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DESIGN AND SIMULATIVE ANALYSIS OF PISTON IN AN ADVANCE METALS ON SOLIDWORKS

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Abstract : The achievement of this research is to design, implement and then perform experimental comparison a PISTON through SOLIDWORKS software under various metals such as Aluminium 4032 and 2618. 2618 forged pistons. They grow and contact substantially more than their 4032 kin. Much of the time these cylinders are utilized in outrageous dashing applications like NASCAR and NHRA. 2618 Pistons require a more noteworthy cylinder to exhaust leeway because of their inclination to extend when warming up. This cycle can be heard during a virus start and is known as cylinder slap. The essential explanation they are utilized in elite applications is their easy-going nature under high effect circumstances, for example, explosion. In any case, their adaptability implies you penance life span, as they mutilate a lot speedier than a 4032 produced aluminum cylinder. Thus, on the off chance that you plan on putting a ton of weight on your HEMI and heading off to the strip regularly you might need to think about the advantages of a 2618 cylinder. 4032 produced cylinders are a high silicon based material. This implies that they extend substantially less than 2618 cylinders. The propensity to grow less implies that the cylinder can have a more tight cylinder to exhaust leeway. The more tight clearances make a weakling by and large activity of the engine. 4032 is a truly steady permit that opposes mutilations, for example, ring honesty. The amalgam's quality and security likewise loans its self to a more extended life cycle ability. Anyway because of its less flexible nature we don't suggest utilizing this sort of cylinder in case you're intending to assemble your HEMI stroker engine for a helped application. In case you're hoping to fabricate a normally suctioned HEMI stroker motor and don't anticipate mishandling the engine consistently you ought to consider a 4032 cylinder for you manufacture. The reason why I am choosing the ideas because to identify which material is suited for high performance engines. The operations which I have done are 2D design, 3D design, evaluation, simulation. As I mentioned earlier, I gave the detailed report of material properties, simulation , evaluation and orthographic view by SOLIDWORKS software. Atlast I concluded, I chosen Aluminium 2618 is the suitable material to get higher performance, more ductility with the inducement of high load and higher thermal conductivity when compared to other metals which is used in this project.

Index Terms - *2D Drafting – 3D Designing – Evaluation – Simulation – Resulting.*

1. INTRODUCTION

After doing comparative analysis of various type of Al alloy i.e.in between A2618 aluminium alloy, A4032 aluminium alloy, Al-GHS1300 and Ti-6Al-4U aluminium alloy for total deformation, equivalent von-mises stress and equivalent von-mises strain. From the analyzed result through this work, it is concluded that stress occurred by using this material is lower than the permissible stress value, so that Al-GHS1300 is best material for piston. Having analyzed all stresses, strains and total deformation in an allowable range, the main design questions have been answered and the objectives of the project achieved [1]. The piston undergoes maximum deformation due to the pressure at the center of the top surface. But the deformation observed is only 1.5786e-005 m, which is practically negligible. If the deformation was more pronounced, ribs would be added for reinforcement of the structure. Unlike the deformation model, the regions of high stress concentration is above the support region which comes in contact with the wrist pin. The maximum stress reaches 1.9815e+007 Pa i.e. 19.81 Mpa which lies well below the yield strength of the piston and hence does not need further reinforcement. From the results of the finite element analysis we can infer that Aluminum alloy 4032 is a suitable material for manufacturing forged piston for the given engine specifications under the intended operation conditions. For higher loads and more rigorous loading conditions such as track focused cars, Aluminum alloy 2618 would be the preferred material but owing to the high wear index the piston may need to be inspected frequently and replaced if required [2]. There are number of variations in piston design which include shape, mass, provision for expansion, skirt design and type of material. Here piston material was replaced by pure aluminium-12.5% silicon based composite material reinforced with 3% silicon carbide and 15% cenosphere particulates and the performance of a piston is compared with the former materials like LM26 and A4032. It is observed that the analysis results clearly shows that the piston with aluminium MMC material has better results than the former materials LM26 and A4032. It also indicated that have minimum displacement than conventional materials. When compared to the conventional material the new material found to have less weight and more strength [3]. The parameters used for the simulation are operating gas pressure, temperature and material properties of piston. The specifications used for the study of these pistons belong to four stroke single cylinder engine of Bajaj pulsar 220 cc. This project illustrates the procedure for analytical design of three aluminum alloy pistons using specifications of four stroke single cylinder engine of Bajaj pulsar 220 cc motorcycle. The results predict the maximum stress and critical region on the different aluminum alloy pistons using FEA. It is important to locate the critical area of concentrated stress for appropriate modifications. Static and thermal stress analysis is performed by using ANSYS 14.1. The best aluminum alloy material is selected based on stress analysis results. The analysis results are used to optimize piston geometry of best aluminum alloy [4]. During the combustion of fuel in diesel engine, high temperature and pressure will be created as engine runs at high speed and loads. This results in development of high thermal and structural stresses in the piston and if these stresses exceed the design value, failure of piston may take place. To avoid these failures, intensity of stresses should be avoided. In this work an attempt is made to reduce the intensity of stresses by replacing conventional aluminum alloy material of piston with aluminum silicon carbide composite by commercial analysis software package ANSYS [5].

2. SELECTION OF MATERIAL

2.1 Material Composition:

NAME OF THE METAL	**ALUMINIM 2618**	**ALUMINIUM 4032**
MATERIAL COMPOSITION		
CHEMICAL COMPOUNDS	**CONTAINMENT IN PERCENTAGES**	
Aluminium, Al	93.7%	85%
Copper, Cu	2.30%	0.90%
Magnesium, Mg	1.60%	1%
Ferrous, Fe	1.1%	-
Nickel, Ni	1%	0.9%
Silicon, Si	0.18%	12.20%
Titanium, Ti	0.07%	-

Table-1: Chemical composition of Aluminium 2618 and 4032

3. DSEIGN PROCEDURE

3.1 To Draw The 3D Modeling Of PISTON:

- Draw the piston body.
- Draw the ring groove for piston by the three consecutive square-revolved cut on top and one at bottom with desired measurements.
- Cut the body from bottom to centre on both sides to design the piston pin boss reinforcement and piston pin boss on inner side.
- Click the fillet tool to blend all the corners of the piston.

3.2 To Simulate The 3D Modeling Of PISTON:

- SolidWorks Add-Ins – SolidWorks Simulation – Simulation – New study.
- Click Static – Click OK.
- Select the material which we want to test.
- Fixtures – Select the fixed part of the geometry – Click OK.
- External Loads – Pressure – Apply the maximum pressure of the material where it is needed – Reverse direction – Click OK.
- External Loads – Temperature – Apply the maximum temperature able to withstand of the material where it is needed – Reverse direction – Click OK.
- Mesh – Select the level of mesh – Give the meshing parameters – Click OK – Ensure the meshing is done.
- Run the result.

4. EXPERIMENTAL WORK

In my project experimental work is implied by planning the PISTON in SolidWorks software. In this exploration I done the works like 2D drafting, 3D demonstrating, assessment, taking examination report, and afterward recreation. Here I incorporate the orthographic view, mass properties, simulated diagram(Von-Mises, Displacement and strain) of structural analysis and thermal analysis.

4.1. Orthographic View:

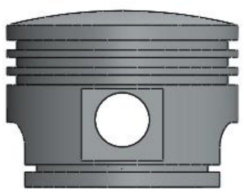

Fig-1: Front Plane of Piston

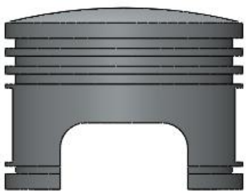

Fig-2: Left Plane of Piston

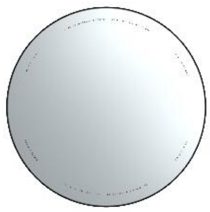

Fig-3: Top Plane of Piston

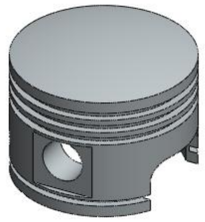

Fig-4: Trimetric Plane of Piston

4.2. Mass Properties

4.2.1. Mass Properties of Al 2618:

- Density = 0.00 grams per cubic millimeter
- Mass = 1203.03 grams
- Total weld mass = 0.00 grams
- Volume = 435880.51 cubic millimeters
- Surface area = 89121.22 square millimeters
- Center of mass: (millimeters)
  - X = 0.00
  - Y = -26.90
  - Z = 0.00
- Principal axes of inertia and principal moments of inertia: (grams * square millimeters)
- Taken at the center of mass.
  - Ix = (0.00, 0.00, 1.00) Px = 1822397.56
  - Iy = (1.00, 0.00, 0.00) Py = 2008295.82
  - Iz = (0.00, 1.00, 0.00) Pz = 2561003.87
- Moments of inertia: (grams * square millimeters)
- Taken at the center of mass and aligned with the output coordinate system.
  - Lxx = 2008295.82 Lxy = 2.79 Lxz = 12.87
  - Lyx = 2.79 Lyy = 2561003.87 Lyz = -2.53
  - Lzx = 12.87 Lzy = -2.53 Lzz = 1822397.57
- Moments of inertia: (grams * square millimeters)
- Taken at the output coordinate system.
  - Ixx = 2879142.34 Ixy = 4.63 Ixz = 12.87
  - Iyx = 4.63 Iyy = 2561003.87 Iyz = -4.63
  - Izx = 12.87 Izy = -4.63 Izz = 2693244.08

4.2.2 Mass properties of Aluminium 4032:

- Density = 0.00 grams per cubic millimeter
- Mass = 1168.16 grams
- Total weld mass = 0.00 grams
- Volume = 435880.51 cubic millimeters
- Surface area = 89121.22 square millimeters
- Center of mass: (millimeters)
  - X = 0.00
  - Y = -26.90
  - Z = 0.00
- Principal axes of inertia and principal moments of inertia: (grams * square millimeters)
- Taken at the center of mass.
  - Ix = (0.00, 0.00, 1.00) Px = 1769574.44
  - Iy = (1.00, 0.00, 0.00) Py = 1950084.35
  - Iz = (0.00, 1.00, 0.00) Pz = 2486771.87
- Moments of inertia: (grams * square millimeters)
- Taken at the center of mass and aligned with the output coordinate system.
  - Lxx = 1950084.34 Lxy = 2.71 Lxz = 12.50
  - Lyx = 2.71 Lyy = 2486771.87 Lyz = -2.45

- Lzx = 12.50 Lzy = -2.45 Lzz = 1769574.45

❖ Moments of inertia: (grams * square millimeters)

❖ Taken at the output coordinate system.

- Ixx = 2795688.93 Ixy = 4.49 Ixz = 12.50
- Iyx = 4.49 Iyy = 2486771.87 Iyz = -4.49
- Izx = 12.50 Izy = -4.49 Izz = 2615179.03

4.3. Symmetrical Analysis

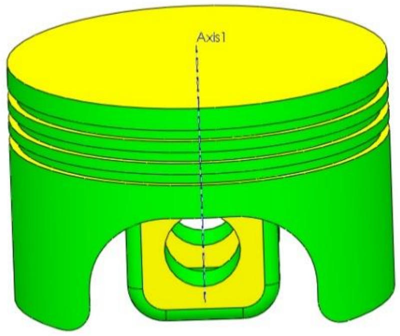

Fig-5: Structural analysis model view of piston

4.3.1. Results:

Parameter	Value
Plane	Asymmetric plane
Unique face count (Red)	18
Symmetric face count (Green)	34
Asymmetric face count (Yellow)	16

Table-2 Result of structural analysis

4.4. Simulated Diagram

4.4.1. Structural Analysis:

4.4.1.1 Aluminium 2618:

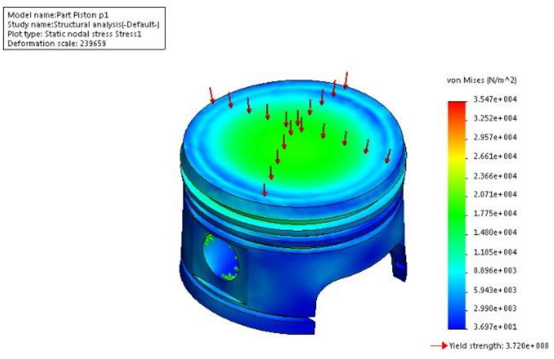

Fig-6: Von-Mises Diagram

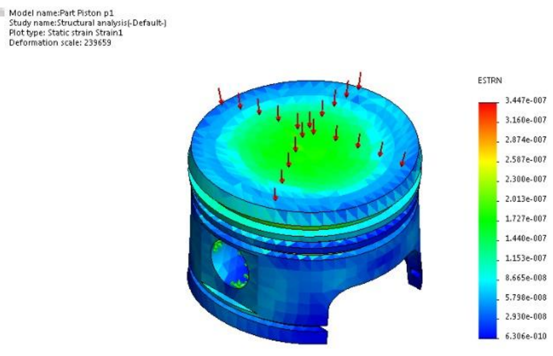

Fig-7: Strain Diagram

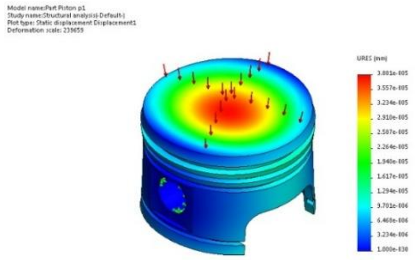

Fig-8: Displacement Diagram

4.4.1.2. Aluminium 4032:

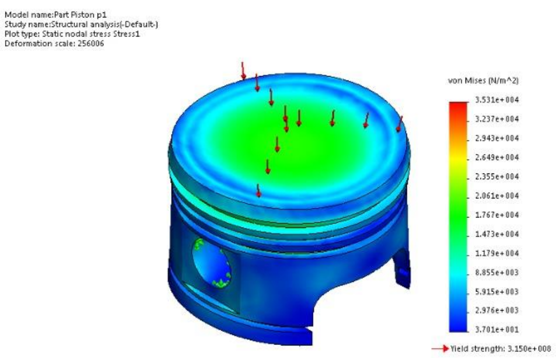

Fig-9: Von-Mises Diagram

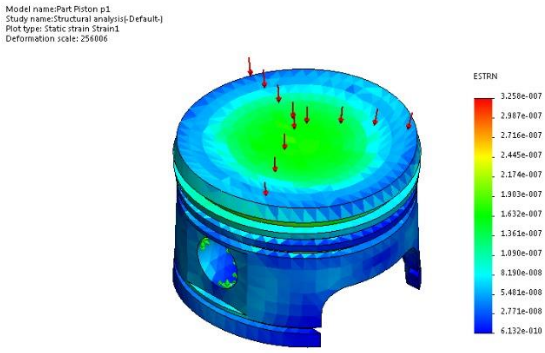

Fig-10: Strain Diagram

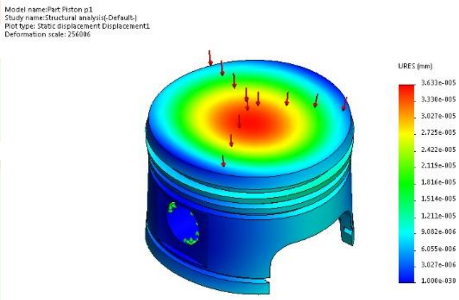

Fig-11: Displacement Diagram

4.4.2. Thermal Analysis:

4.4.2.1. Aluminium 2618:

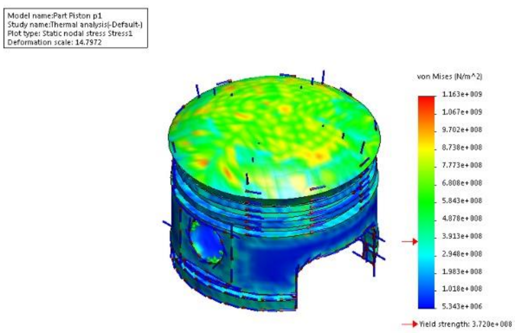

Fig-12: Von-Mises Diagram

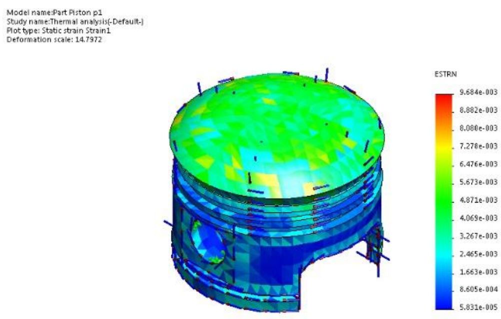

Fig-13: Strain Diagram

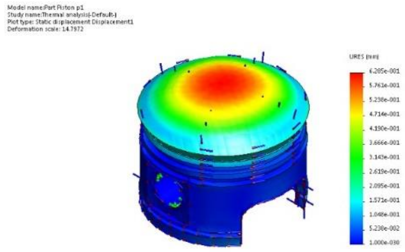

Fig-14: Displacement Diagram

4.4.2.2 Aluminium 4032:

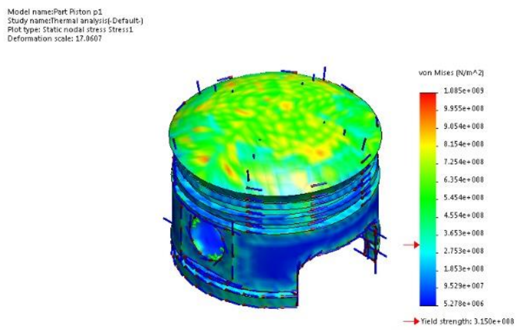

Fig-15: Von-Mises Diagram

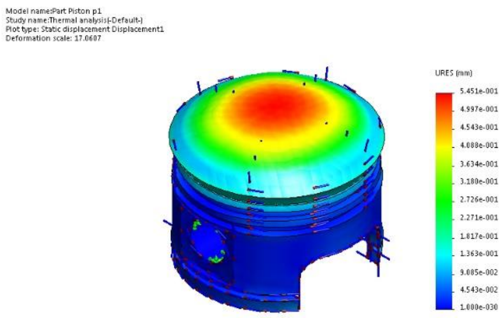

Fig-16 Displacement Diagram

5. RESULTS AND DISCUSSION

As the table concludes increased mechanical properties of piston. There is a step-by-step increased nature in mass density, thermal expansion co-efficient, yield strength, tensile strength, poisson's ratio, elastic modulus. As it shows the increment of properties in Aluminium 2618 when compared to Aluminium 4032. Here I enclosed the comparative property table below:

Mechanical Properties / ***Name of the Component***	***Elastic Modulus***	***Poisson's Ratio***	***Tensile Strength***	***Yield Strength***	***Thermal Expansion Co-Efficient***	***Mass Density***
Aluminium 2618	$7.45e^{010}$ N/m^2	0.33 N/A	440 MPa	370 MPa	$2.2e^{-005}$ /K	2760 Kg/m^3
Aluminium 4032	$7.9e^{010}$ N/m^2	0.34 N/A	370 MPa	315 MPa	$1.94e^{-005}$ /K	2680 Kg/m^3

Table-3: Mechanical properties of Aluminium 2618 and 4032

6. CONCLUSION

SolidWorks grades with Aluminium 2618 and 4032 was successfully designed via SolidWorks software. Test results revealed that grade Aluminium 2618 enhances the mechanical properties of the project. There is a increment of mechanical properties like mass density, thermal expansion co-efficient, yield strength, tensile strength, poisson's ratio, elastic modulus one-by-one which is shown in results and discussion chapter. So the Aluminium 2618 proves that it is suited to manufacture the piston to get higher performance, better strength and high thermal conductivity. Hence It is purely done by own through SolidWorks software.

7. REFERENCE

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