THERMAL LOAD EFFECT ON EXHAUST VALVE BY USING CONVENTIONAL AND MIXED FUELS

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Abstract- *An engine valve is a mechanical device that regulates the supply of fuel to an engine. It is an important part of any engine system and comprised of a stem and a head. Exhaust valve is precision engine components used to open to permit the burned gases to exhaust from cylinders.*

In this thesis, methane fluid is mixed with ethane are calculated for their combination properties. The nano particle for volume fraction 0.2, 0.4, 0.6 & 0.8. Theoretical calculations are done determine the properties for nano fluids and those properties are used as inputs for analysis.

In this thesis, a finite-element method is used for modeling the thermal analysis of an exhaust valve. The temperature distribution and resultant thermal stresses are evaluated. Detailed analyses are performed to estimate the boundary conditions of an internal combustion engine. In this thesis, CREO parametric is employed for modeling and ANSYS is used for analysis of the exhaust valve.

CFD analysis to determine the pressure drop, heat transfer coefficient, mass flow rate and heat transfer rate for mixed fluids (methane and ethane) at different volume fractions.

1. INTRODUCTION TO IC ENGINE VALVE

1.1. Valves Train Components for Internal Combustions Engines, which include

1. Inlet and Exhaust Valves
2. Valve Guides
3. Tappets
4. Camshafts

What does an engine do?

- It generates the power required for moving the vehicle or any other specific purpose.
- It converts the energy contained in fuel to useful mechanical energy, by burning the fuel inside a combustion chamber.
- An engine contains number of parts like Valves and other Valve train components, Piston, camshaft, Connecting rod, Cylinder block, Cylinder head etc., from which REVL supplying some of the valve train components to engine manufacturers.

1.2. Types of Engines

1.2.1. From the basic concept there are 2 major types of engine. Which are subdivided further based on their working principle.

1. Internal Combustion Engines (IC Engines)
   a) 2 Stroke Engines
   b) 4 Stroke Engines
2. External combustion Engines (EC Engines)
   a) Steam engines (E.g. Locomotives)
   b) Turbine engines (E.g. Aircraft)

1.2.2. Based on the Fuel Used, IC Engines can be classified as follows.

1. Diesel Engines (CI Engines)
   a) DI / IDI / CRDI
   b) NA / Turbo Charged
2. Petrol Engines (SI Engines)
   a) Carburetor Engines
   b) SPFI / MPFI Engines
3. Gas Engines
   a) LPG
   b) CNG

1.2.3. Based on the Application, IC Engines can be classified as follows

1. Automotive Engines
   a) On road Vehicles
   b) Off road Vehicles
   c) Marine Applications
   d) Racing Vehicles
2. Stationary Engines
   a) Generators
   b) Power Plants

1.2.4. Automotive Applications can be further subdivided as follows

1. on road Vehicles
   a) 2 Wheelers
   b) Passenger cars
   c) Multi Utility Vehicles
   b) Light Commercial Vehicles
   d) Heavy Commercial Vehicles
2. off road Vehicles
   a) Tractors & Farm Equipments
   b) Earth Moving Equipments

What is a Valve Train?

- It is the set of components in a 4-stroke engine, responsible for smooth functioning of the inlet and exhaust valve
- It makes the valve to open and close as per the timing required for the correct functioning of the engine
- The performance of the engine is severely depends proper functioning of valve train. Any malfunctioning in the valve train system could even lead to severe damage to the engine

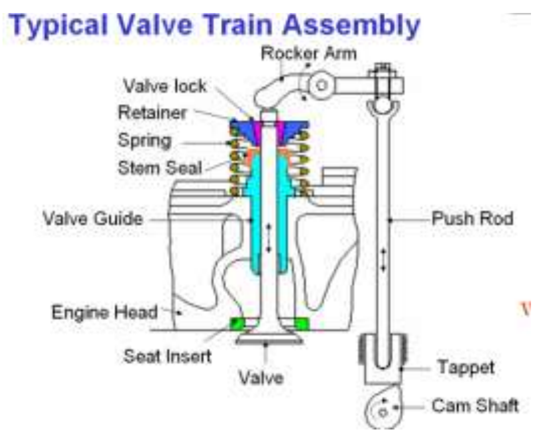

Fig-1: Typical Valve Train Assembly

About Valves:

Engine Valve is one of the main parts which are used in all IC Engines. Each cylinder in the engine has one inlet and one exhaust valve. Now a days engine are designed with multi valves viz., two inlet and one exhaust or Two inlet and Two exhaust valves which prevents air pollution and improves engine efficiency.

Function of Inlet Valve: The inlet which operates by the action of Tappet movement, allows air and fuel mixture into the cylinder.

Function of Exhaust valve: The exhaust valve allows burnt gases to escape from the cylinder to atmosphere.

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Valve Efficiency: Depends on the following characteristics like Hardness, Face roundness and sliding properties capable to withstand high temperature etc.

As compared to inlet, exhaust valve operates at high temperature as exhaust gases (around 800 Deg C) escape through it. As it resulting in early ways and gets corrosion, austenitic steel is used for manufacture of exhaust valve and martens tic steel is used for manufacture of inlet valve.

The manufacturing process involves upset and forging, heat treatment and machining (turning and grinding) and special processes like TIG welding, Projection Welding, PTA Welding, Friction Welding, Induction Hardening and Nitriding.

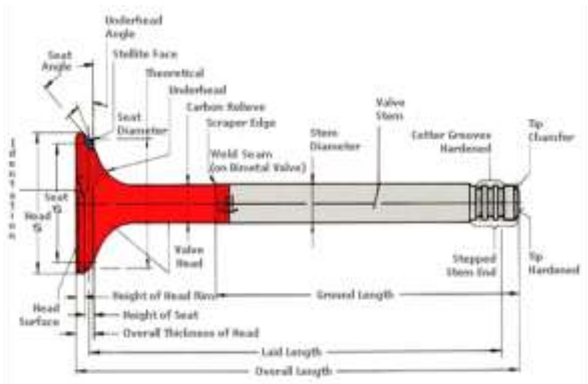

Fig-2:

Valve Dimensions:

Working Requirements for Valves

1. Inlet Valve

   a) Allow incoming charge into the engine
   b) Seal the port without leak for remaining Period
   c) Resistance to wear at the mating surfaces
   d) Good sliding surface for seizure resistance

2. Exhaust Valve

   a) Allow gases go out of the engine
   b) Seal the port without leak for remaining Period
   c) Strength to with stand high temperatures
   d) Resistance to wear at the mating surfaces
   e) Good sliding surface for seizure resistance

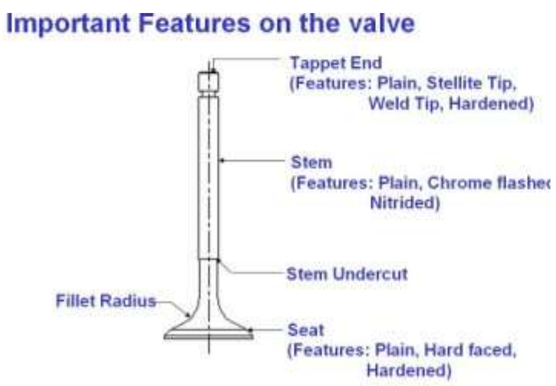

Fig- 3: Important Features on the Valve

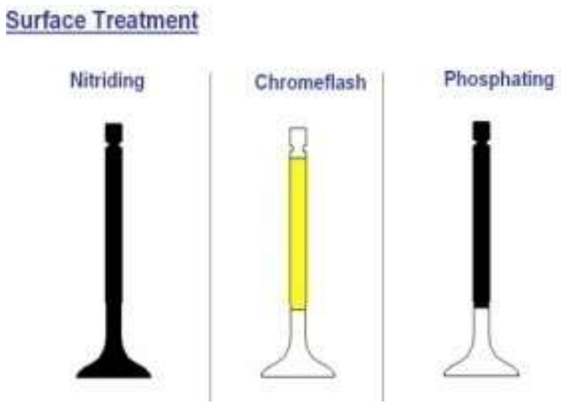

Fig-4.: Surface Treatment

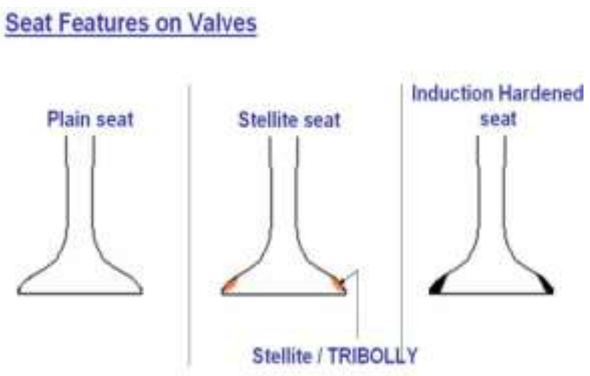

Fig-.5: Seat Features on Valves

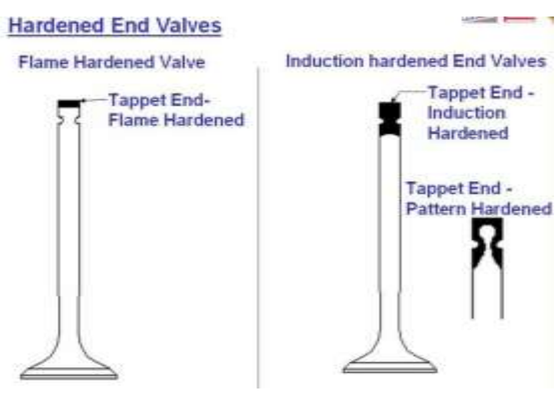

Fig-6: Hardened End Valves

DESIGN CALCULATIONS OF EXHAUST VALVE

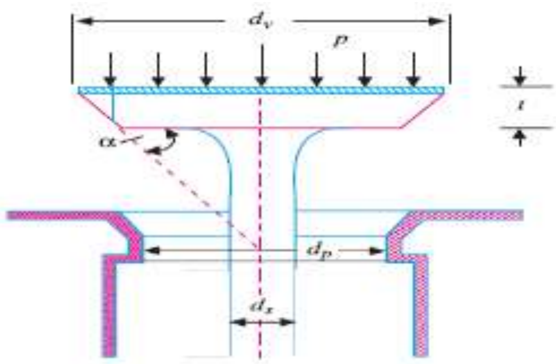

Fig-.7: Design Calculations of exhaust Valve

DESIGN OF OUTLET VALVE

a. **Size of valve port**

$$a_p \, v_p = aV$$

V = 90m/s = 90000mm/s

$$a_p = \frac{3802.66 \times 10933.33}{90000} = 462\text{mm}$$

$$a_p = \frac{\pi}{4}(d_p)^2$$

$$(d_p)^2 = \frac{462 \times 4}{\pi} = 588.53 \quad = \quad d_p = 24.25\text{mm}$$

b .Thickness of valve disc

$$t = Kd_p\sqrt{\frac{p}{\sigma_b}}$$

$$t = 0.42 \times 24.25\sqrt{\frac{10.936}{100}} = 3.36\text{mm}$$

c. Maximum lift of the valve

h = lift of the valve

$$h = \frac{d_p}{4\cos\alpha} = \frac{24.25}{4\cos 30^0} = \frac{24.25}{3.46} = 7\text{mm}$$

d. Valve steam diameter

$$d_s = \frac{24.25}{8} + 6.35 \text{ or}$$

$$d_s = 3.03 + 6.35$$

$$d_s = 9.38 \text{ (or) } 1403\text{mm}$$

$$\tan\alpha = \frac{2(h+t)}{(\frac{d_v}{2})} = \frac{2(h+t)}{d_v}$$

$$\tan 30 = \frac{2(3.36+7)}{d_v}$$

$$d_v = \frac{20.72}{0.577} = 35.9\text{mm} = 36\text{mm}$$

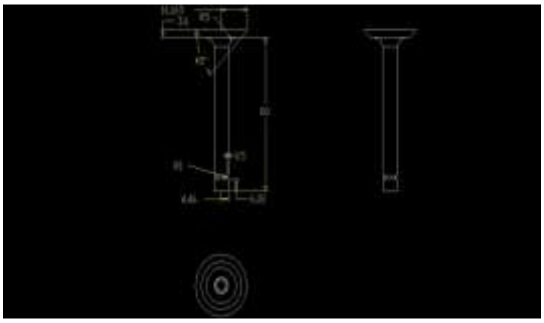

Fig-8: 2D DRAWING

2. LITERATURE REVIEW

1. Combustion Analysis of Inverted M Type Piston CI Engine by Using CFD.

Increasing computational power of modern computers, multi-dimensional Computational Fluid Dynamics (CFD) has found more and more applications in diesel engine research, design and development. Various successful applications have proven the reliability of using multidimensional CFD tools to assist in diesel engine research, design and development. By using CFD tools effectively it is easy to predict and analyse various details that are technically difficult like in cylinder process of diesel combustion, temperature & pressure contours, emission etc. prior to experimental tests to reduce the number of investigated parameters as well as time and thus costs. A multidimensional model was created and analysis of combustion was done using FLUENT, ANSYS 14.5 package.

INTRODUCTION TO CAD

Computer-aided design (**CAD**), also known as **computer-aided design and drafting** (**CADD**), is the use of computer technology for the process of design and design-documentation. Computer Aided Drafting describes the process of drafting with a computer. CADD software, or environments, provide the user with input-tools for the purpose of streamlining design processes; drafting, documentation, and manufacturing processes. CADD output is often in the form of electronic files for print or machining operations.

INTRODUCTION TO CREO

PTC CREO, formerly known as Pro/ENGINEER, is 3D modeling software used in mechanical engineering, design, manufacturing, and in CAD drafting service firms. It was one of the first 3D CAD modeling applications that used a rule-based parametric system. Using parameters, dimensions and features to capture the behavior of the product, it can optimize the development product as well as the design itself.

Fig-9: 3D MODEL OF EXHAUST VALVE

INTRODUCTION TO FEA

Finite element analysis is a method of solving, usually approximately, certain problems in engineering and science. It is used mainly for problems for which no exact solution, expressible in some mathematical form, is available. As such, it is a numerical rather than an analytical method. Methods of this type are needed because analytical methods cannot cope with the real, complicated problems that are met with in engineering.

INTRODUCTION TO ANSYS

ANSYS is general-purpose finite element analysis (FEA) software package. Finite Element Analysis is a numerical method of deconstructing a complex system into very small pieces (of user-designated size) called elements. The software implements equations that govern the behaviour of these elements and solves them all; creating a comprehensive explanation of how the system acts as a whole.

CALCULATIONS TO DETERMINE PROPERTIES OF NANO FLUID BY CHANGING VOLUME FRACTIONS

Volume fraction=0.2, 0.4,0 .6 & 0.8

MATERIAL PROPERTIES

Methane
Density = 3880 kg/m^3
Thermal conductivity =40 W/m-k
Specific heat = 910J/kg-k
Viscosity =

Ethane
Density = 4930 kg/m^3
Thermal conductivity =330 W/m-k
Specific heat = 711 J/kg-k
Viscosity =

NOMENCLATURE
ρ_{nf} = Density of nano fluid (kg/m^3)
ρ_s = Density of solid material (kg/m^3)
ρ_w = Density of fluid material (water) (kg/m^3)

ϕ = Volume fraction
C_{pw} = Specific heat of fluid material (water) (j/kg-k)
C_{ps} = Specific heat of solid material (j/kg-k)
μ_w = Viscosity of fluid (water) (kg/m-s)
μ_{nf} = Viscosity of Nano fluid (kg/m-s)
K_w = Thermal conductivity of fluid material (water) (W/m-k)
K_s = Thermal conductivity of solid material (W/m-k)

NANO FLUID CALCULATIONS

ALUMINUM OXIDE
DENSITY OF NANO FLUID

$\rho_{nf} = \phi \times \rho_s + [(1-\phi) \times \rho_w]$

SPECIFIC HEAT OF NANO FLUID

$$C_{p\,nf} = \frac{\phi \times \rho s \times Cps + (1-\phi)(\rho w \times Cpw)}{\phi \times \rho s + (1-\phi) \times \rho w}$$

VISCOSITY OF NANO FLUID

$\mu_{nf} = \mu_w\,(1+2.5\phi)$

THERMAL CONDUCTIVITY OF NANO FLUID

$$K_{nf} = \frac{K2 + 2K1 - 2\phi(K1-K2)}{K2 + 2K1 + (K1-K2)2k2} \times k_1$$

Table-1: Specification of the Nano Fluids

Volume fraction	Density (ρ)	Specific heat (Cp)	Thermal conductivity (w/m-k)	Viscosity (kg/m-s)
0.2	0.9276	1674.76	0.01901	0.000111
0.4	1.1982	1655.9904	0.02073	0.000148
0.6	1.4688	1644.134	0.022456	0.000185
0.8	1.7394	1635.96792	0.024177	0.000222

CFD ANALYSIS OF VALVE

→→Ansys → workbench→ select analysis system → fluid flow fluent → double click
→→Select geometry → right click → import geometry → select browse →open part → ok

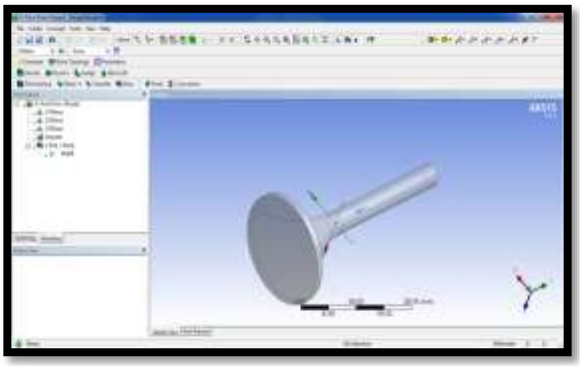

Fig-10: Work Bench Model

→→ Select mesh on work bench → right click →edit → select mesh on left side part tree → right click → generate mesh →

Fig-12: Work Bench Model Mesh

Select faces → right click → create named section → enter name → water inlet
Select faces → right click → create named section → enter name → water outlet
Model → energy equation → on.
Viscous → edit → k- epsilon
Enhanced Wall Treatment → ok
Materials → new → create or edit → specify fluid material or specify properties → ok
Select gasoline
Boundary conditions → select fluid inlet → Edit → Enter velocity → 10m/s and Inlet Temperature –
Solution → Solution Initialization → Hybrid Initialization →done
Run calculations → no of iterations = 50 → calculate → calculation complete

→→ Results → graphics and animations → contours → setup
Velocity = 10m/s

Volume fraction =0.2

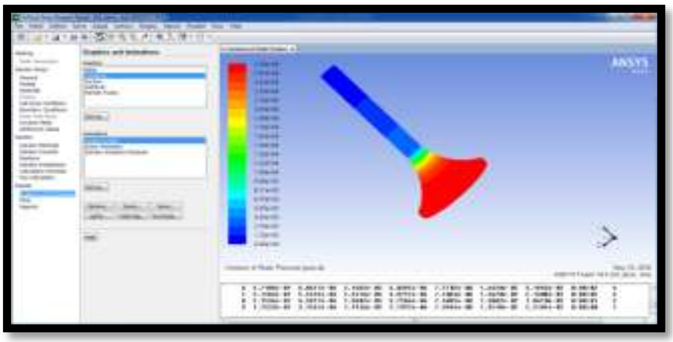

Fig-13.: Static pressure

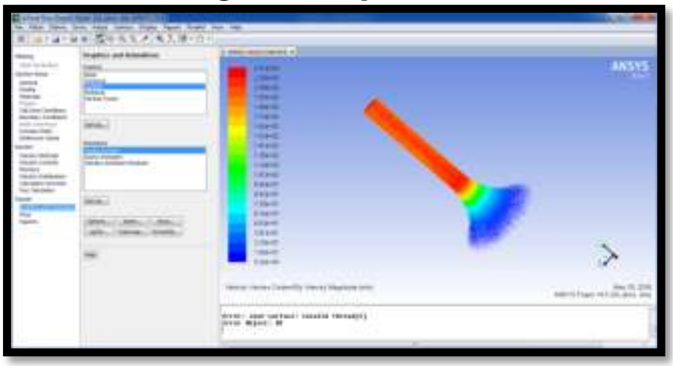

Fig-14: Velocity

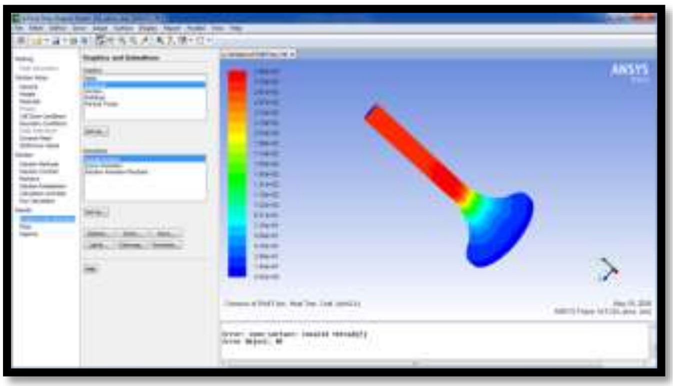

Fig-15: Heat transfer coefficient

Mass Flow Rate	(kg/s)
inlet	0.24605182
interior-____msbr	15.007729
outlet	-0.24598695
wall-____msbr	0
Net	6.4864755e-05

Fig- 16: Mass flow rate

Total Heat Transfer Rate	(w)
inlet	319298.41
outlet	-319214.34
wall-____msbr	0
Net	84.0625

Fig- 17: Heat transfer rate

THERMAL ANALYSIS OF HOLLOW EXHAUST VALVE

MATERIAL-STAINLESS STEEL

Open work bench 14.5>select **steady state thermal** in analysis systems>select geometry>right click on the geometry>import geometry>select **IGES** file>open

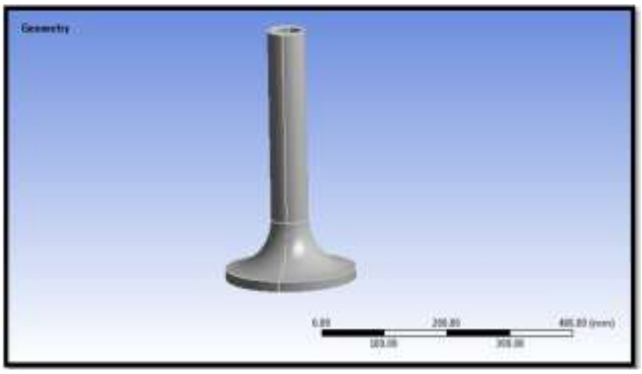

Fig-18: IMPORTED MODEL

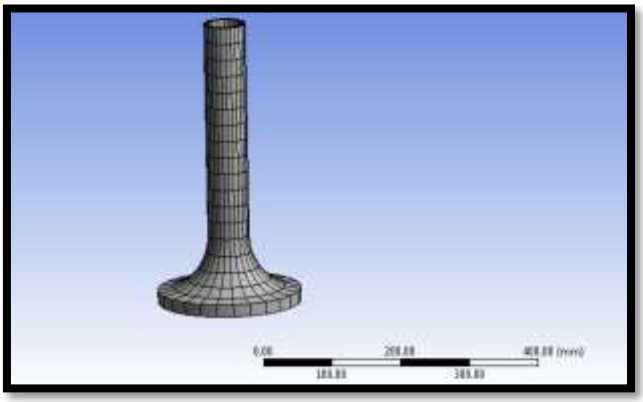

Fig-19: MESHED MODEL

Finite element analysis or FEA representing a real project as a "mesh" a series of small, regularly shaped tetrahedron connected elements, as shown in the above fig.And then setting up and solving huge arrays of simultaneous equations. The finer the mesh, the more accurate the results but more computing power is required.

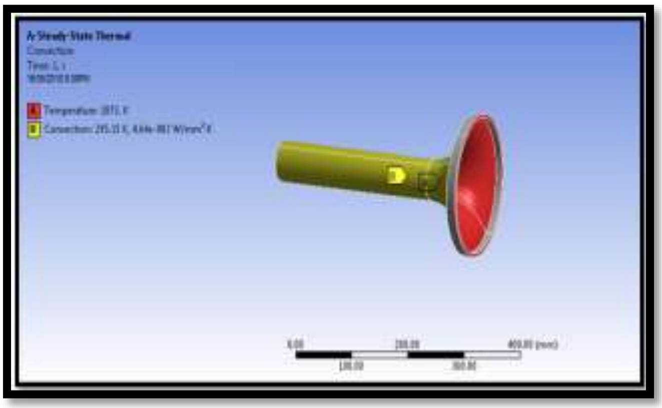

Fig- 20: BOUNDARY CONDITIONS

T =1073K
Select steady state thermal >right click>insert>select convection> enter film coefficient value Select steady state thermal >right click>insert>select heat flux
Select steady state thermal >right click>solve
Solution>right click on solution>insert>select temperature

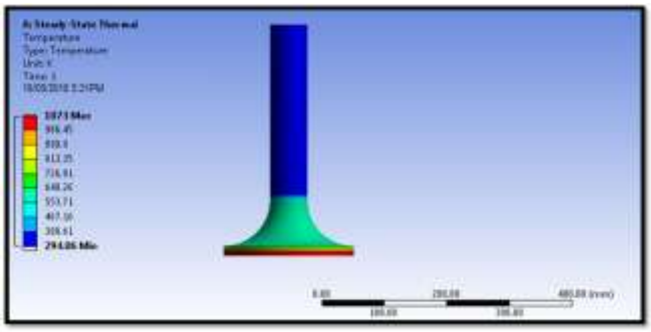

Fig-21: TEMPERATURE

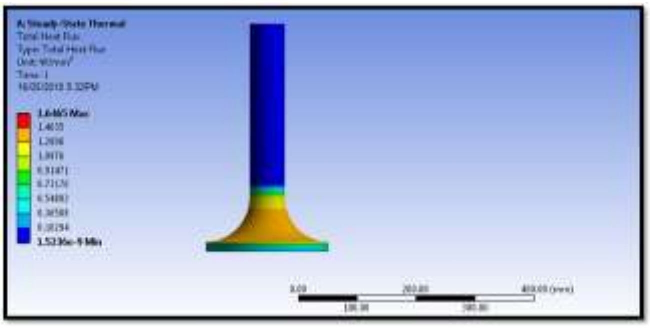

Fig-22: HEAT FLUX

RESULT

Table-2: CFD Results

Volume Fraction	Pressure (Pa)	Heat transfer Coefficient (w/ m²-k)	Mass Flow rate (kg/s)	Heat transfer rate (W)
0.2	2.70e+0.4	2.90e+0.2	0.000064864	84.0625
0.4	3.48e+0.2	3.26e+0.2	0.000047415	60.375
0.6	4.26e+0.4	3.62e+0.2	0.000080376	101.9375
0.8	5.07e+0.4	3.97e+0.2	0.0000542104	68.8125

Table-3: Thermal Results

Material	Temperature		Heat Flux(w/mm²)
	Min	Max	
Stainless Steel	294.06	1073	1.6465
Aluminum Alloy	295.15	1073	6.9237

THEORETICAL CALCULATIONS

Volume fraction (Φ) = 0.2

$$Re = \frac{\ell \times v \times L}{\mu} = \frac{0.9276\times10\times0.107}{0.000111} = 8941.72$$

$$Pr = \frac{cp\times\mu}{kw} = \frac{1674.76\times0.000111}{0.01901} = 9.778$$

$$Nu = 0.024\times(Re)^{0.8}\times(Pr)^{0.4} = 0.024\times(8941.72)^{0.8}\times(9.778)^{0.4} = 86.586$$

$$hfc = \frac{Kw\times Nu}{DH} = \frac{0.01901\times86.586}{0.05} = 32.919 \text{ w/m}^2\text{-k}$$

Volume fraction (Φ) = 0.4

$$Re = \frac{\ell \times v \times L}{\mu} = \frac{1.1982\times10\times0.107}{0.000148} = 8662.66$$

$$Pr = \frac{cp\times\mu}{kw} = \frac{1655.9904\times0.000148}{0.02073} = 11.822$$

$$Nu = 0.024\times(Re)^{0.8}\times(Pr)^{0.4} = 0.024\times(8662.66)^{0.8}\times(11.822)^{0.4} = 91.0769$$

$$hfc = \frac{Kw\times Nu}{DH} = \frac{0.02073\times91.0769}{0.05} = 37.760 \text{ w/m}^2\text{-k}$$

Volume fraction (Φ) = 0.6

$Re = \frac{\ell \times v \times L}{\mu}$
$= \frac{1.4688 \times 10 \times 0.107}{0.000185}$
= 8495.22

$Pr = \frac{cp \times \mu}{kw}$
$= \frac{1644.134 \times 0.000185}{0.022456}$
= 13.544

Nu = 0.024×(Re)^0.8×(Pr)^0.4
= 0.024×(8495.22)^0.8×(13.544)^0.4
= 94.6781

$hfc = \frac{Kw \times Nu}{DH}$
$= \frac{0022456 \times 94.6781}{0.05}$
= 42.521 w/m²-k

Volume fraction (Φ) = 0.8

$Re = \frac{\ell \times v \times L}{\mu}$
$= \frac{1.7394 \times 10 \times 0.107}{0.000222}$
= 8383.59

$Pr = \frac{cp \times \mu}{kw}$
$= \frac{1635.96792 \times 0.000222}{0.024177}$
= 15.0219

Nu = 0.024×(Re)^0.8×(Pr)^0.4
= 0.024×(8383.59)^0.8×(15.021)^0.4
= 97.6415

$hfc = \frac{Kw \times Nu}{DH}$
$= \frac{0024177 \times 97.6415}{0.05}$
= 47.2135 w/m²-k

COMPARISON OF ANALYTICAL AND THEORETICAL

Table-4: Comparison of Analytical and Theoretical

Analytical	Theoretical
Heat transfer coefficient(w/m²-k)	**Heat transfer coefficient(w/m²-k)**
2.90e+02	3.2e+02
3.26e+02	3.7e+02
3.62e+02	4.2e+02
3.97e+02	4.7e+02

3. CONCLUSIONS

On this thesis, methane fluid is combined with ethane are calculated for their combo homes. The nano particle for volume fraction 0.2, zero. Four, 0.6 & zero. Eight. Theoretical calculations are executed investigate the residences for nano fluids and people houses are used as inputs for evaluation.

On this thesis, a finite-detail procedure is used for modeling the thermal analysis of an exhaust valve. The temperature distribution and resultant thermal stresses are evaluated. Certain analyses are performed to estimate the boundary stipulations of an interior combustion engine. On this thesis, CREO parametric is employed for modeling and ANSYS is used for evaluation of the exhaust valve.

By way of observing the CFD evaluation outcome the stress and warmness switch coefficient values are raises by using growing the quantity fraction and mass glide cost and heat switch rate values are more at volume fraction 0.6. So it may be concluded the methane and ethane combination quantity fraction at zero.6 is better fluid.

Via staring at the thermal analysis results the extra warmness flux price for aluminum alloy.

REFERENCES

1. J. M. Cherrie, Factors Influencing Valve Temperatures in Passenger Car Engines, SAE Paper 650484, 1965.
2. R. P. Worthen and T. N. Tunnecliffe, Temperature Controlled Engine Valves, SAE Paper 820501, 1982
3. Z. Johan, A. C. M. Moraes, J. C. Buell, and R. M. Ferencz, In-Cylinder Cold Flow Simu-lation Using a Finite Element Method, Comput. Meth. Appl. Mech. Eng., vol. 190, pp. 3069–3080, 2001.
4. R. Prasad and N. K. Samria, Heat Transfer and Stress Fields in the Inlet and Exhaust
5. Valves of a Semi-adiabatic Diesel Engine, Comput. Struct, vol. 34, no. 5, pp. 765–777, 1990.
6. R. Prasad and N. K. Samria, Transient Heat Transfer Studies on a Diesel Engine Valve, Int. J. Mech. Sci., vol. 33, no. 3, pp. 179–195, 1991.
7. C. R. Ferguson and A. T. Kirkpatrick, Internal Combustion Engines, 2nd ed., Wiley, New York, 2001.
8. A. C. Alkidas, Intake-Valve Temperature and the Factors Affecting It, SAE Paper 971729, 1997.
9. J. Cowart and W. Cheng, Intake Valve Thermal Behavior during Steady-State and Tran-sient Engine Operation, SAE Paper 1999-01-3643, 1999.

10. R. P. Worthen and D. G. Rauen, Measurement of Valve Temperatures and Strain in a Firing Engine, SAE Paper 860356, 1986.
11. H. Cheng-Hung and J. Tzann-Ming, Inverse Problem of Determining the Periodic Ther-mal Contact Conductance between Exhaust Valve and Seat in an Internal Combustion.