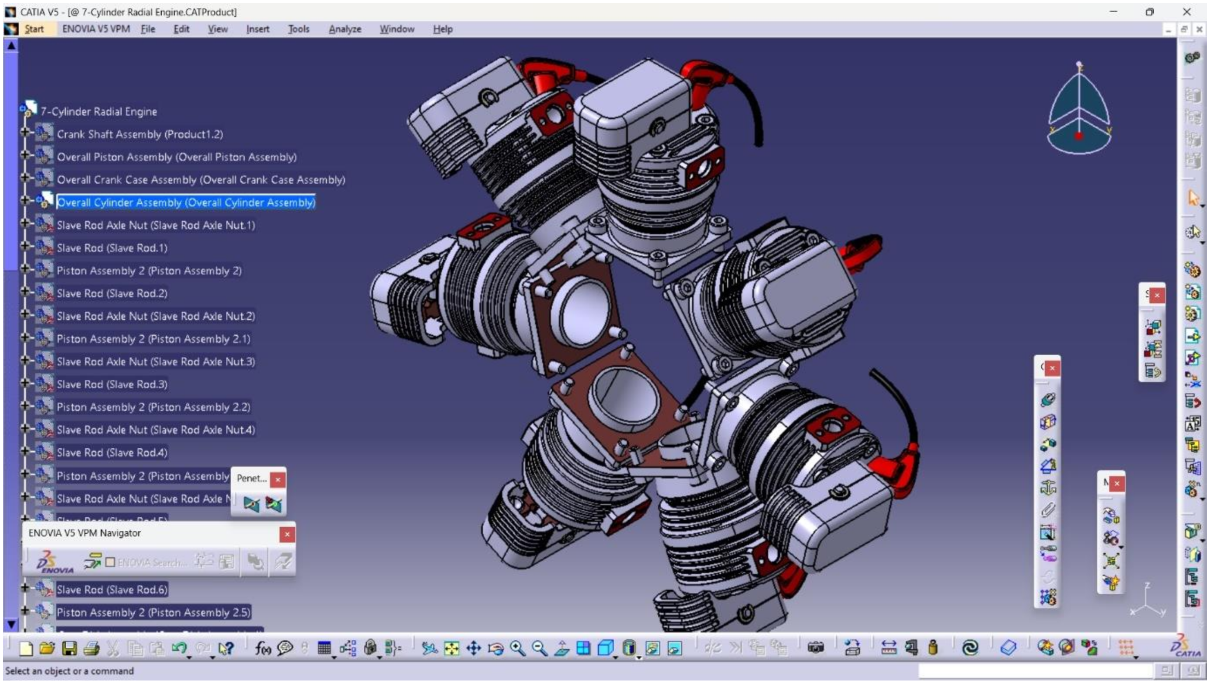


Fig- 62: Overall Cylinder Assembly

5.2.6. Overall Crank Case Assembly:

Overall Crank Case assembly consists of "Crank Case Assembly" and minor parts such as:

- Exhaust Gas Seal Buffer, Buffer Nut and Exhaust Gas Pipe are used for the function of Exhaustion.
- Suction pipe, Suction pipe ring and Suction Gas seal Buffer are used for the function of Suction.
- And minor parts like ISO based Bolts and Nuts are used for tightening the components.

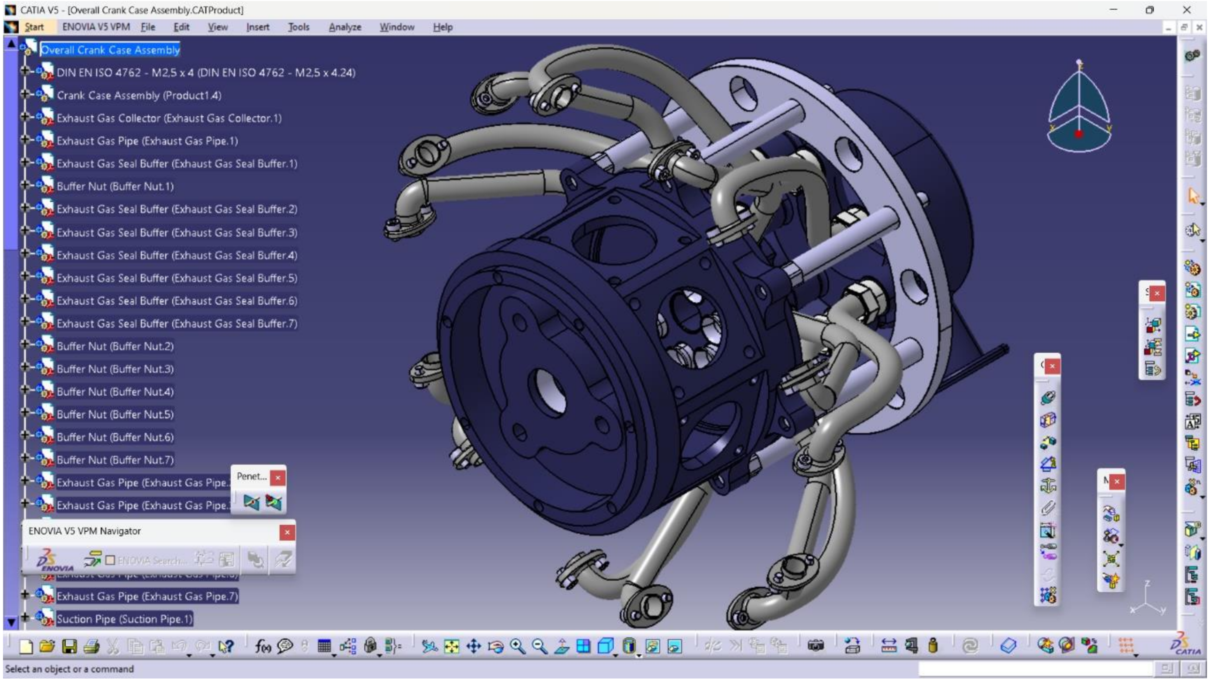


Fig- 63: Overall Crank Case Assembly

5.2.7. Cam Disk Assembly:

Cam Disk Assembly is create using the components: Cam Disk Front, Cam Disk Back, Ball Bearing (DIN 625 T3 - 4202 - 15 x 35 x 14), Internal Gear and 3 sets of DIN EN ISO 7046-1 - M1,6 x 3 - 4.8 – Z.

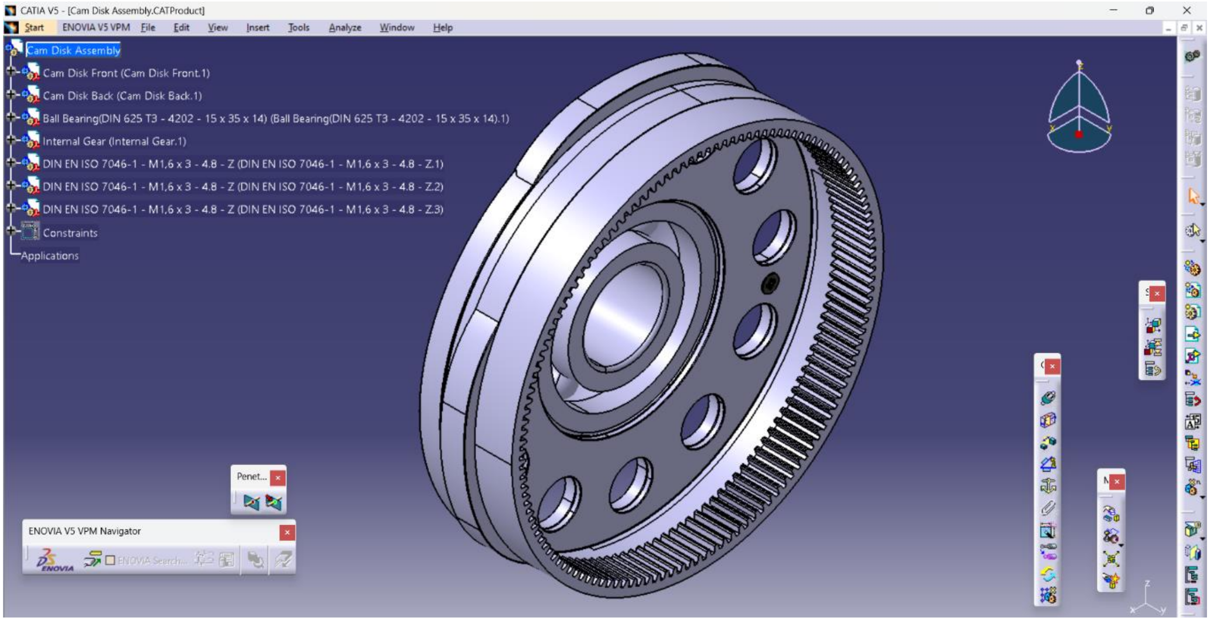


Fig- 64: Cam Disk Assembly

5.2.8. Cam Housing Assembly:

Cam Housing Assembly is create using the components: Cam Housing, Cam Housing Pin, Cam Housing Pin 2, Ball Bearing (DIN 625 T1 - 6001 - 12 x 28 x 8) and Stoessel bearing bush with required commands.

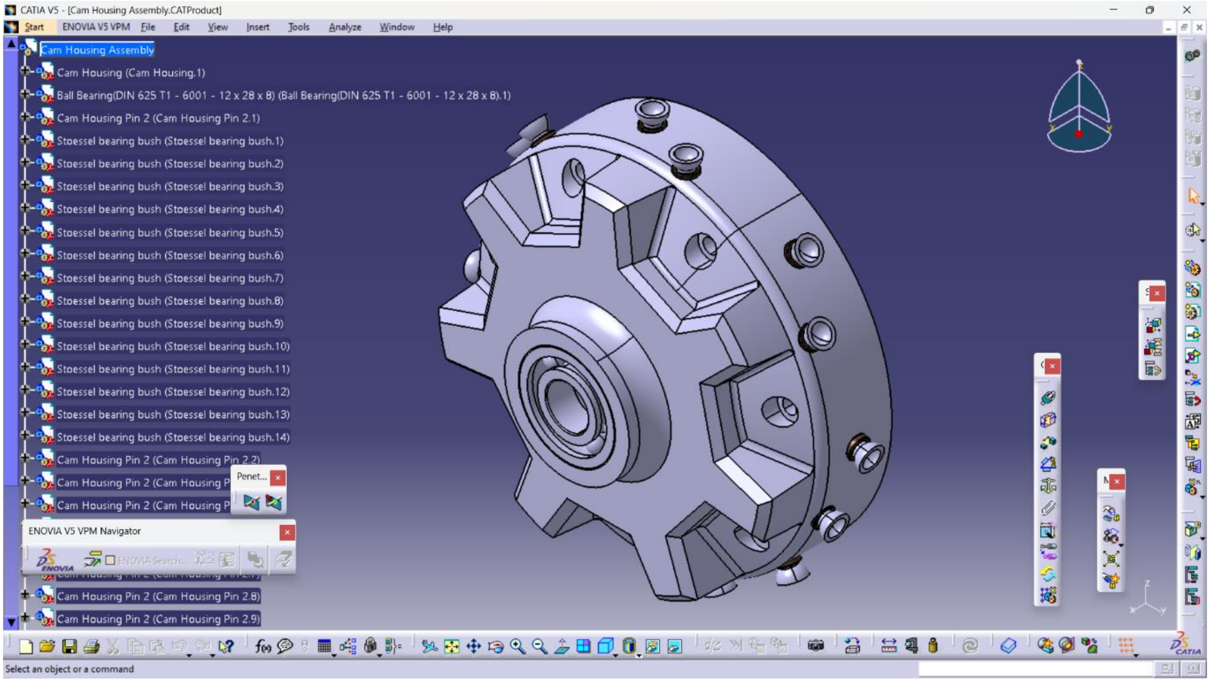


Fig- 65: Cam Housing Assembly

5.2.9. Final Assembly of 7-Cylinder Radial Engine:

The assembly design of 7-Cylinder Radial Engine is created using all the above-mentioned assembly designs with some minor parts of assembly out of specification tree of above-mentioned assemblies.

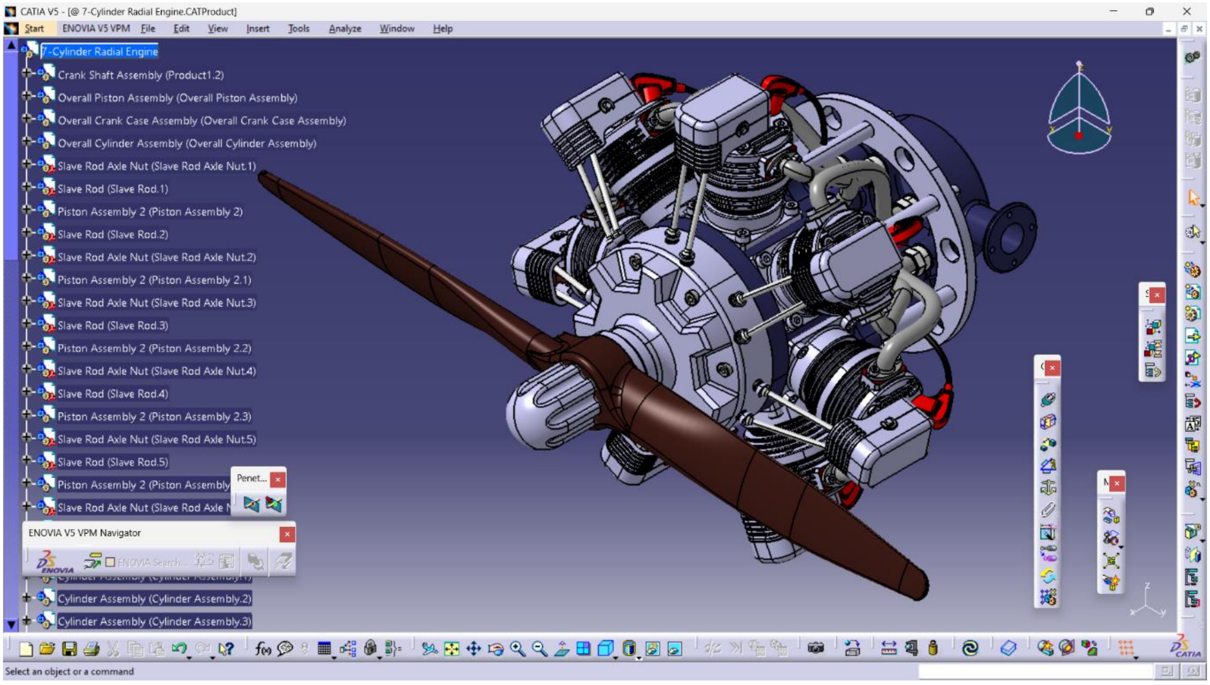


Fig- 66: Final Assembly Design of 7-Cylinder Radial Engine

CHAPTER – VI

6. DRAFTING OF A CATIA PRODUCT

6.1. DRAFTING PROCEDURE:

- Start the CATIA V5R20 installed on the desktop.
- Go to the “Start” menu and click on “Drafting” under the tab of “Mechanical Design”.
- A pop-up window will appear to select the specifications of the sheet. After selecting required specifications click on “Ok”.

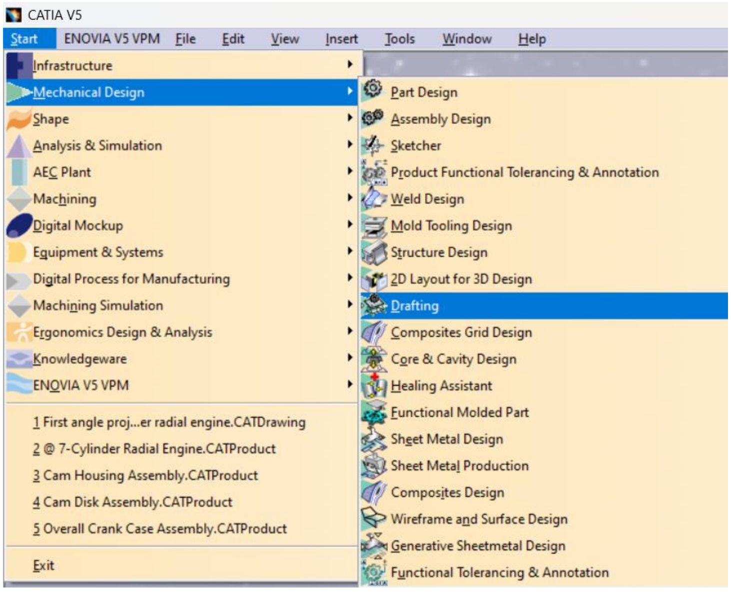


Fig- 81: Drafting module from Start menu

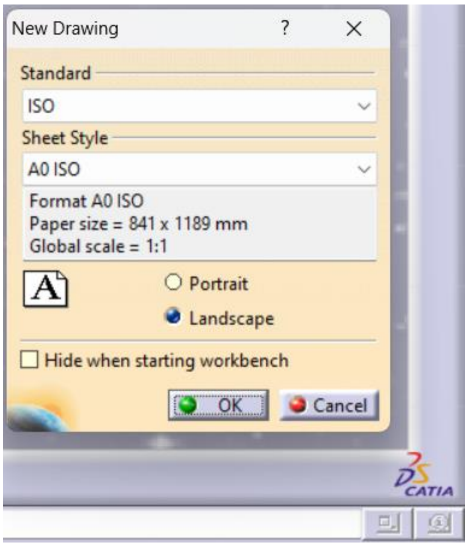


Fig- 82: Pop-up window to select the specifications of the sheet

- The screen will be redirected to the “Drafting” module with a sheet named “Sheet1”.

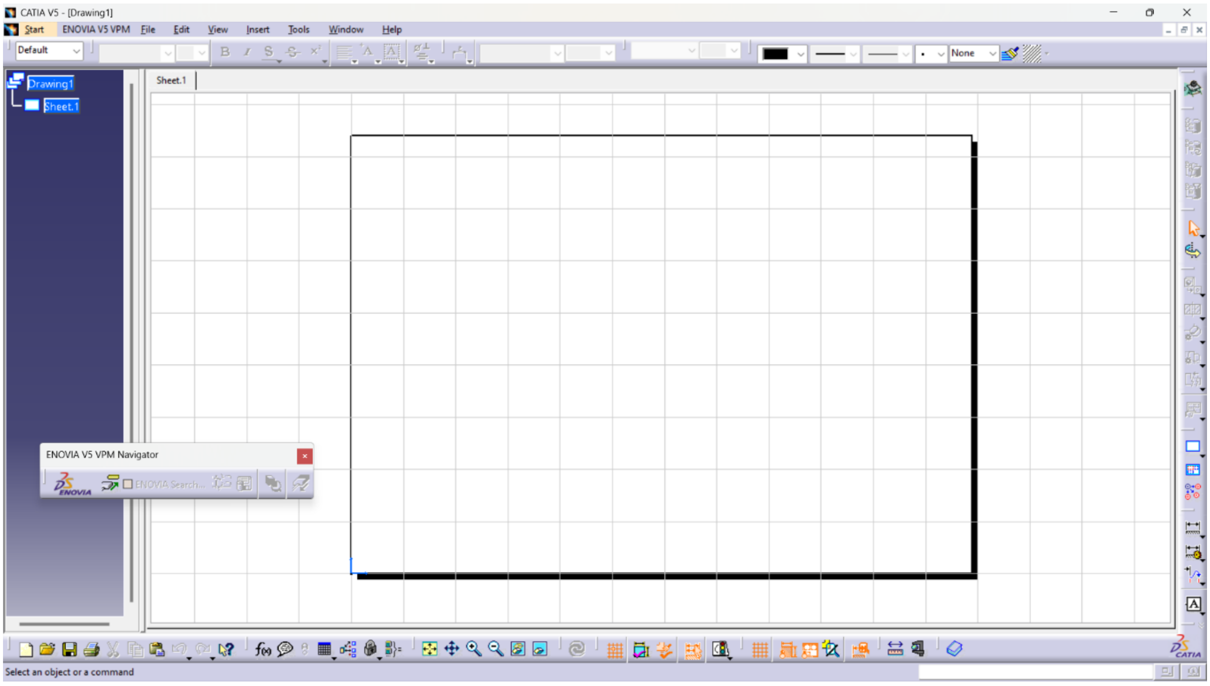


Fig- 67: Drafting module with "Sheet1"

- Under the “Projections” tools bar from right side of Docking area, click on required commands like “Front view”, “Isometric view”, etc. to make the view of a component to be projected on the “Sheet1”.
- Under the “Sections” tools bar just below the “Projection” tools bar, click on required commands like “Offset section view”, “Aligned section view”, etc. to make the view of a component to be projected on “Sheet1”.
- Sheet can be flipped back, on clicking “Sheet Background” under “Edit” toll bar from top side of Docking area.
- Create a frame and title block of the “Sheet1” using “Frame and Title Block” under left side of Docking area.

Likewise, a lot of operations and views of a component can be projected on the sheet using the required commands.

6.2. DRAFTING OF 7-CYLINDER RADIAL ENGINE:

As all the Part designs of 7-Cylinder radial engine are assembled, lets step into the Drafting of 7-Cylinder radial engine.

6.2.1. Projection Views:

Open the assembly design of 7-Cylinder radial engine. Navigate to the Drafting module from start menu, and select projection views (Front, Top and Left) to be projected on the sheet and select the modify the specifications of sheet as given:

- Standard ISO
- Format A0 ISO
- Paper size = 841 x 1189 mm
- Global scale = 1:1

The Top, Front and Left side views are projected on the “Sheet1”. Go to “Sheet Background” and insert “Frame and Title Block” and name it as “Projection Views”.

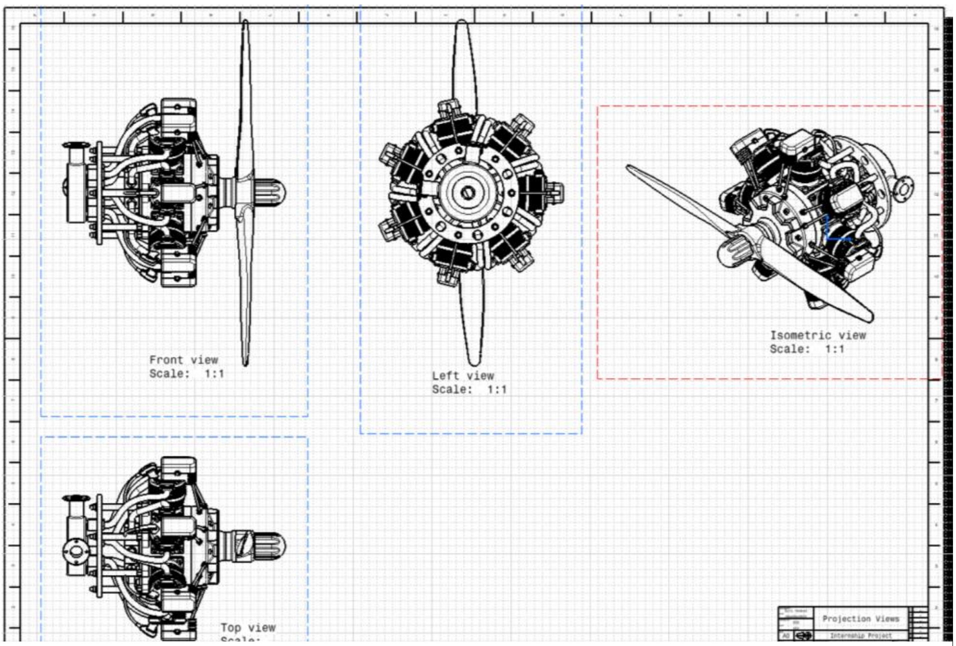


Fig- 68 : Drafting based on Projection Views

6.2.2. Sectional Views:

Open the assembly design of 7-Cylinder radial engine. Navigate to the Drafting module from start menu, and select blank sheet where sectional views need to be projected on the sheet and select the modify the specifications of sheet as given:

- Standard ISO
- Format A0 ISO
- Paper size = 841 x 1189 mm
- Global scale = 1:1

Project the front view of assembly design of 7-Cylinder radial engine using “Front View” command under “Projections” tool bar located on right side docking area. The drafting of front view of 7-Cylinder radial engine is created. Create the sectional views from the drafted front view of 7-cylinder radial engine, using “Offset Section view” under “Sections” toolbar. Go to “Sheet Background” and insert “Frame and Title Block” and name it as “Sectional Views”.

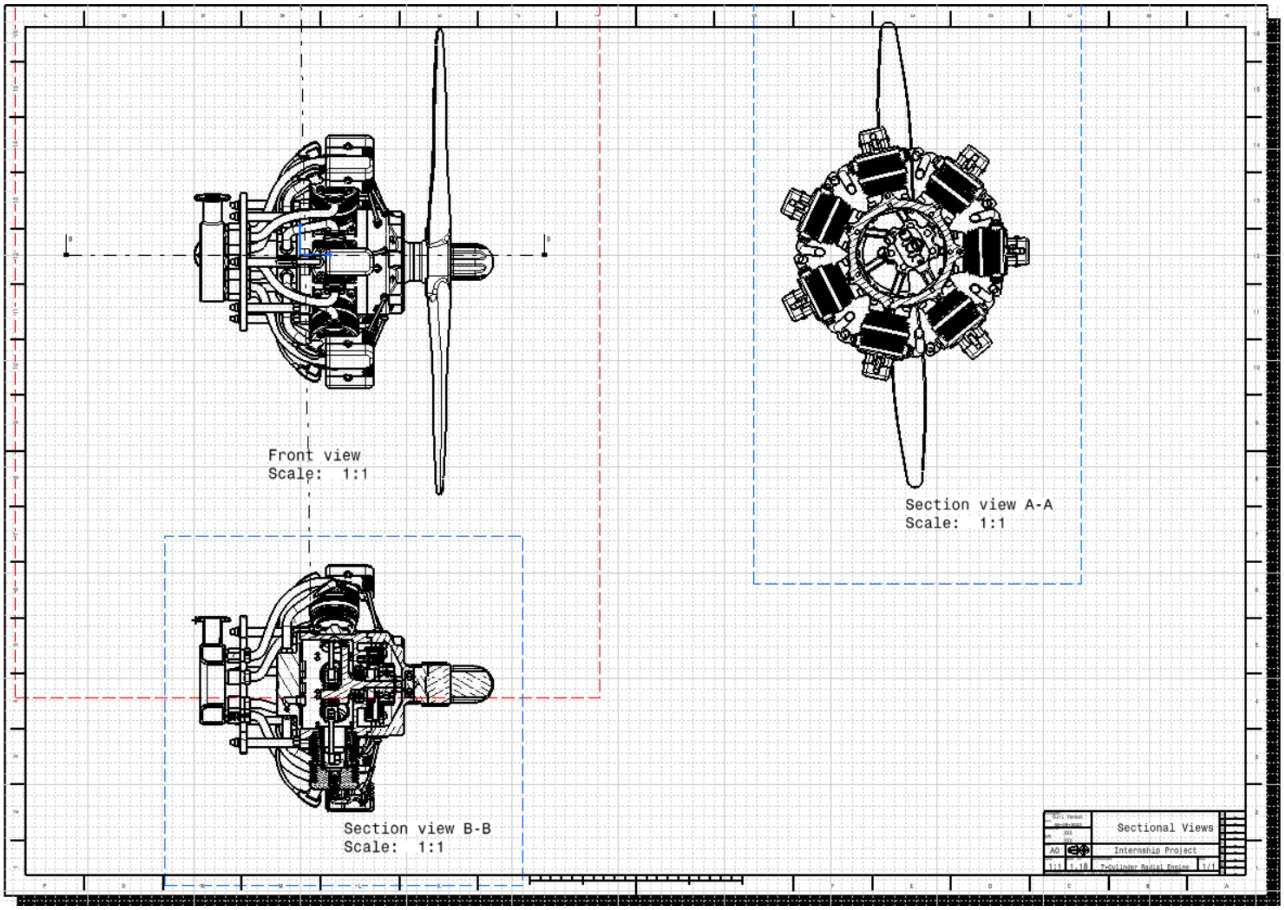


Fig- 69: Drafting based on Sectional Views

6.2.3. Bill of Materials:

Open the assembly design of 7-Cylinder radial engine. Navigate to the Drafting module from start menu, and select blank sheet where bill of materials needs to be plotted on the sheet and select the modify the specifications of sheet as given:

- Standard ISO
- Format A0 ISO
- Paper size = 841 x 1189 mm
- Global scale = 1:1

Project the isometric view of assembly design of 7-Cylinder radial engine, using “Isometric View” command under “Projections” tool bar located on right side docking area. The drafting of isometric view of 7-Cylinder radial engine is created. Plotting of the Bill of materials from the drafted isometric view of 7-cylinder radial engine is done by following these steps:

“Generation” under “Insert” toolbar > “Bill of Materials” at bottom of list > “Bill of Materials” > Select the drafted isometric view of 7-cylinder radial engine and click on left button of mouse.

Go to “Sheet Background” and insert “Frame and Title Block” and name it as “Sectional Views”.

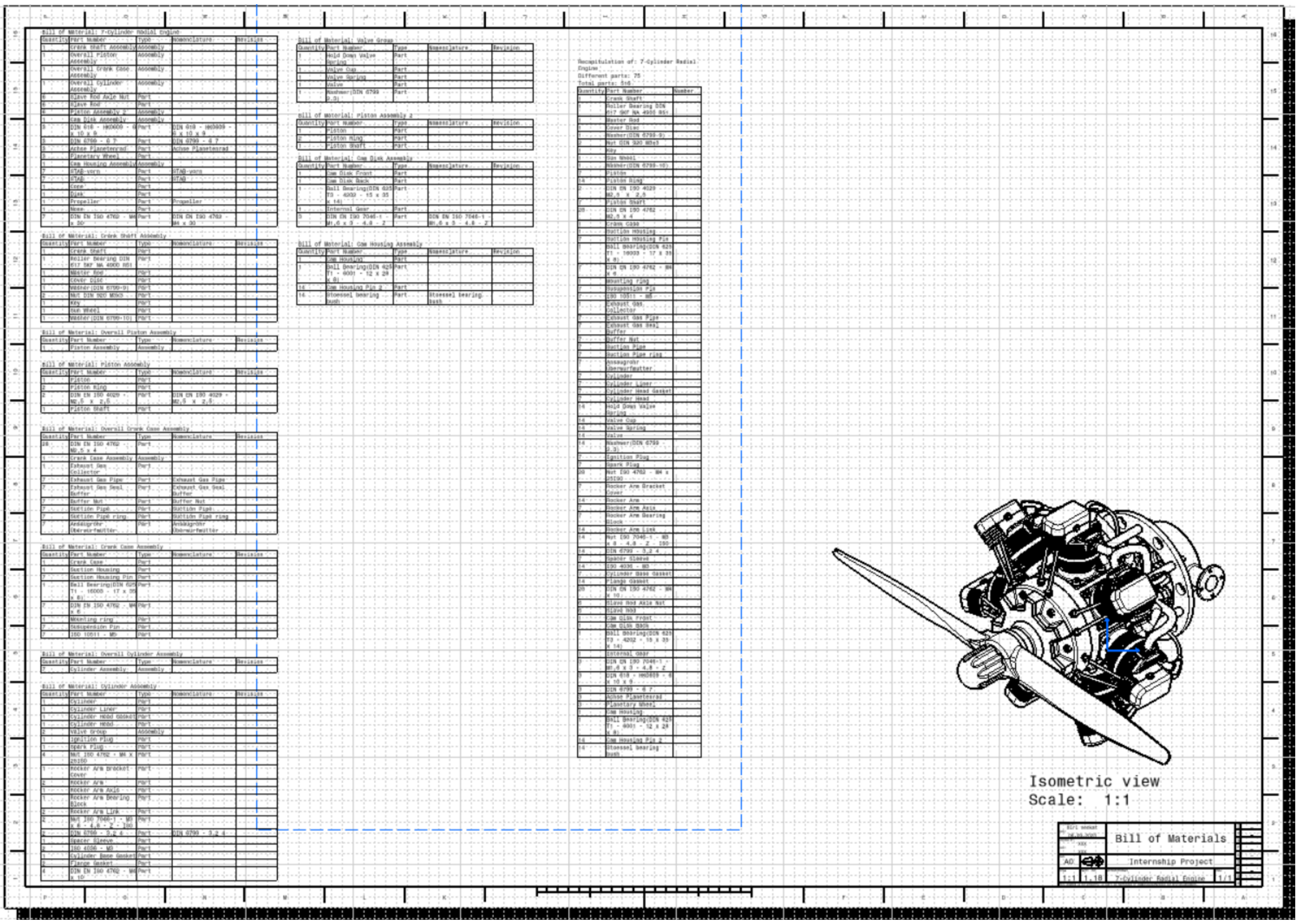


Fig- 70: Drafting based on Bill of Materials

7. CONCLUSION

In the pursuit of engineering excellence and innovation, the project "Design of a 7-Cylinder Radial Engine in CATIA" has been a challenging yet rewarding endeavour. Over the course of this project, we have explored the intricacies of aerospace and mechanical engineering, utilizing cutting-edge design software to create a functional and efficient radial engine. This conclusion serves as a reflection on the journey we have undertaken, the achievements made, and the potential avenues for future development.

1. Achievement of Project Goals:

Our primary goal was to design a 7-cylinder radial engine using CATIA, and we have successfully achieved this objective. We meticulously analysed the design requirements, considered various design parameters, and integrated them into a comprehensive CAD model. The final design showcases the intricate interplay between form and function, incorporating features that optimize performance, durability, and manufacturability.

2. Innovative Design Features:

Throughout the project, we incorporated several innovative design features, including:

- Optimized Cylinder Arrangement: The 7-cylinder radial configuration offers a balance between power output and compactness, making it suitable for various aircraft applications.
- Streamlined Cooling System: We integrated an efficient cooling system to maintain the engine's operational temperature within acceptable limits, enhancing its reliability and longevity.
- Advanced Materials: We considered the use of modern materials to ensure strength-to-weight ratios and overall engine efficiency.
- Enhanced Airflow: The design incorporates features to improve airflow through the engine, contributing to combustion efficiency and performance.

3. Challenges and Learning:

This project was not without its challenges. We encountered complexities in designing components to withstand high temperatures, pressures, and vibrations. Overcoming these challenges required extensive research, iteration, and collaboration. This experience has provided us with valuable insights into the world of engineering design and the importance of teamwork.

In conclusion, the "Design of a 7-Cylinder Radial Engine in CATIA" project has been a remarkable journey that has expanded our knowledge, skills, and appreciation for engineering excellence. This project represents a significant step towards advancing aerospace technology and serves as a testament to the dedication and ingenuity of our team. As we move forward, we look forward to applying the lessons learned and continuing our exploration of innovative engineering solutions.

7. REFERENCES

A comprehensive list of scholarly articles, engineering textbooks, software documentation, and research papers that guided and informed the design and development of the 7-Cylinder Radial Engine in CATIA project

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