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A Comparative Study on Forecasting and Analysis of 4140 Material Composition of Connecting Rod for Various Applications

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Abstract:

This paper presents a perfect forecasting proposal for composition of material for connecting rod. The material of connecting rod is as important as it will break the work or production. The material of connecting rod is highly inevitable due to its role in work mechanism of various machineries. Diesel generator set and steam engines are few places where connecting rods perform pivot role. Here an attempt is made to forecast the appropriate material composition including alloy percentage for specific operation for material 4041. Fuzzy logic is used to forecast the material composition with percentage in Mat lab environment.

Keywords

Connecting Rod, Ductability, Fuzzy Logic, 4140

1. Introduction

Connecting Rods are used practically in all varieties of automobile engines. These behave as an intermediate link between the piston and the crankshaft of an engine of an automobile. It is responsible for transmission the up and down motion of the piston to the crankshaft of the engine, by converting the reciprocating motion of the piston to the rotary motion of crankshaft. Now a day's Aluminum connecting rods are used in Automobile Internal combustion engine but aluminum connecting rod having a more ductile & low stiffness. [2]. Connecting rod is one of the important driving parts of Light vehicle engine it forms a simple mechanism that converts linear motion into rotary motion that means the connecting rod is used to transfer linear, reciprocating motion of the piston into rotary motion of the crankshaft.[5]

The one end, small end the connecting rod connected to the piston of the engine by the mean of piston pin and the mechanism, the other end, the bigger end being connected to the crankshaft with lower end big end bearing by generally two bolts. Connecting rod is most important components of the complete engine assembly as it acts as a mediator between piston assembly and crankshaft. To provide the maximum rigidity with minimum weight, the cross section of the connecting rod is made as and I – section end of the rod is a solid eye of connecting rod or a split eye that is used to holding the piston pin. The big end works on the crank pin and is always split. In some connecting rods, a hole is drilled between two ends for carrying lubricating oil from the big end to the small end for lubrication of piston and the piston pin. The connecting rod fabricated from an AISI/SAE 4140 low alloy steel; chemical composition, mechanical properties and microstructure were appropriate for the application. [1]. The only problem with using steel rods is that the material is extremely heavy, which consumes more power and adds stress to the rotating assembly. Performance steel rods can be made from 4340 and even 300M grade steel. The tensile strength, yield strength, and hardness of 4340 steel depends on the temperature at which the steel is forged, and how the steel is heat treated.[7] The 4340 is also a type of 4140. It is the modification of 4140 that changes the composition of material. The most common types of Connecting rods material are steel and aluminum and most common manufacturing processes are casting,

forging and powdered metallurgy. Connecting rods are widely used in variety of engines such as, in-line engines, V-engine, opposed cylinder engines, radial engines and opposed-piston engines [8]. The connecting rod faces a complex state of loading. It undergoes high cyclic loads of the order of 10^8 to 10^9 cycles, which range from high compressive loads due to combustion, to high tensile loads due to inertia [3]. The major stresses induced in the connecting rod are a combination of axial and bending stresses in operation [10]. The protection of connecting rod from corrosion has very important issue but in case of material 4140 resistivity of material will increase according to the requirement.[4]

The materials used for connecting rods are mild carbon steels (having 0.35 to 0.45 percent carbon), alloy steels (chromium-nickel or chromium-molybdenum steels) and different alloys like aluminum alloys, magnesium alloys, titanium alloys and polymeric materials. These alloys are used for different applications depending upon the ultimate tensile strength required for the particular application [9]. The material of connecting rod is as important as it may break the work or production. The material of connecting rod is highly inevitable due to its role in work mechanism of various machineries such as Diesel generator set or IC engines. Here an attempt is made to forecast the appropriate material composition including alloy percentage for specific operation for material 4041 material using Fuzzy logic technique through tool box used in Mat lab environment.

Sadaphale The research work describes the design & modeling analysis of IC engine connecting rod using two different Materials. 1st one aluminum material & second one aluminum fly ash silicon based composite material & compare to the farmer material to the new Material found to have less weight & better stiffness. Carrying out that modification to engine element will result ineffective reduction of weight increase of durability or machinability of particular part will lead to decrease of overall engine weight improvement in its traction parameter & increasing performance of engine [1].

Apasi *et.*al. The study deals with the performance of metal matrix composite connecting rod and the regular carbon steel connecting rod. The study work commenced with casting of the Metal Matrix Composite sample connecting rod by stir-casting method and purchasing the Regular (carbon steel) connecting rod to serve as control. A performance test of the two sample connecting rods was carried out using a Toyota starlet Engine of 12 valve model E series. The tentative result obtained showed that the duration and rate of fuel consumption for the regular connecting rod varied from 0.3 to 0.636kw/h, while that of the composite connecting rod, varied from 0.33 to 0.58kw/h. But for both connecting rods as the speed increases the brake horse power also increased. [2]

Jeeva Bharathi et.al. The conventional connecting rod used in the engines was replaced with a composite connecting rod. The predictable connecting rod and the Composite connecting rod were analyzed by finite element methods. From the results, it is clear that the stress induced in the composite connecting rod is found to be lower than that of the conventional connecting rod. Composite connecting rod material is replaced for good fatigue strength, minimizing weight and without violating the limiting constraint formed by induced stress. A reduction of 31.5% weight is achieved when a conventional connecting rod is replaced with composite connecting rod under identical conditions of design parameters [3].

Pathan and Wasekar This research paper gives idea about the result weight of the connecting rod can be reduced by replacing the old material AB60 by Aluminum Fly ash silicon compound which has higher strength and is manufactured using industrial waste such as fly ash [4].

Bedse and Ahire The main objective of this research work is design evaluation through finite element analysis for fatigue life of Hero Honda Motor Cycle connecting rod. By using FEA and Experimentation method find the structural system of the existing connecting rod and on the

basis FEA and Experimentation result recommend the best alternative design for connecting rod. 3D model of connecting rod is created in CATIA software and it will be analyze in HYPERMESH software. The structural strength of connecting rod will be verified on [5].

Patil and Chhapkhan The work used for connecting rod is analyzed by using three different materials such as AISI4340 steel alloy, AISI7068 and Titanium alloy. Results of axial load carrying capacity and weight reduction of connecting rod of material AISI4340 and Titanium alloy is compared. By checking and comparing the results of materials in finalizing the results are shown in below [6].

2. Soft Computing Technique with Special Reference to Fuzzy Logic

In present research work, application of soft computing techniques is made to solve the research problem. Following are the details of techniques. Soft computing could be a branch, in which, a shot is created to make intelligent wiser and quick machines & systems. Intelligence provides the ability to derive the solution and not merely arrive to the solution. Purity of thinking, machine intelligence, freedom to figure, dimensions, quality and indistinctness handling capability will increase we tend to go higher within the hierarchy. the ultimate slogan is to develop hardware and package which {can| which is able to} add an identical approach as citizenry can do. Intuitive consciousness knowledge is additionally one in all the vital space within the soft computing, that is usually cultivated by meditation. this is often so, a unprecedented challenge and nearly a replacement development, to incorporate consciousness into the computers. Soft computing is associate rising assortment of methodologies that aim to take advantage of tolerance for inexactitude, uncertainty, and partial truth to attain strength, traceableness and total low price. Soft computing methodologies are advantageous in several applications. In distinction to analytical strategies, soft computing methodologies mimic consciousness and knowledge in many.

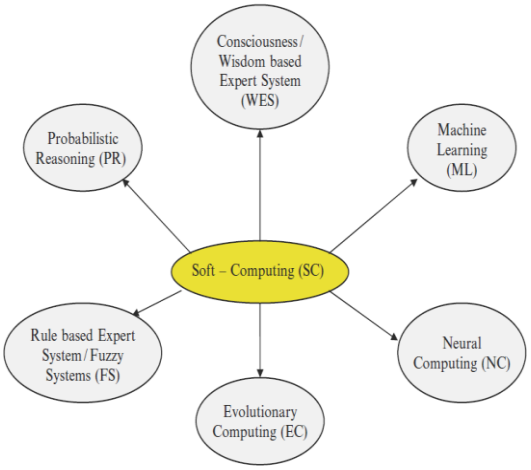

Figure 1: Soft Computing Techniques with branches

Soft computing may be a partnership within which every of the partner's contributes a definite methodology for addressing issues in its domain. During this perspective the principal constituent methodologies in SC area unit complementary instead of competitive. What is more, soft computing is also viewed as a foundation part for the rising field of abstract intelligence.

3. Simulation & Result

This section presents the simulation of proposed work and results. Fuzzy logic is used for deciding the priority among different alloy composition for better requirement of material. The proposed work is focused on composition, application, and analysis and forecasting of specific mixing of alloys for specific applications of material 4140. The 4140 material has some very specific physical properties like high tensile strength, hardness, ductility, machinability etc. The material is extremely useful where high mechanical torque, constant operation for long time

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& high temperature working atmosphere is present so the material should match the required standard. It is used in internal part of internal combustion engine as connecting rod or cam shaft. The composition of 4140 material already discussed in chapter no 2. Here the proposed work is simulated on MATLAB environment through fuzzy logic tool box. The fuzzy logic method gives fast and accurate result of material composition. Composition of 4140 varies with different properties of material. These variations of properties of material check by fuzzy logic tool in MATLAB software. The composition of 4140 material continuously changes accordingly your requirement that depends upon variation of composition under given limit. Five input parameter is used as a group of properties. According to the number of properties input parameter are selected and these input parameter are direction of alloy of these properties. By considering all these input parameter total five input variable are designed. Then priority of each alloy counted as a output parameter. So there are five output variable are designed.

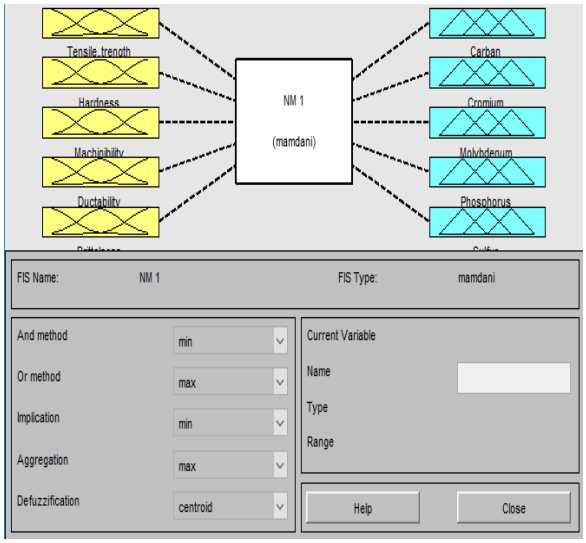

Figure 2: Input output variables

There are five input variable named as a tensile strength, hardness machinability etc. For variable tensile strength five membership functions are selected. First low, medium, high and other is very high.0 to 1 is the range for this input variable in which 0 to 0.2 is taken as very low, 0.2 to 0.4 is taken as low, 0.4 to 0.6 is taken as medium, 0.6 to 0.8 is taken as high, and 0.8 to 1 is taken as very high.

The next variable is hardness. There are also five membership functions is this variable four shape and range are same as tensile strength.

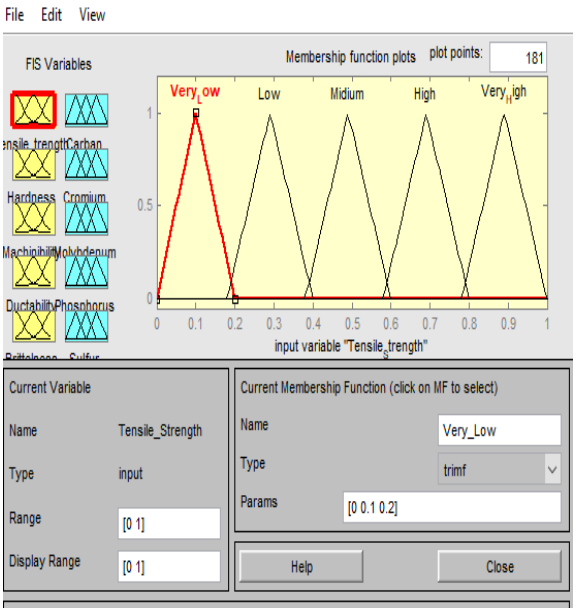

Figure 3: Membership function of tensile strength

Then there are five output variable named as given in fig. For every output variable there are four memberships function named as low, medium, high and very high.

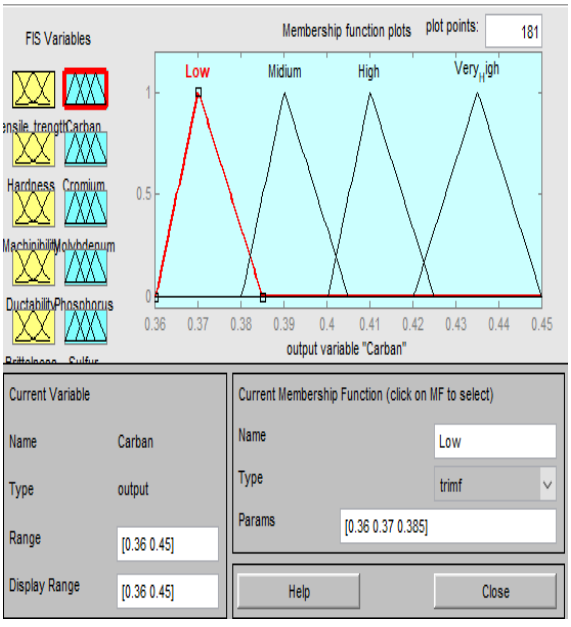

Figure 4: Membership function of output variable

On applying boundary conditions following results were obtained.

Table No 1:
Connecting Rods Material Composition for different Application using 4140

Sr No	Connecting Rod	Carbon C (in %)	Chromium Cr (in %)	Molybdenum Mo (in %)	Phosphorus P (in %)	Sulfur S (in %)
1	Diesel Generator	0.435	1.06	0.215	0.0149	0.019
2	IC Engine (petrol)	0.412	1.05	0.215	0.024	0.014
3	IC Engine (Diesel)	0.412	1.05	0.237	0.024	0.014
4	Steam Engine	0.405	0.95	0.02	00.02	0.02
5	Reciprocating Compressor	0.452	1.02	0.19	0.0149	0.0149

4. Conclusion

The 4010 material is specially designed for heavy work and robust performance. The connecting rod technology requires extra care during design and drawing even in selection of proper materials for manufacturing. Here fuzzy logic is used to forecast the general requirement of specific application based composition of alloy. Every different application requires a specific composition of metals and alloys. Fuzzy logic tool box using mat lab shows excellent result and ease of use even for beginners. The work shows here is a different kind of work itself and extremely useful in selection of material for connecting rod in seconds without any mathematical calculations. 4140 material is used extensively for such applications but within this material to a possibility of partial changes of metal compositions due to different applications based on different physical properties required.

The proposed work is good enough to select the proper material composition but at every place there is a possibility to improve. The use of other Artificial Intelligence techniques such as Machine learning and ANN may also use for selection of composition and a comparative study may present for manufacturer those who are interested in CAM and automation.

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