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Comparison Studies on Mechanical Properties of Hybrid Metal Matrix Composite

[1]Ravi Butola[*], [2] Dadge Mukesh Shamrao, [3]Ranganath M.Singari
([1,2,3]Department of Mechanical Engineering, Delhi Technological University, Delhi, India)
[*]Email: ravibutola33855@gmail.com

Abstract : In this study, we are trying to develop Hybrid matrix composite (HMMC) reinforced with natural fibres which include Rice Husk Ash (RHA), Ground Nut Ash (GSA), and other reinforcement like SiC, Graphite. Different reinforcements have different effects on hybrid metal matrix composite. In this paper we have optimize it with the help of software called Quantum XL. Which utilizes the Design of experiment technique for the optimization. Such optimization process is necessary for the improvement in the properties of hybrid metal matrix composites. The main effects plot for Fracture Toughness, specific strength and percentage elongation. Properties like hardness, ultimate tensile strength, fracture toughness etc have been studied rigorously and been summarise. The results obtained from this study will help us to decide that in what proportion of the various reinforcement should be mixed.

Keywords: Hybrid Metal matrix Composites, Reinforcement, Hardness, ultimate tensile strength.

1. INTRODUCTION

Aluminium alloys reinforced with ceramic particles exhibit superior mechanical properties to unreinforced Al alloys and hence are candidates for engineering applications. Most of the research work is carried out to develop composites using various recycled waste In our project, we are trying to develop an Aluminium matrix composite reinforced with various natural ashes which includes Rice Husk Ash, Coconut Fibre Ash, Sugarcane Bagasse Ash and Ground Nut Ash. During milling of paddy about 78 % of weight is received as rice, broken rice and bran, rest 22 % of the weight of paddy is received as husk. This husk contains about 75 % organic volatile matter and the balance 25 % of the weight of this husk is converted into ash during the firing process. This ash is known as rice husk ash (RHA). Similarly, we can obtain coconut fibre, groundnut remains ash and sugarcane bagasse ash and these all can be used in combination with RHA to impart superior properties to Aluminium. As we know from the reviews of the various research papers that excess of any ash in aluminium can deteriorate its properties. Hence, we need to optimize the content of ashes in order to achieve optimized properties of the composite like fracture toughness, percentage elongation, ultimate tensile strength etc. So, that is why we need a specific amount of combination of these ashes. Hence, in this report we will optimize it with the help of software called Quantum XL which utilizes the design of experiment (DOE) technique for the optimization. Sharma and Butola [1] have reported that adding a new element in the Metal Matrix Composite makes it Hybrid. HMMC's provide better machinability and tribological properties. In CNC turning process, Surface Roughness and MRR are two main parameters. The Objective of the present paper review is to determine the optimum machining parameters in CNC turning of HMMC using different algorithms and techniques. Ravi et al. [2] have study Aluminium composites have a wide range of applications and serve as an important tool in various industries. Different reinforcements have different effects on aluminium matrix composite. In this paper these different effects and properties are studied for reinforcing materials such as Silicon Carbide, Graphite, Fly ash, Rice husk ash and boron halide. Prasad and Shobha [3] have reported Microstructural characteristics of hybrid composites reinforced by SiC and rice husk ash (RHA) particles. The presence of RHA and SiC particles were also confirmed in the SEM micrographs of hybrid composites. From this we can conclude that it is possible to obtain nearly uniform distribution of particles in the hybrid composites. It has been found by the researchers that the ultimate tensile strength of hybrid composites containing alumina and RHA decreases with an increase in RHA percentage. Alaneme KK et al [4] This may be attributed to the reason that the elastic modulus of silica (which is a major constituent of the RHA) is in the range of 60–70 GPa i.e nearly about of pure aluminium. But, the elastic modulus of ceramics particulates (SiC or Al_2O_3) is of much higher value (the order of 300–450 GPa). Prasad SD et al [5,6] have reported that, the load carrying capacity of the hybrid composites will be dependent on the amount of ceramics particulates rather than RHA contents. However, the specific strength of Al/2 wt.%RHA/8 wt.%Al_2O_3(45.5 MPa/g/cm3) hybrid composite was found to be higher than the ceramic reinforced composite (~2% higher. The specific strength and percent elongation of the hybrid composites decreased with increase in contents of agro-waste ashes with a few exceptions. It has been observed that the addition of lightweight reinforcements reduces the density of the hybrid composites. Boopathi et al. [7] have observed an increasing trend in the hardness of composite with increase in weight fraction of reinforcements. They observed maximum hardness for Al/10 wt.% SiC/10 wt.% fly ash hybrid composites. Low values of hardness and strength are preferred to improve the machinability of composites. Alaneme et al. [8] have investigated the hardness of HAMCs reinforced with ceramics particles and agro waste ashes (RHA) and observed decrease in hardness value with increase in RHA contents. The four types of composites were developed: AI, AII, AIII, and AIV having weight ratio of RHA and alumina as 0:10, 2:8, 3:7 and 6:4 respectively to evaluate variation of hardness with RHA contents. The results show that the hardness of AII, AIII, AIV hybrid composite decreased by a fraction of 4.58%, 8.14% and 10.94%, respectively, in comparison with the single reinforced composite (AI). Chawla and Shen [9], the direct strengthening arises as a result of the addition of harder and stiffer reinforcements in the soft matrix. Due to presence of hard phase in the composites, the applied load is transferred from the matrix to the reinforcement through the interface. The increase in reinforcement fraction or decrease in particle size increases the amount of in direct strengthening due to increase in dislocation density. Tiwary et al. [10] Aluminium alloys reinforced with natural ash exhibit superior mechanical properties to unreinforced Al alloys. To develop an Aluminium matrix composite reinforced with various natural ashes which includes Rice Husk Ash and Ground Nut Ash. In this paper these different effects and properties are studied for reinforcing materials such as natural ashes which include Rice Husk Ash (RHA), and Groundnut Shell Ash (GSA) Properties like hardness, ultimate tensile strength, fracture toughness etc have been studied.

2. DATA AND ANALYSIS

2.1 Design of Experiments

Design experiments can be used to systematically investigate the process or product variables that influence product quality. After you identify the process conditions and product components that influence product quality, you can direct improvement efforts to enhance a product's manufacturability, reliability, quality, and field performance Well-designed experiments can produce significantly more information and often require fewer runs than haphazard or unplanned experiments. For example, if there is an interaction between two input variables, be sure to include both variables in your design rather than doing a "one factor at a time" experiment. An interaction occurs when the effect of one input variable is influenced by the level of another input variable. Designed experiments are often carried out in four phases: planning, screening, optimization, and verification.

2.2 Planning

Careful planning can help you avoid problems that can occur during the execution of the experimental plan. For example, personnel, equipment availability, funding, and the mechanical aspects of your system may affect your ability to complete the experiment. The preparation required before beginning experimentation depends on the problem. These are following. Define the problem, Define the objective. , Develop an experimental plan that will provide meaningful information.

2.3 Screening

Screening reduces the number of variables by identifying the key variables that affect product quality. This reduction allows you to focus process improvement efforts on the really important variables, or the "vital few." Screening may also suggest the "best" or optimal settings for these factors, and indicate whether or not curvature exists in the responses. Then, you can use optimization methods to determine the best settings and define the nature of the curvature.

2.4 Optimization

After you have identified the "vital few" by screening, you need to determine the "best" or optimal values for these experimental factors. Optimal factor values depend on the process objective. For example, you may want to maximize process yield or reduce product variability. • Factorial Designs Overview describes methods for designing and analyzing general full factorial designs.

2.5 Verification

Verification involves performing a follow-up experiment at the predicted "best" processing conditions to confirm the optimization results. For example, you may perform a few verification runs at the optimal settings, and then obtain a confidence interval for the mean response.

3. RESULT AND DISCUSSION

3.1 Main effect plots

When performing a statistical analysis, one of the simplest graphical tools at our disposal is a Main Effects Plot. This plot shows the average outcome for each value of each variable, combining the effects of the other variables as if all variables were independent. The main effects plot displays the means for each group within a categorical variable. DOE creates the main effects plot by plotting the means for each value of a categorical variable. A line connects the points for each variable. Look at the line to determine whether a main effect is present for a categorical variable. In the design of experiments and analysis of variance, a main effect is the effect of an independent variable on a dependent variable averaging across the levels of any other independent variables.

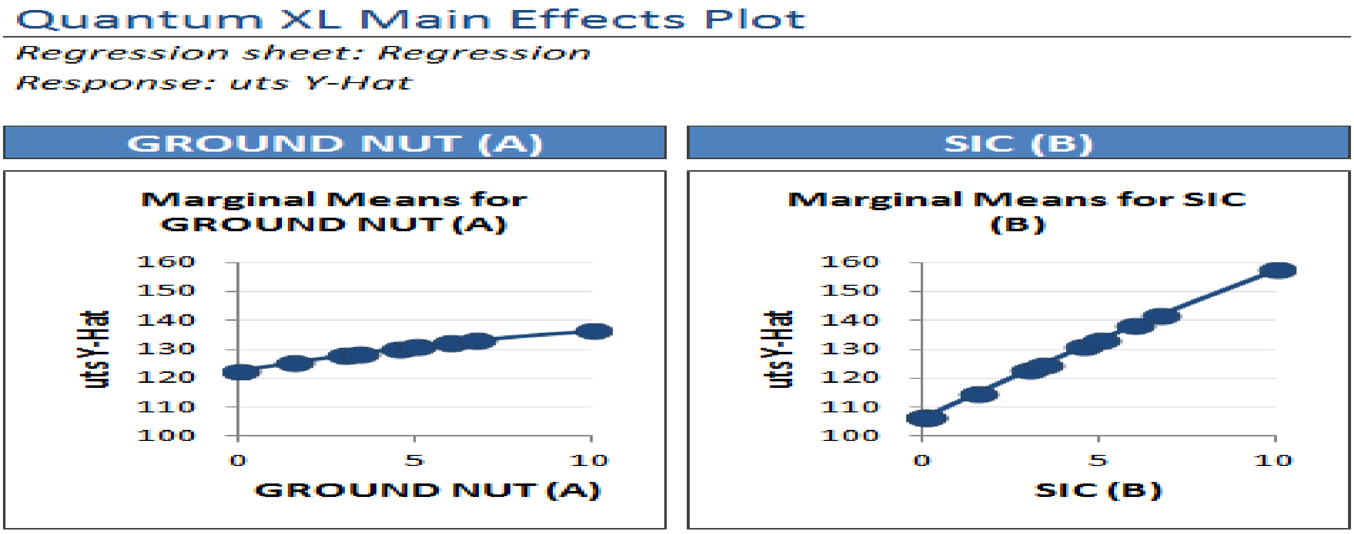

Fig 1: Shows main effect plot of variations of ultimate tensile strength vs varying %age composition of GSA and SIC

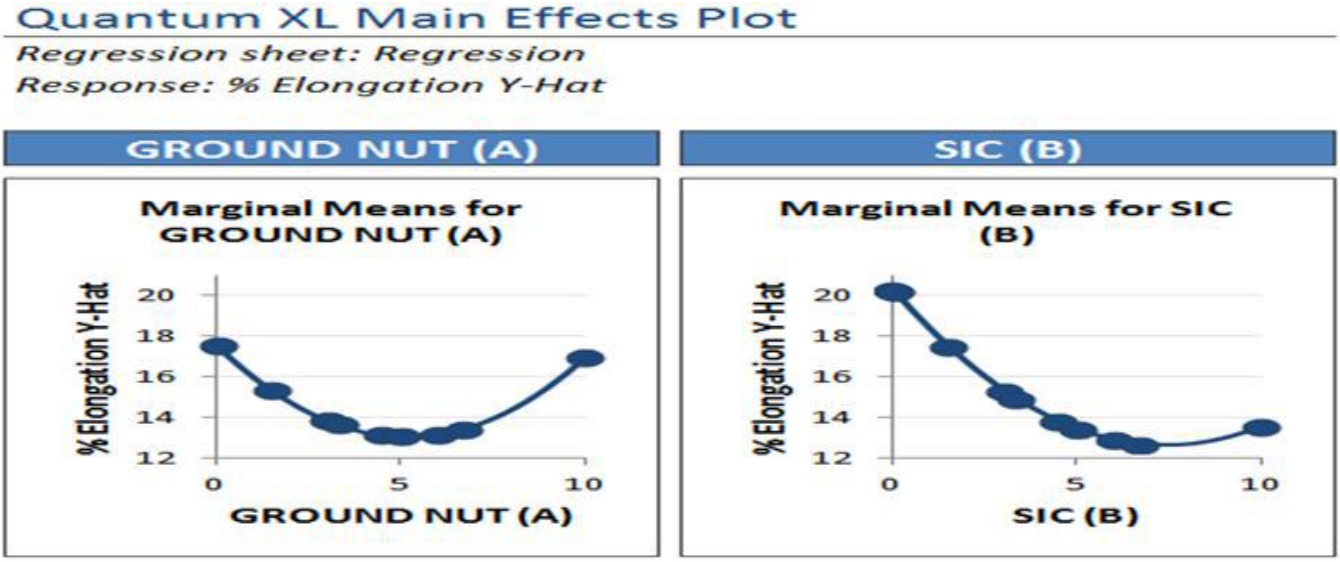

Fig 2: Shows main effect plot of variations of percentage elongation vs varying %age composition of SIC and GSA

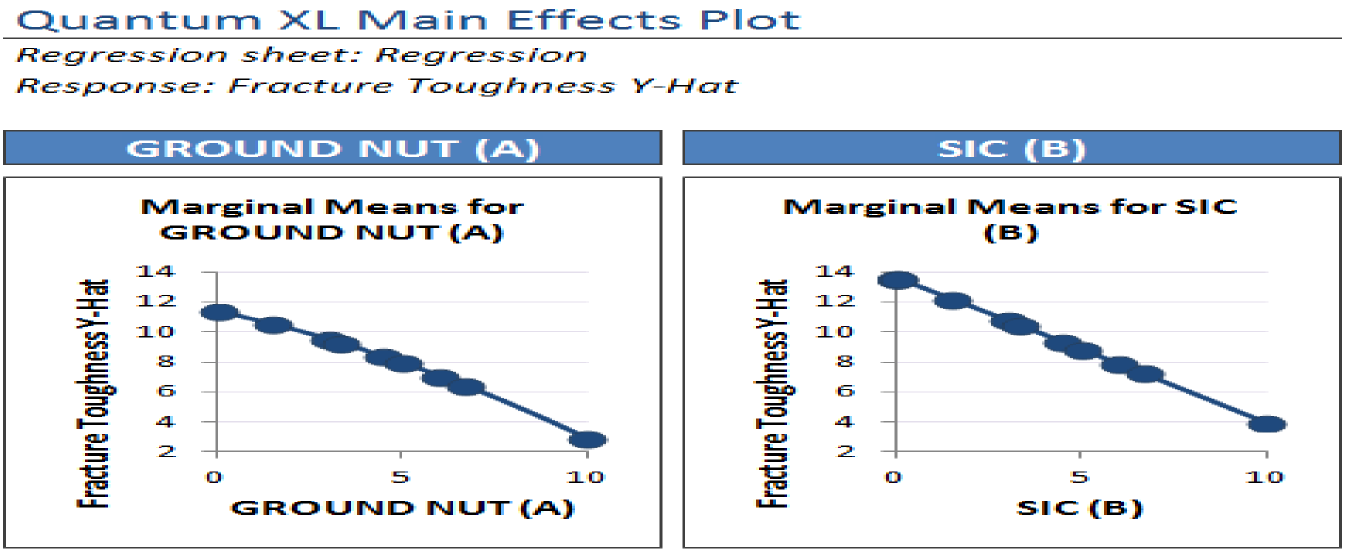

Fig 3: Shows main effect plot of variations of fracture toughness vs varying %age composition of SIC and GSA

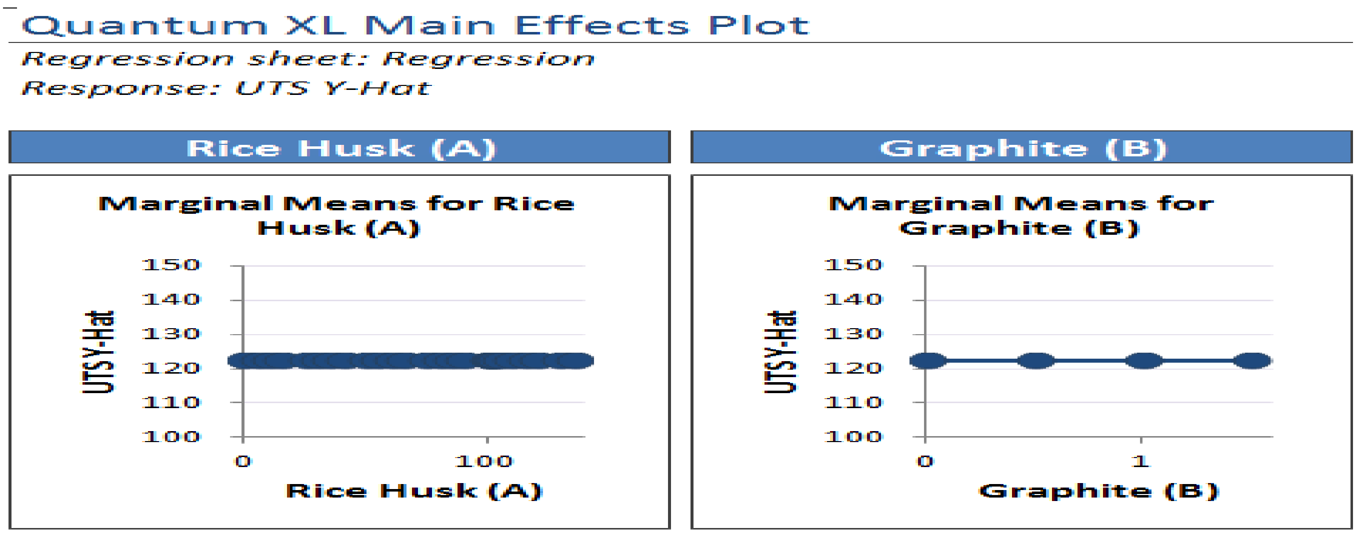

Fig 4**:** Shows main effect plot of variations of ultimate tensile strength vs varying %age composition of graphite and RHA

3.2 Interaction plots

We have used an interaction plot to show how the relationship between one factor and a continuous response depends on the value of the second factor. This plot displays means for the levels of one factor on the x-axis and a separate line for each level of another factor. The lines are evaluated to understand how the interactions affect the relationship between the factors and the response. There are 2 conditions in an interaction plot and they are if lines are parallel then there is no interaction occurs. If lines are intersecting then an interaction occurs. The more non parallel the lines are, the greater the strength of the interaction.

3.3 RHA and Graphite v/s Vickers Hardness*:*

As shown in both the graphs below, the interaction between Rice Husk and Graphite for Vickers Hardness and UTS is quite weak and that can be concluded by the non-intersecting lines:-

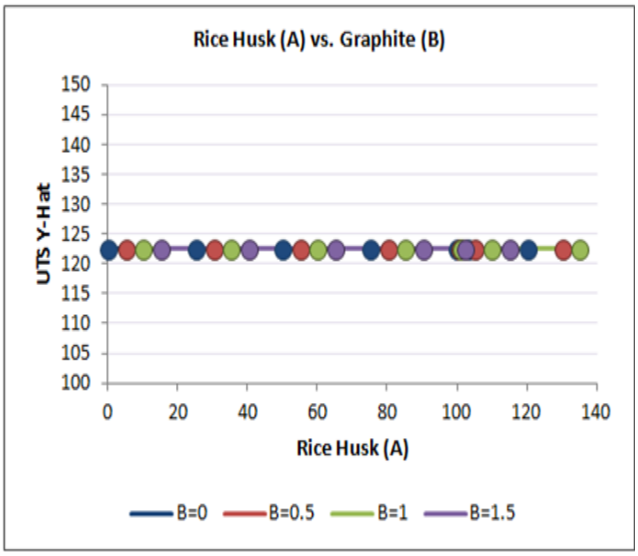

Fig 5: Interaction plot of variations of UTS vs RHA

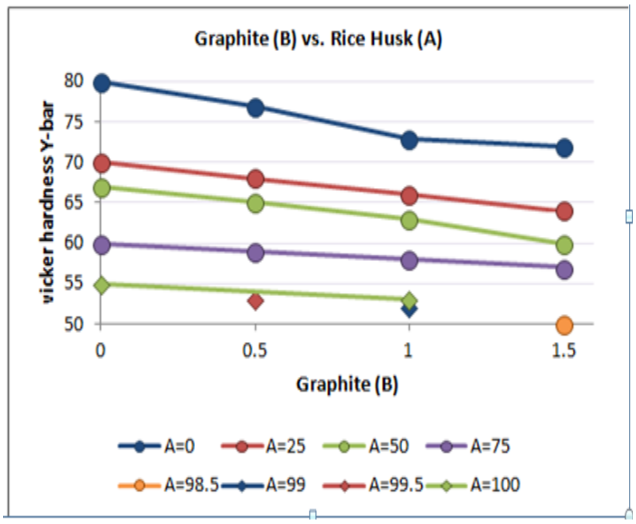

Fig 6**:** Interaction plot of Hardness vs Graphite

4. CONCLUSION

The conclusion derived by this investigation about the main effects plot of various reinforcement on the mechanical properties of hybrid metal matrix composite has been studied.

1. The context of factorial designs and regression models to distinguish main effects from interaction effects.
2. When the line is horizontal (parallel to the x-axis), there is no main effect present and the response mean is the same across all factor levels.
3. When the line is not horizontal, there is a main effect present. The response mean is not the same across all factor levels. The steeper the slope of the line the greater the magnitude of the main effects.
4. In an interaction plot and they are if lines are parallel then, there is no interaction occurs. If lines are intersecting then an interaction occurs. The more non parallel the lines are, the greater the strength of the interaction.

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