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Thermal analysis of I.C. valve with Variation in base Surface Using ANSYS

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Abstract- Poppet valves are the inlet and outflow valves of internal combustion engines. The valve mechanism controls these valves. When valves are exposed to high temperatures, thermal evaluation is critical for predicting and stopping valve failures. The valve train's primary function is to guarantee that the gases change direction at all engine speeds. The I.C. valve devices' structure. These components are found in the engine and are responsible for recognising the position of the piston and crankshaft and actuating the entry and exhaust valves at the appropriate times. Thermal analysis of 99.3cc poppet valves is modelled and simulated in this work. Modeling of the valves was done in ANSYS using solid function and thermal analysis. Thermal analysis was used to determine the directed heat, total heat stream, and temperature. For each valve, we employed structural steel material and proposed the appropriate content on a thermal basis. Thermal analyses of the valve in stationary state must be performed using 3 mm fillet poppet thicknesses at apertures of 8 mm, 10 mm, and 12 mm, as well as 3 x 45 degrees chamfer at apertures of 8 mm, 10 mm, and 12 mm at an angle of 45 0. Concave, convex, and flat valve bases are the three types of base designs available.

Keywords- Poppet valve, FEM, ANSYS, Valve mechanism, Thermal Analysis, I.C. Engine.

I. INTRODUCTION

To regulate the flow and exchange of gases in internal combustion engines, intake and exhaust valves are critical driving components. An equipment known as a valve train instrument is used to keep the workroom safe from collectors. There are two ways to use it. Precision is required for the engine's internal burning valves.

They're able to open and close as needed. Through the activation of induction valves, new charge is discharged into the air. Various types of valves are used by the producers; popping valves, sliding valves, and rotor valves are just a few examples. The temperature and stress study of IC valves must be given significant consideration since every sort of valve failure impacts motor efficiency. Their problems may be solved by implementing an internal The working region of the cylinder. The engine's internal fuel valves are exactly what they seem to be. They may be opened and closed as needed. The fresh fuel mixture enters via the input valves, while the flammable fuel bits are expelled by the exhaust valves. Engine valves come in a variety of shapes and sizes, depending on the manufacturer. Poppet valves, slide valves, rotating valves, and sleeve valves are a few examples.

1.Poppet Valve

Be a result of its extensive flow paths over the valve's basic structure, a poppet valve might be referred to as "very streamline." The poppet valve is usually simple to open. The valves are made of pure nickel and chromium nickel. Although exit valves are constructed of nickel chromium, chromium silicone, superfluous speed wire, steel, high nickel chromium, metallic tungsten, and cobalt stainless steel, they are nevertheless susceptible to corrosion. These parts help the valve fulfil its unique function in the internal combustion engine. The spring valve conveys the valve to the other end while keeping it pushed against its seat and providing leakage proofing. When the engine comes close to shutting down, the valve stem slowly stretches. Outlet valve clearance is just slightly more than intake valve clearance. Not for any other reason than high temperatures generated by combustion at a certain point have hardly diminished exhaust valve pressure.

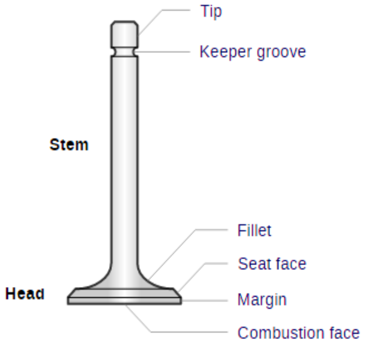

Figure 1: Nomenclature of Poppet valve

III.VALVE MECHANISM IN INTERNAL COMBUSTION ENGINE

In this case, the cam is employed to govern the rotation of the valve around the tap. As a consequence of the valve replacement, the gases in the valve stem's manual were burnt up and down in the manual. In order to construct this programme, which normally works at half motor speed, it is necessary to employ a cam and cam rotation. In addition to keeping the pump securely in place on its seat, the spring also helps to guarantee that the valve is leak-proof, and it easily returns the pump to its former position. After the engine has been shut down, the valve stem will slowly warm up and extend as it is exposed to air. A valve tappet clearance is maintained at all times in order to prevent the valve stem and other components from being strained.

When estimating the clearance value for an engine, the operating temperature of the engine is also taken into account. By adjusting the settings screw, you may change the poppet valve allowance to suit your needs. When a valve is not given to discriminate between sizes, an alternative is to use a long valve or to polish the bottom of a valve to get the desired result. Because of the additional noise and loss of power from the engine, even a little malfunctioning valve will make it impossible to have a good night's sleep. Remember to keep the valve in mind whenever you are making a choice. In terms of height, the exhaust valve is a little higher than the input valve, but not by much. Because of the higher temperatures of the exhaust gas created during combustion, the exhaust valve expands at a little faster pace than it would otherwise.

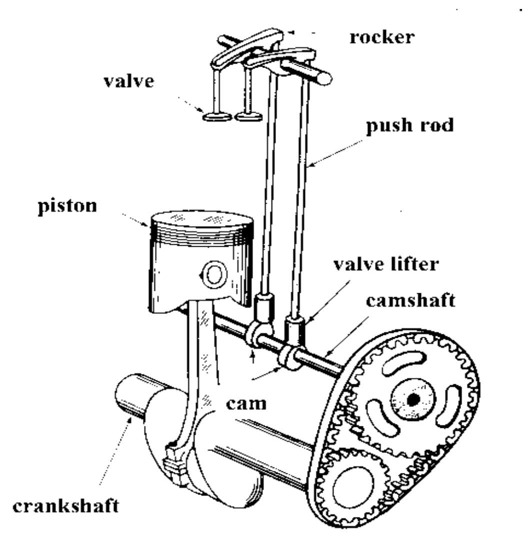

Figure 2: Valve Mechanism

In the design, it was clearly stated that the project would need a lot of hard labour. In a finite element analysis, the goal is to recreate the mathematical behaviour of the real engineering structure. Fillet and chamfer poppet valves are both examples of poppet valves. A chamfer or a fillet is a smaller or larger in diameter. A physical structure may be described by a model, which includes all the necessary nodes, units, materials, constants, boundary conditions, and other characteristics. It's necessary to build the model from the ground up and then apply boundary conditions to each node before doing the final analysis.

IV.DESIGN OF POPPET VALVE MODEL

The design has been established via extensive investigation by Strong. The format of the IGS FILE has been changed. It is possible to make the standard compatible with ANSYS programmes for that configuration. ANSYS imports the template and the research begins. The valve Poppet is set up in accordance with the design and data reference documents for the system in question.

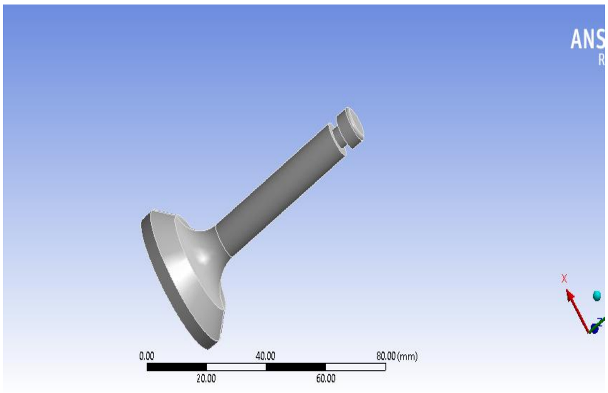

Figure 3 Model of Poppet Valve

V.MESHING THE MODEL

It's possible to break down the Poppet Valve model into a grid of basic, finite components for analysis. A simple polynomial profile function and nodal motions are intended to assess the difference in displacement between components. Stresses and stress equations are generated by nodal deflections that have not been detected. The equilibrium equations are then combined in a programmable matrix that is easy to use.

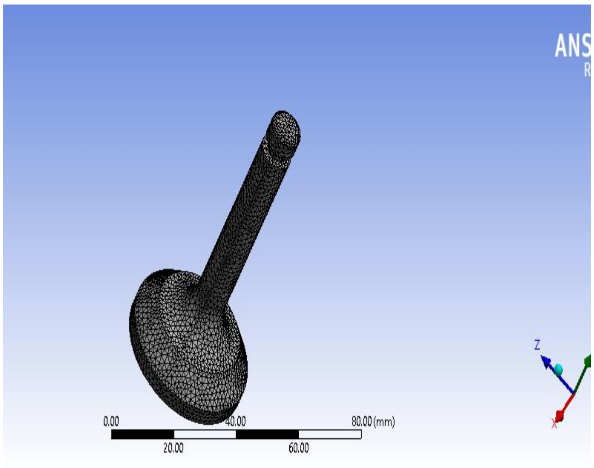

Figure 4: Meshing the Poppet valve using ANSYS

1. Boundary Conditions For Analysis Of Poppet Valve Using ANSYS

In order to do a thermal analysis on our Poppet valve, we must first apply a proper boundary condition. Poppet valve bottom flat face is heated to 1250 degrees Celsius. According to Figure 5, convection was extended from inside and outside of the Poppet valve in order to achieve maximum failure. Figure 5 depicts the proper Poppet valve limitations.

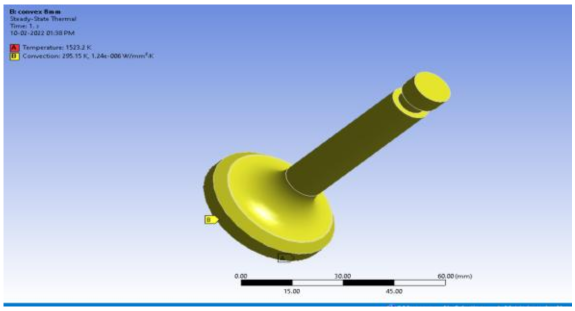

Figure 5: Static thermal boundary conditions of Poppet valve

The average temperature applied is 1250 ^{0}C and it works uniformly on the valve surface floor. Under a static heat state, the three degrees of freedom of the cockpit Valve are restricted. Temperature restraints and convection temperature of 100 ^{0}C are known as the above two boundary conditions. As seen in Figure 5, the boundary conditions are. Boundary conditions for both chamfer and fillet geometry poppet valves.

VI.RESULTS AND DISCUSSION

1. Material Properties

In this research, structural steel was considered as a material. The material's qualities are explained in the description. The FEA model and three distinct forms of stress fields, together referred to as a thermal stress field, are subjected to a variety of boundary conditions and loads that a mechanical stress field may attain. There are two varieties of poppet valves on display: a poppet valve with a fillet and a poppet valve without a fillet. The dimensions of the fillet or chamfer are different.

Table1: Material Properties for Structural steel.

Structural Steel	Structural Steel
Density	7850kg/m^3
Poisson ratio	0.29
young's modulus	200000 MPa
tensile ultimate strength	460 MPa
tensile yield strength	250 MPa
thermal conductivity	60.5w/m/c
coefficient of thermal expansion	12 (µm/mK)

Table 2: Design of Poppet valve with base surface variations.

Poppet valve base design	Base thickness
Convex	8 mm
Concave	10 mm
Flat	12 m

2.Analysis of Poppet valve with variations of base type and base thickness of poppet valve using Chamfer3x45°

The purpose of this Chamfer is to streamline the gas so that it may easily be ejected from the exhaust collection. Many poppet valves are built at a 45-degree angle so that exhaust gases may be rushed around a circle at fast speed under high pressure. This generates a vacuum that fills the cylinder to the brim. Concave, convex, and flat base designs for poppet valves were chosen, as well as base thickness of poppet valves with 3 mm fillet radius at 8 mm, 10 mm, and 12 mm.

3.Thermal analysis of Poppet valve with Concave base type with chamfer of 3 x 45°

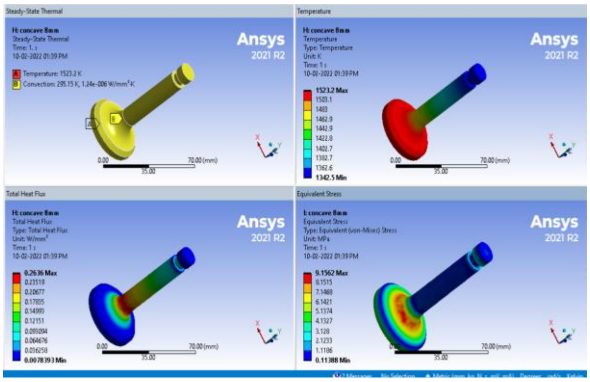

Figure 6: Base type concave with 8 mm thickness.

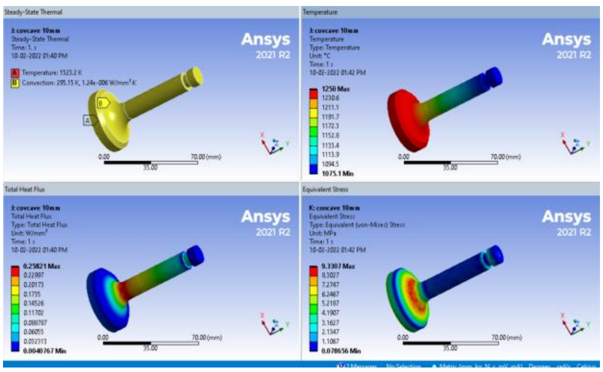

Figure 7: Base type concave with 10 mm thickness

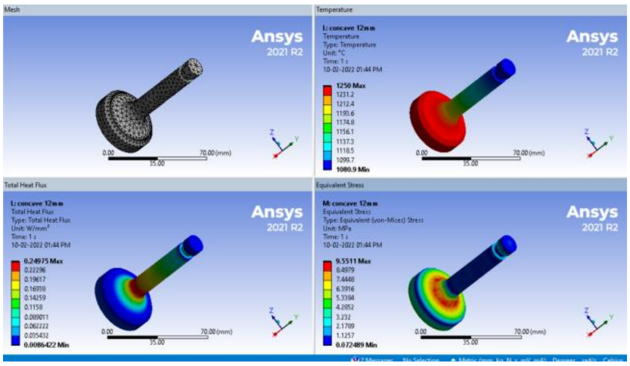

Figure 8: Base type concave with 12 mm thickness.

4. Thermal analysis of Poppet valve with Convex base type with chamfer of 3 x 45°

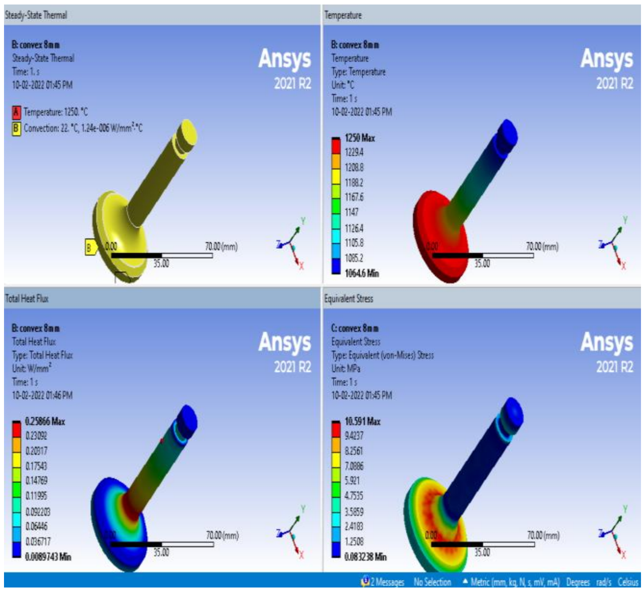

Figure 9: Base type Convex with 8 mm thickness.

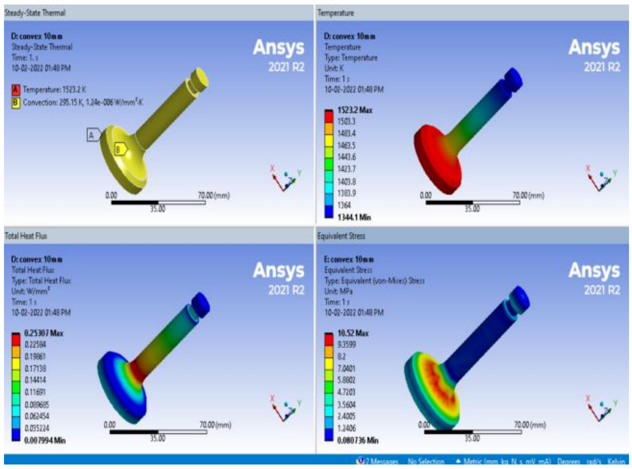

Figure 10: Base type Convex with 10 mm thickness

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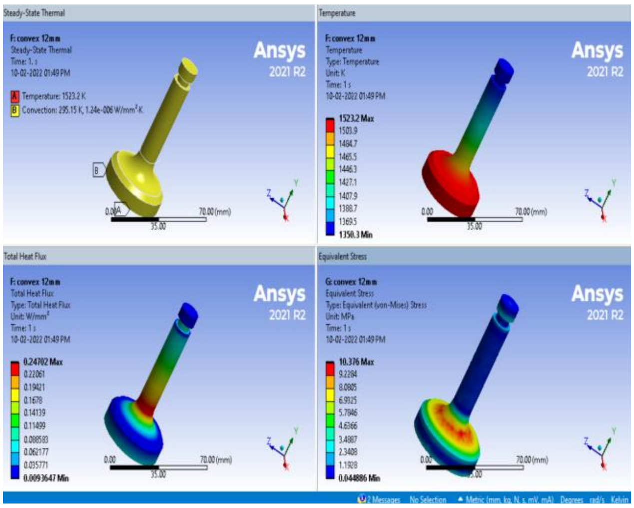

Figure 11: Base type Convex with 12 mm thickness

5. Thermal analysis of Poppet valve with Flat base typewith chamfer of 3 x 45°

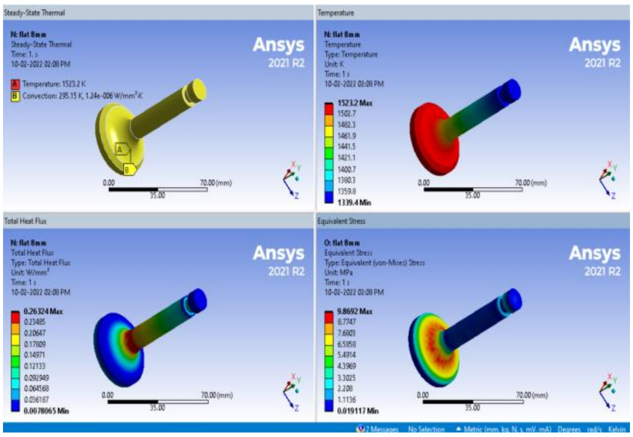

Figure 12: Base type Flat with 8 mm thickness

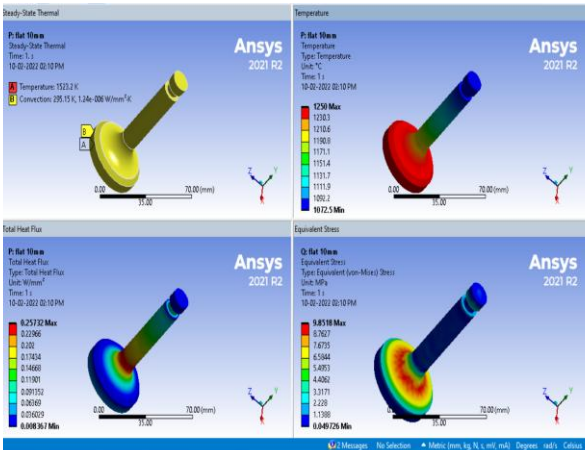

Figure 13: Base type Flat with 10 mm thickness

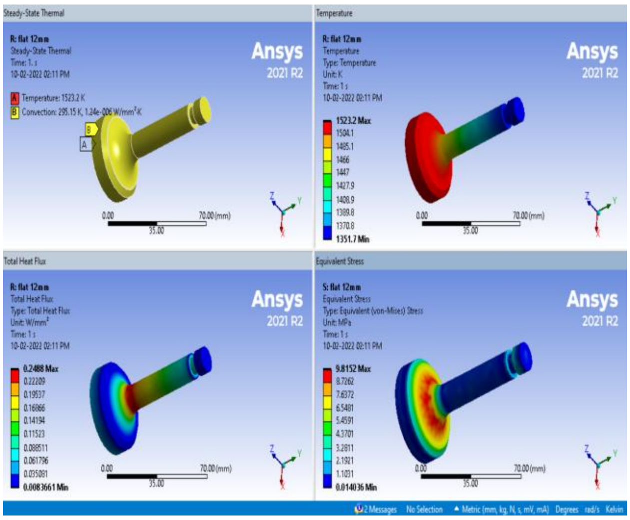

Figure 14: Base type Flat with 12 mm thickness

6. Analysis of Poppet valve with variations of base type and base thickness of poppet valve using fillet radius 3mm

The purpose of this Chamfer is to streamline the gas so that it may easily be ejected from the exhaust collection. Many poppet valves are built at a 45-degree angle so that exhaust gases may be rushed around a circle at fast speed under high pressure. It creates a vortex, which fills the container to the brim. Valve bases that are concave, convex, or flat, as well as the base span of a poppet valve The three varieties of base designs used for the poppet valve are 3 mm fillet radius of 8 mm, 10 mm, and 12 mm.

7. Thermal analysis of Poppet valve with Concave base type

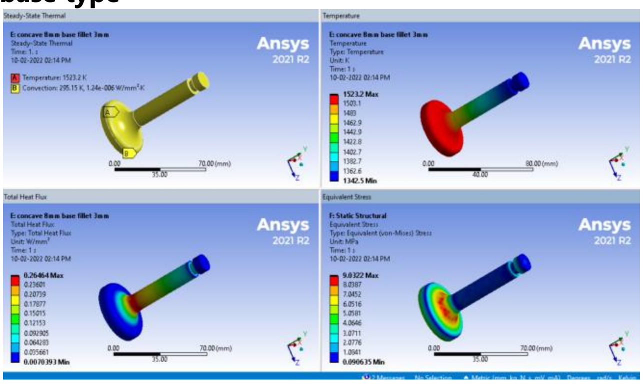

Figure 15: Base type Concave with 8 mm thickness.

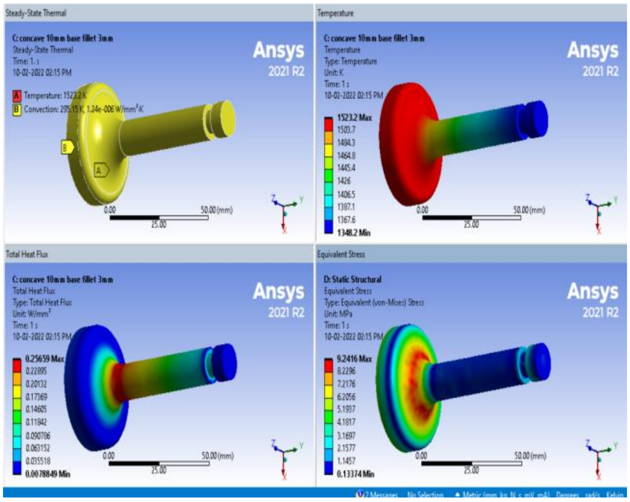

Figure 16: Base type Concave with 10 mm thickness.

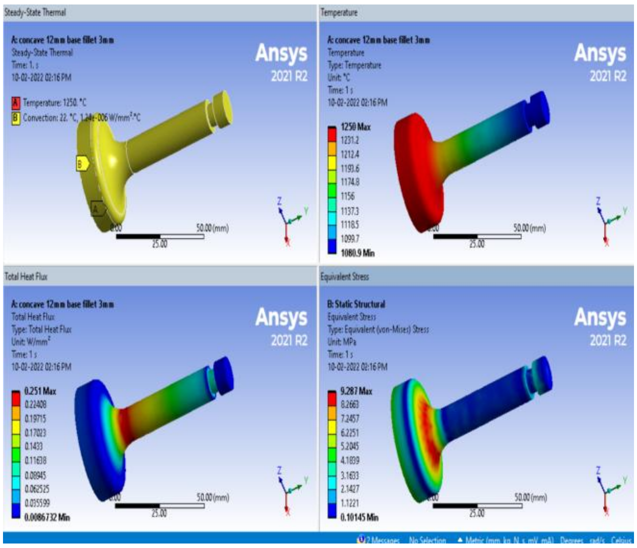

Figure 17: Base type Concave with 12 mm thickness

1.Thermal analysis of Poppet valve with Convex base type

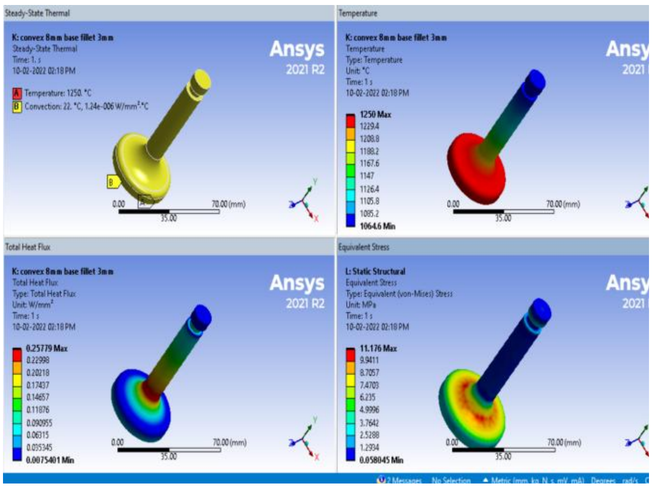

Figure 18: Base type Convex with 8 mm thickness

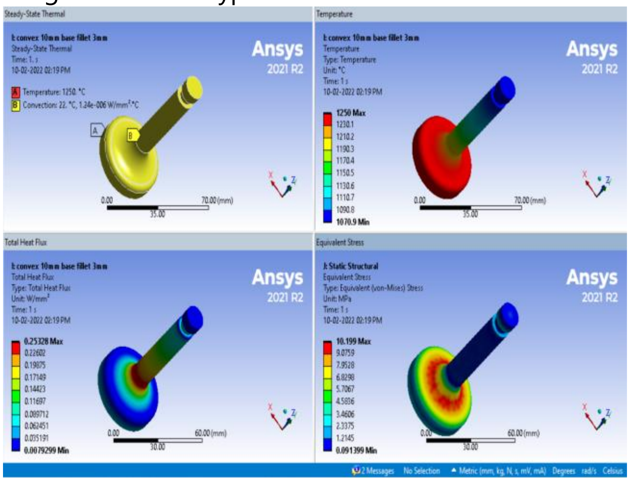

Figure 19: Base type Convex with 10 mm thickness.

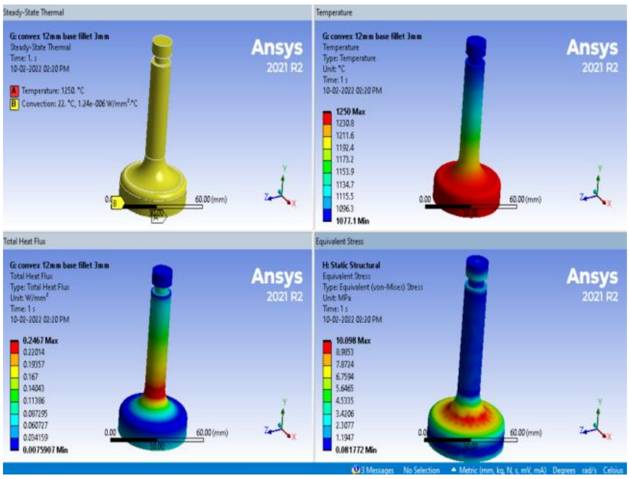

Figure 20: Base type Convex with 12 mm thickness.

1.Thermal analysis of Poppet valve with Flat base type

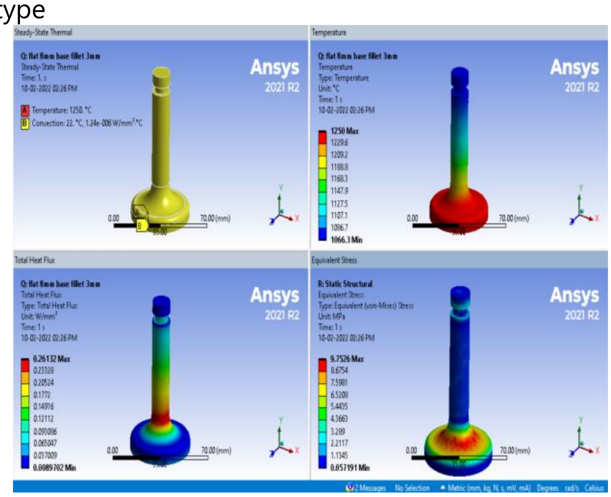

Figure 21: Base type Flat with 8 mm thickness.

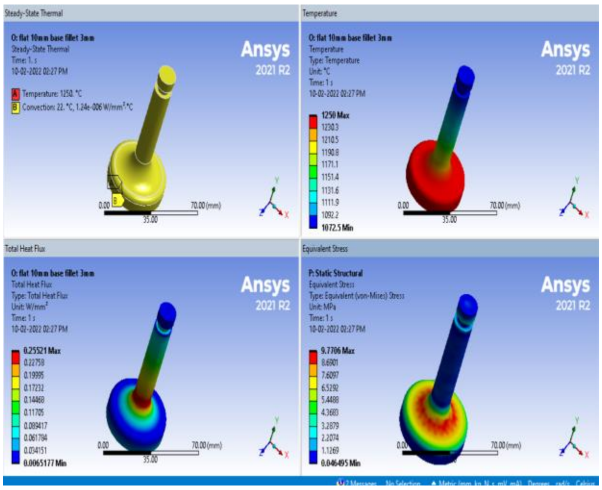

Figure 22: Base type Flat with 10 mm thickness.

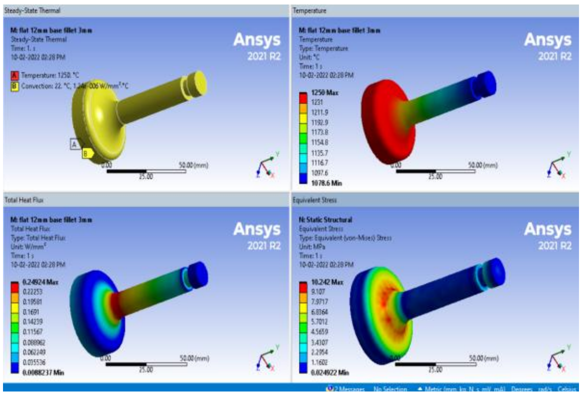

Figure 23: Base type Flat with 12 mm thickness.

The inlet outlet valve plays an significant role in the engine power; both filet and chamfer are tested to determine the overall stress pressure on the lower surface of the valveDue to the thermal conductivity of the materials, the highest value for the maximum temperatures found in the Poppet valve is due to the total maximum flow of heat in both Poppet valve materials. Therefore, the advance materials and various design, analytical tools can be carried on further research.

1 .Results due to Chamfer on Poppet valve with variations in base surface

Table 3: results of Poppet valve with 8mm base thickness

Results	Convex	Concave	Flat
Thermal Stress with chamfer (M Pa)	10.59	9.15	9.86
Total Heat Flux with chamfer (W/mm^2)	0.258	0.263	0.263
Temperature Drop with chamfer°C	164.8	160.6	163.7
Weight (kg)	0.212	0.152	0.182

Table 4: results of Poppet valve with 10mm base thickness

Results	Convex	Concave	Flat
Thermal Stress with chamfer (MPa)	10.52	9.33	9.85
Total Heat Flux with chamfer (W/mm^2)	0.253	0.258	0.257
Temperature Drop with chamfer°C	139	155.5	138.1
Weight (kg)	0.234	0.174	0.204

Table 5: results of Poppet valve with 12 mm base thickness

Results	Convex	Concave	Flat
Thermal Stress with chamfer (M Pa)	10.37	9.55	9.81
Total Heat Flux with chamfer (W/mm^2)	0.247	0.249	0.248
Temperature Drop with chamfer°C	134.4	150.3	152.2
Weight (kg)	0.256	0.195	0.226

1.Results due to fillet radius on Poppet valve with variations in base surface.

Table 6: Thermal stresses and heat flux variations in 8mm base thickness with fillet.

Results	Convex	Concave	Flat
Thermal Stress with fillet (M Pa)	11.17	9.03	9.75
Total Heat Flux with fillet (W/mm^2)	0.257	0.264	0.261
Temperature Drop with fillet°C	164.8	150.6	153.3
Weight (kg)	0.215	0.154	0.185

Table 7: Thermal stresses and heat flux variations in 10mm base thickness with fillet.

Results	Convex	Concave	Flat
Thermal Stress with fillet (M Pa)	10.19	9.24	9.77
Total Heat Flux with fillet (W/mm^2)	0.253	0.256	0.255
Temperature Drop with fille t°C	159.2	155.5	157.8
Weight (kg)	0.237	0.176	0.207

Table 8 Thermal stresses and heat flux variations in 12 mm base thickness with fillet

Results	Convex	Concave	Flat
Thermal Stress with fillet (MPa)	10.09	9.28	10.24
Total Heat Flux with fillet (W/mm^2)	0.246	0.251	0.249
Temperature Drop with fillet°C	153.7	150.3	152.4
Weight (kg)	0.259	0.198	0.228

V.COMPARISON OF RESULTS

The overall distribution of thermal stress on the whole region of the valves is shown in Figure 14 and Figure 16. The thermal load distribution shows in figures 14, 16. From Fig.14, we can see that the maximum thermal stress is 22.783 MPa, from figure 16 we can see maximum thermal stresses 24.783 which does higher than fillet radius applied valve and it occurs at all surface of valve.

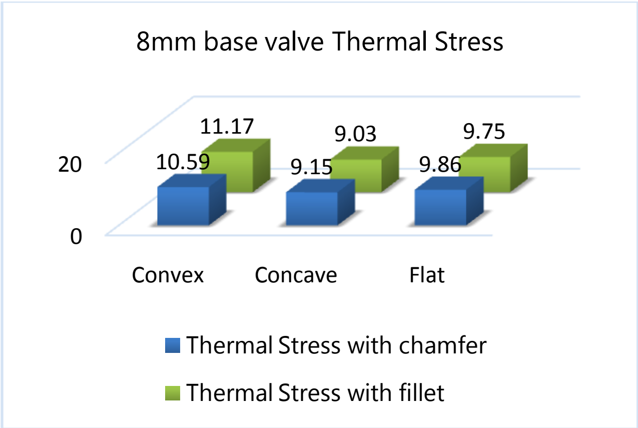

Figure 24: Thermal stresses Comparison of 8 mm thick base of valve.

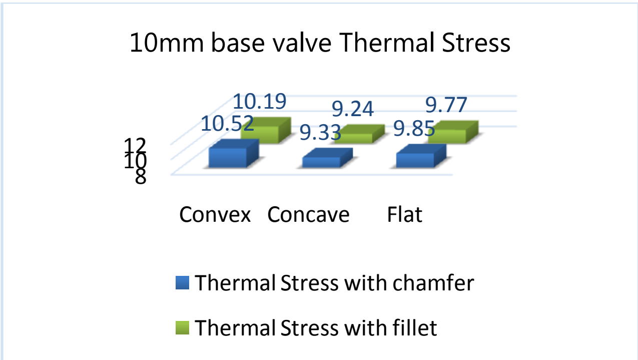

Figure 25 Thermal stresses Comparison of 10 mm thick base of valve.

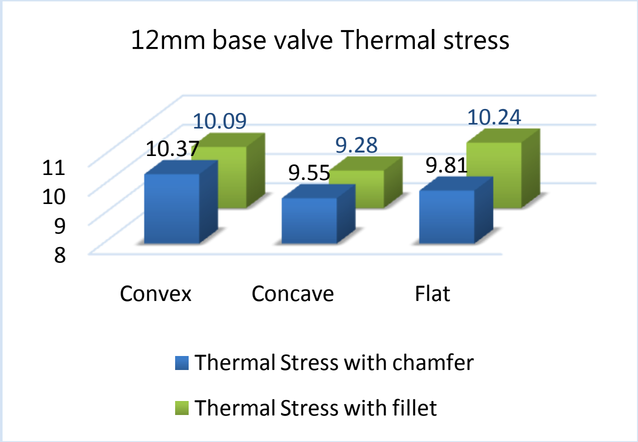

Figure 26: Thermal stresses Comparison of 12 mm thick base of valve.

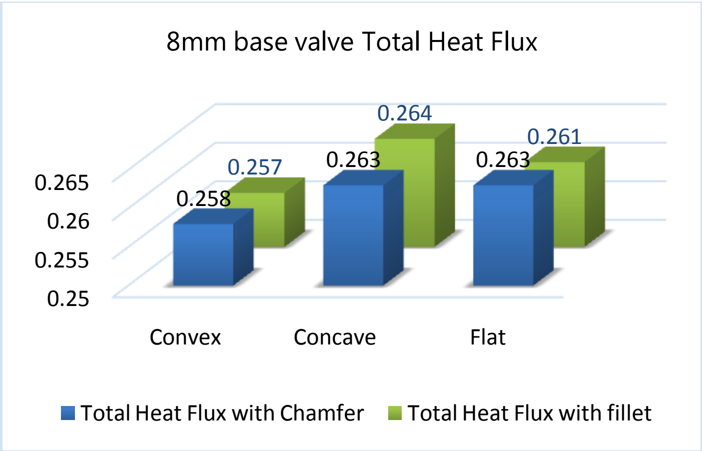

Figure 27: Comparison of heat flux at 8 mm thickness of valve.

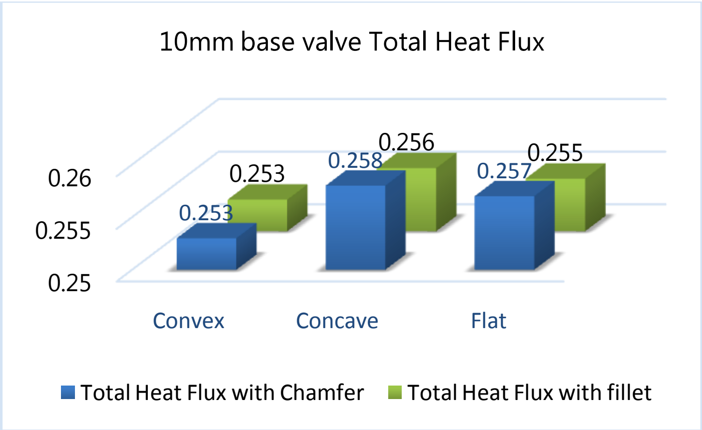

Figure 28: Comparison of heat flux at 10 mm thickness of valve

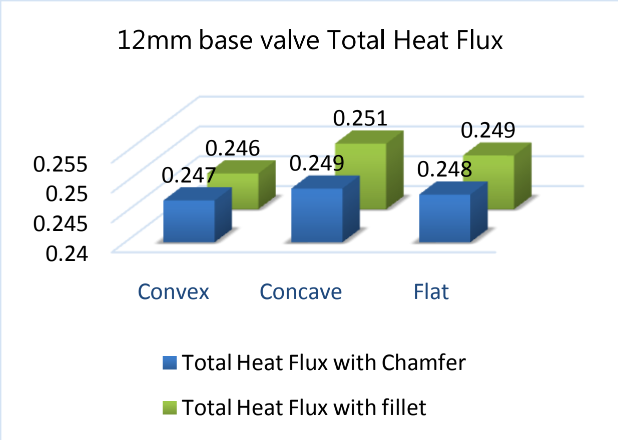

Figure 29: Comparison of heat flux at 12 mm thickness of valve

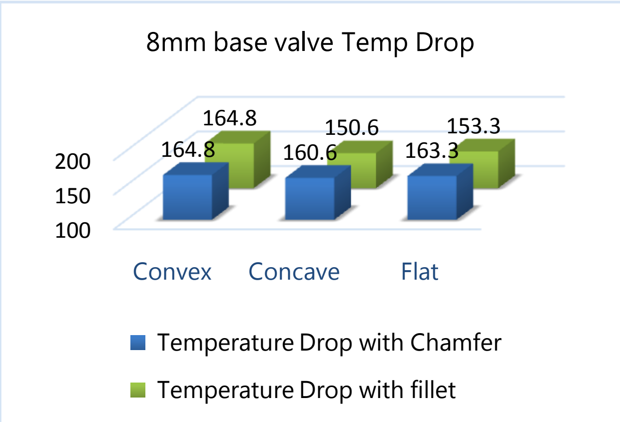

Figure:30 Comparison of temperature drop at 8 mm thickness of valve.

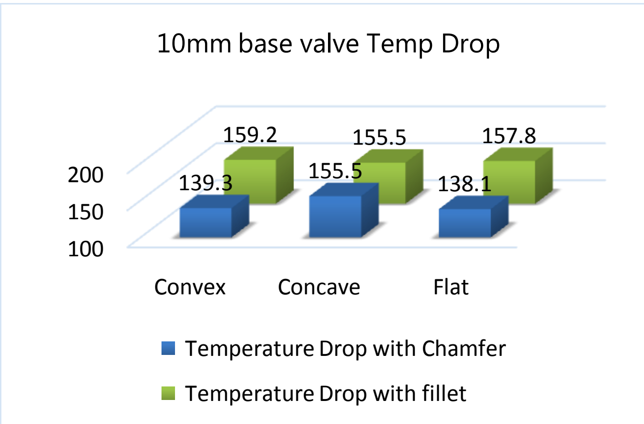

Figure 31: Comparison of temperature drop at 10 mm thickness of valve.

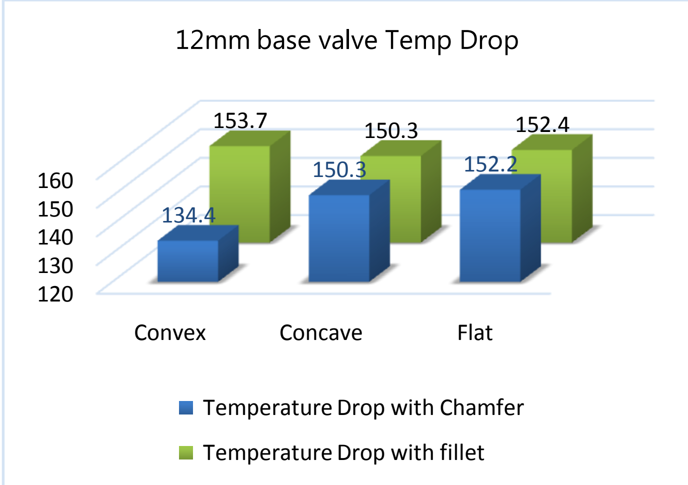

Figure 32: Comparison of temperature drop at 12 mm thickness of valve.

VI.CONCLUSION

The thermal modelling of the poppet valve and its function under thermal motor settings without the cylinder being burnt was taken into account for this research. We created the model for the designed model using SolidWorks software. For the Poppet valve, a steady state thermal study was performed utilizing a single metal and three kinds of base surface fillets and chamfers, namely convex, concave, and flat surfaces with varying base thickness. Thermal analysis was carried out. According to the findings of the research, the following conclusions were reached.

- Further study into the fundamentals, materials, and functioning of valves is required.
- The valve configuration is determined by the needs for inspecting the valves and their failure mechanisms.
- At a concave 8 mm base with fillet valve, the maximum thermal stress was measured to be 11.17 MPa.
- At a concave 10 mm base with a fillet radius, the minimum thermal stresses were determined to be 9.24 MPa.
- At the concave fillet radius of the poppet valve, the maximum heat flux was measured to be 0.264 w/mm2.
- In comparison to others, the maximum temperature decrease on an 8 mm thick valve was determined to be 164.8 oC at a convex type base design.

As a result, it's evident that a convex design with an 8 mm fillet radius is optimum, and a 10 mm poppet valve with a fillet delivers the best heat transmission at 159.2 °C. According to the research, an 8mm thickness is optimal, and a convex design with 8 mm or a concave design with 10 mm provides greater heat transmission and temperature decrease to prevent poppet valves from failure or rapid engine breakage caused by poppet valve failure. According to our research, the best and ideal approach for building a poppet valve for an I.C. engine is to use a base surface convex type design.

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