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REVIEW ARTICLE

SIGNIFICANCE OF ALUMINIUM ALLOYS IN AUTOMOBILE ENGINE COMPONENTS: A REVIEW

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ABSTRACT

Now-a-days the automobile manufacturers are continuously trying to reduce the automobile weight and increase the vehicle performance. Aluminium, in today's world, is widely used in manufacturing of automobile components. In this paper, Aluminium and its alloys and their application in automobile engine components such as Engine block, piston and connecting rod is studied. Also a comparative study of aluminium with other materials used for manufacturing in automobile sector has been made. This study is very useful to design engineers for understanding the significance of aluminium and its alloys for manufacturing automobile component in the industry.

INTRODUCTION

In today's world due to increase in vehicle population the rate of emission (pollution) is on the peak. Thus researchers are continuously trying to develop technologies which will help to reduce the emission. By adopting various methods like reducing weights, more refined engines and using alternate materials for manufacturing this can be achieved. Using aluminium instead of conventional materials for manufacturing of automobiles helps in reduction of weight as well as reduces the emission when especially used in manufacturing of engine components. Thus optimization of weight is vital and hence it is important to replace the conventional materials by more lighter, efficient materials which are aluminium and its alloys.

One of the most important properties includes its resistance to corrosion. Pure aluminium provides a good corrosion resistance due to formation of a barrier oxide film on the surface which even if destroyed is reformed in most environments. (Rana *et al*, 2012.) Also the density of aluminium is lower (1/3rd of all the commonly used metals in industry). Some of the important aluminium properties include high specific strength, high wear and seizure resistance, high stiffness, better high temperature strength, controlled thermal expansion coefficient and improved damping capacity. These properties are obtained by addition of certain alloying elements and by heat treatment process (heating and cooling accordingly). These alloying elements are selected based on their effects and suitability.

Aluminium alloys are classified into different series according to the alloying element added. (Example-1xxx, 2xxx etc.) (Sukiman *et al*, 2013.)

LITERATURE SURVEY

Manufacturing of different mechanical component are using different metal & non-metals. Mostly design the automobile component & manufacturing using metal & their alloys. For this study we are refer the different researcher literature and focus the significance of aluminium alloy. Few researcher works is highlighted in this literature survey Rana *et al*. [2012] described the effects of some alloying elements on the microstructures and mechanical properties of Aluminum alloys and aluminum alloy composites used in automotive industries. Sukiman *et al* [2013] described the corrosion effect on various aluminium alloys in different environment with analytical data. Jonathan *et al* [2003] discussed about development of a

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aluminium alloy by NASA, it is a high performance piston alloys to meet U.S. automotive legislation requiring low exhaust emission. Ahmed *et al* [2014] suggested the use of aluminum alloy instead of steel connecting rod on the basis of design and fabrication. Nguyen [2005] discussed about various materials which can be used for manufacturing engine blocks. Sasi *et al* [2012] describes that replacing the steel components with aluminum components will reduce the weight but the strength is not enough so by taking the aluminum alloy such that the aluminum alloy exhibits the strength like the steel because of its alloying material and own property of less weight.

MATERIAL AND METHOD

Aluminum material widely uses for manufacturing the automobile engine cylinder block, piston, connecting rod and cylinder liners. Aluminum materials light in weight & rapidly increase & decrease temperature, this is helpful for engine overall performance. So according to this we are considering the cylinder block, piston, connecting rod in this study.

The aluminum is not direct use for manufacturing automobile component, Aluminum alloys are generally use & gives good effect. The Table 1 mention different aluminum alloys properties

Table 1 Properties of aluminum

Aluminium alloy	Alloying Element	Properties
1xxx	-	99% pure aluminium, generally not directly used or sold but has the best corrosion resistance and also used in cladding application.
2xxx	Copper	Provides significant strength by promotion of age hardening. Can provide a strength excess of 500Mpa depending on temper.
3xxx	Manganese	Addition of this provides a good corrosion resistance and moderate strength with a very good formability.
4xxx	Silicon	Addition of silicon provides high castability, machinability and fluidity.
5xxx	Magnesium	Provides medium strength, excellent marine corrosion resistance.
6xxx	Magnesium & silicon	Addition of silicon alone lowers the melting temperature to overcome this magnesium is also added. Besides it provides med-high strength and have good corrosion resistance.
7xxx	Zinc	Very high strength can be achieved but it is prone to corrosion.
8xxx	Lithium	Provides high strength and stiffness also lowering the density.

Case Study

For this study we have considered the automobile engine cylinder block, piston and connecting rod and how the efficiency can be improved using an alternate material which is "Aluminium alloys".

The Figure 1 shows aluminum alloy cylinder block and piston.

Aluminium cylinder block and piston head

Normal working temperature for automobile engine is around 100^{o}C to 150^{o}c. The melting point of aluminiumhighly depends on its purity, for 99.99% pure aluminium at atmospheric pressure, it is 660^{o}c but this reduces to 635^{o}c for 99.5% commonly used pure aluminum. Due to alloying of aluminium with various metals it reduces further down to 500^{o}c for some magnesium alloys under certain conditions. Increase in melting point is directly related to increase in pressure; it is 980^{o}c at 50 kbar. Alloys of aluminium are used to manufacture aluminium fins for better heat dissipation.

Figure 1 Cylinder blocks& Piston.

The coefficient of thermal expansion is not linear over the range from minus 200^{o}c to plus 600^{o}c but for practical use it is considered to be constant between the temperature ranges from 20 to 100^{o}c. The coefficient of thermal expansion is mainly characterized by alloying elements used and their proportions. (Ron Cobden *et al*, 1994) Use of copper and silicon reduces expansion, while magnesium increases it. High temperature aluminium alloys can be used for manufacturing engine blocks, pistons, connecting rods and piston heads etc. so as to reduce the weight and increase the efficiency of the automotive engines. Due to increase in strictness of emission standards for automotive engines in all countries, NASA 398 aluminium alloy is exclusively applicable for pistons, connecting rods and various engine components in order to reduce hazardous emission. From the various experiments performed on automotive engines it has been clear that the unburned fuel comes mostly from an opening that is formed between the cylinder wall surface, piston outside wall, and the top of the piston ring**.** If the flame in the combustion chamber cannot travel deep into the combustion chamber and enters in the opening, the unburned fuel is exhausted out of the Combustion chamber in the expansion stroke as the main source of hazardous emissions.

This can be resolved by reducing the opening volume by moving the top piston-ring closer to the top of the piston. For

such a development of the piston would require a high strength, high temperature alloy to prevent the piston failure due to high mechanical and thermal loading of the piston and piston ring groove and ring. Aluminium alloys have been successfully used for manufacturing high performance diesel and direct fuel injection gasoline engines, with increase in the power of engine, engine components will require high fatigue strength, high wear resistance and sustainability at high temperature. (Jonathan A. Lee, 2003)

Use of aluminum for manufacturing of automotive engines is mainly because of its light weight as compared to other materials. Light weight of pistons requires less amount of energy to move up and down and hence increases efficiency. But aluminium itself does not satisfy the properties required it has be alloyed with various materials. Cost and ease of manufacturing also plays important role in use of aluminium. Cost of aluminium is higher than the cost of cast iron. Major disadvantage of use of aluminium for piston and engine block is that they produces large amount of friction. This problem can be solved by using one as aluminium and other by cast iron. Layer of cast iron or steel can also be used between the two. Because of its thermal conductivity it provides better cooling for engines hence over heating of the engines is not an issue. There are two aluminum alloys that are mainly used in the manufacturing of cylinder blocks: 319 and A356. Aluminum alloy 319 has a composition of 85.8-91.5 wt.% aluminum, 5.5-6.5 wt. %silicon, 3-4 wt.% copper, 0.35 maximum wt.% nickel, maximum 0.25 wt.% titanium, maximum0.5 wt.% manganese, maximum 1% iron, maximum 0.1 wt.% magnesium, and maximum 1 wt.% zinc. The alloy has good casting characteristics, corrosion resistance, and thermal conductivity. When heat treated with the T5 process, it possesses high strength and rigidity forengine block use. (Hieu Nguyen, 2005)

Similarly aluminium alloy is also used for manufacturing of Connecting rod of I.C Engine
As shown in figure 03

Connecting rod used in engine made of aluminium alloy 5086-H32

Figure 2 Connecting Rod

The connecting rod connects the piston to the crankshaft. The connecting rod is usually made of steel, but when replaced by aluminium increases the ability to absorb high impact and also reduces the weight. Usually aluminium connecting rod is used in high performance engine. Generally steel is used for manufacturing of connecting rod because it gives high strength, high durability and lower cost. But the main disadvantage is its high mass density which exerts excessive stresses on the crankshaft of a high speed engine. This requires a heavier crankshaft for carrying the loads, thus decreasing the maximum RPM. Also this reduces the acceleration or declaration rates of engine speed. Thus replacing conventional steel connecting rod by aluminium reduces the weight of the engine component, thus reducing inertia loads, reducing engine weight and improving engine performance and fuel economy. The more recent pickup truck GMT-400 (1988 model) carries a composite driveshaft that is pultruded around a 0.2cm thick and 10cm diameter aluminum tube. This driver shaft is 60% lighter than the original steel shaft and possesses superior dampening and torsional properties (Sasi *et al*, 2012).

Comparative study of mainly used materials for manufacturing of connecting rod is given below.

Table 2 Material properties of different alloys **(**Ahmed *et al*, 2014).

Properties	Aluminium 5086-H32	Aluminium 1060	Alloy steel
Density	2600 kg/m^3	2700 kg/m^3	7850kg/m^3
Material type	Isotropic	Isotropic	Isotropic
Poisons ratio	0.33	0.33	0.28
Yield strength	6.89476Ee+007N/m^2	73084.4Mpa	6.20422e+008 N/m^2
Tensile strength	2.9e+008N/m^2	6.89356Ee+007N/m^2	7.23826e+008 N/m^2
Elastic Modulus	7.1e+010N/m^2	6.9e+010N/m^2	2.1e+010 N/m^2

Thus comparative study of the above three alloys gives us the conclusion that the alloy 5086-H32 is the best suited for manufacturing of connecting rod of an internal combustion engine because of its least density and good tensile strenght and elastic modulus. This can be concluded as, the alloy steel can be replaced by alumnium alloy 5086-H32.(5xxx series).

Table 3 Comparision between cast iron and aluminium

Property	Discussion	Suitable material
weight	Weight of aluminium is much lighter than the cast iron	aluminium
Heat dessipation	Heat dessipation of aluminium is better than the cast iron	aluminium
Wear and tear	Resitance to wear and tear is better than that of the aluminium	Cast iron
machinability	Aluminium provides ease in machinability than that of the cast iron	aluminium
Fuel economy	Becouse of less weight aluminium gives higher fuel economy	aluminium
detonation	Better heat dissipation maintains low temprature of combustion engines and hence reduces the detonation	aluminium
High revolution	Becouse of less weight aluminium requires less energy to reach higher rpm	aluminium
Economy	Aluminium is costly as comapred to cast iror	Cast iron

CONCLUSION

This study concludes that aluminium alloys can be a much better alternative for cast iron for manufacturing engine componets. Cost of aluminium is higher than cast iron but if we comapare the results obtained in fuel economy, emissions and reduction in weight it is better to use aluminium.

Pistons made from aluminium alloys requires less energy to move hence higher RPM can achived easily it also provides better cooling becouse of high rate of heat transfer.

This comparative study of aluminium alloys and alloy steel shows that the former gives us a greater yield strength and lighter weight. The only drawback using aluminium in for

manufacturing of connecting rod is it has comparatively less durability to steel. Also looking at the properties the alloy 5086-H32 is best material for manufacturing of the connecting rod. The crank shaft if replaced with aluminum will give good results and induce much less pressure on the aluminum connecting rod and help increase its life.

References

1. R. S. Rana, Rajesh Purohit, and S Das, (2012).Reviews on the Influences of Alloyingelements on the Microstructure and Mechanical Properties of Aluminum Alloys and Aluminum Alloy Composites. *International Journal of Scientific and Research Publications*, Volume 2, Issue 6;, pp.1-7.
2. N. L. Sukiman, X. Zhou, N. Birbilis, A.E. Hughes, M. C. Mol, S. J. Garcia, X. Zhou and G. E. Thompson, (2013) Durability and Corrosion of Aluminium and Its Alloys: Overview, Property Space, Techniques and Developments, pp 1-52.
3. Jonathan A. Lee. (2013) Cast Aluminum Alloy for High Temperature Applications, TMS (The Minerals, Metals &Materials Society, NASA-Marshall Space Flight Center, Mail Code ED33, Huntsville, AL 35812, USA, pp.1-8.
4. G.M Sayeed Ahmed, Sirajuddin Elyas Khany, Syed HamzaShareef, (2014) Design, Fabrication and Analysis of a Connecting Rod with Aluminum Alloys and Carbon Fiber, "*International Journal of Innovative Research in Science, Engineering and Technology*, Vol. 3, Issue 10,1-14.pp.1-14
5. Hieu Nguyen, (2005) Manufacturing Processes and Engineering Materials Used in Automotive Engine Blocks, EGR250 – Materials Science and Engineering, Section B, pp 1-14.
6. Sasi Kiran Prabhala, K. Sunil Ratna Kumar, (2012) DESIGN AND WEIGHT OPTIMIZATION OF IC ENGINE," Prabhala *et al*, *International Journal of Advanced Engineering Research and Studies*, Vol. II, Issue I, Oct.-Dec., pp.1-3.
7. Ron Cobden, Alcan, Banbury.1994, Aluminium: Physical Properties, Characteristics and Alloys, TALAT Lecture 1501, pp.1-60.

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