

Optimization of Mechanical Stir Casting Parameters for Fabrication of Al5083-SiC Alloy Composite through Taguchi Method

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ABSTRACT: The “composite material” is composed of a discrete reinforcement & distributed in a continuous phase of matrix. In Aluminium matrix composite (AMC) one constitutes is aluminium which forms network i.e. matrix phase and another constitute serve as reinforcement which is generally ceramic or non metallic hard material. The basic reason of metals reinforced with hard ceramic particles or fibers are improved properties than its original material like strength, stiffness etc. Stir casting process is mainly used for manufacturing of particulate reinforced metal matrix composite (PMMC). Properties of these materials depend upon many processing parameters and selection of matrix and reinforcements. This paper presents an overview of stir casting process, process parameter, & preparation of AMC material by using aluminium as matrix form and SiC as reinforcement by varying proportion. The optimization and effect of variables such as amount of SiC, stirring speed and quenching type were investigated using a robust design of experiment (DOE), namely, Taguchi method, with two factorial levels. The signal-to-noise (S/N) ratio (‘larger is better’) for hardness and (‘smaller is best’) for wear resistance were used as response variables.

KEYWORDS: Text detection, Inpainting, Morphological operations, Connected component labelling.

I. INTRODUCTION

Now days with the modern development need of developments of advanced engineering materials for various engineering applications goes on increasing. To meet such demands metal matrix composite is one of reliable source. Composite material is one of the reliable solutions for such requirement. In composites, materials are combined in such a way as to enable us to make better use of their parent material while minimizing to some extent the effects of their deficiencies. The simple term ‘composites’ gives indication of the combinations of two or more material in order to improve the properties. In the past few years, materials development has shifted from monolithic to composite materials for adjusting to the global need for reduced weight, low cost, quality, and high performance in structural materials. Driving force for the utilization of AMCs in areas of aerospace and automotive industries include performance, economic and environmental benefits. In AMC one of the constituents is aluminum, which forms percolating network and is termed as matrix phase. The other constituent is embedded in this aluminum and serves as reinforcement, which is usually non-metallic and commonly ceramic such as SiC, Al₂O₃ etc.

Strengthening composites involves considering several variables, such as pre-processing methods for purifying and activating reinforced materials, mixing processes (temperatures, mixing techniques, amount of reinforced materials) and post-processing methods (sintering, extrusion, compaction, thixoforming and heat treatment). According to Wu and Chang and Gurkan and Cebeci, a robust design technique, namely, Taguchi

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Vol. 8, Issue 8, August 2019

method is one of the best tools to optimize parameters for composite development. Ceschini et al indicated that the amount of reinforced material, process temperatures, types of wetting agent, stirring method and stirring duration play key roles in determination of the final physical and mechanical properties of aluminium alloys fabricated by stir casting.

II. EXPERIMENTAL PROCEDURE

Materials: Aluminum alloy 5083 was selected as matrix alloy for synthesis of AMCs. The chemical compositions are shown in Table 1. Silicon Carbide particulates were used as reinforcement material and average particle size was 40 to 60 μm (SiCp- β , 99+% pure).

Plan of investigation:

The research work was planned to be carried out in the following steps:

- Identifying the important controllable process parameters.
- Finding the range of identified parameters viz. weight fraction of reinforcement, stirrer speed and quenching type.
- Developing the composite design matrix.
- Producing the stir-cast specimen as per design matrix.
- Conducting hardness test and wear test recording the values.
- Developing the hardness model and checking the adequacy.
- Results and discussion.

The experimental plan was formulated considering three parameters (variables) and two levels based on the Factorial Design technique. The levels of these variables chosen for experimentation are given in Table 2. Synthesis of aluminum alloy SiC composites casting was done according to composite design matrix. Four samples each with 3% and 6% weight fraction of SiC of composites were fabricated by stir casting.

Table 1: Composition of AA 5083 Al alloy

Element	Zn	Fe	Ti	Cu	Si	Pb	Mn	Mg	Cr	Al
%	0.03	0.173	0.04	0.0181	0.16	0.014	0.526	5.13	0.097	Balance

Table 2: Parameters and their levels

Level	Weight % of SiC (W)	Stirring speed (RPM)	Quenching
+1	3	450	Air
-1	6	650	Water

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Table 3: Design Matrix

Expt. No.	W	S	T
1	+1	+1	+1
2	+1	+1	-1
3	+1	-1	+1
4	+1	-1	-1
5	-1	+1	+1
6	-1	-1	-1
7	-1	-1	+1
8	-1	+1	-1

III. EXPERIMENTATION

First of all, Al 5083 alloy was heated to 680°C in a graphite crucible in electrical resistance furnace until the Aluminium alloy melted completely. The stirring speed and weight percentage of sic has been changed to according to the design matrix. The remaining parameters are kept as constant. The Al5083 is heated 3 hours in the furnace and then the sic particles are added to the furnace and stirring process is started slowly to reach the required speed of the stirrer blade. The stirring time kept as 15 minutes for complete mixing of al and sic particles after that the molten liquid poured into the moulds the work pieces are cooled down as per the design matrix.



Figure 1: Stir casting furnace

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IV. RESULTS AND DISCUSSIONS

Hardness Test:

Hardness Test Brinell hardness test was performed to measure the hardness of the specimens. A force of 250kg was applied on the specimens by indenter of diameter 5mm for 10 seconds. The depression formed was studied under the microscope and the Brinell hardness number was calculated accordingly. Three readings were taken at different positions on the specimens to get maximum accurate results. The readings are then plotted on the table 4 shows the observed readings and results. After completing the experiments according to the L_8 orthogonal array parametric combinations, hardness and wear resistance for each work piece is calculated. For the calculated values of hardness signal to noise ratios(S/N ratio) are obtained by using statistical tool MINITAB 17.



Figure 2: Work pieces after hardness test

Table 4: Hardness and wear values

S.no.	Hardness	Wear
1	53.90	0.0128
2	74.80	0.0091
3	76.07	0.0096
4	76.30	0.0016
5	77.27	0.0028
6	79.77	0.00278
7	70.00	0.0029
8	54.83	0.043

SN ratios can be calculated for the hardness and wear resistance. For the hardness always Larger is better static is preferred and for the wear resistance value smaller is better test static is preferred. According to Taguchi technique hardness is calculated based on Larger is better and wear resistance as smaller is better. The analysis carried out on MINITAB 17 software.

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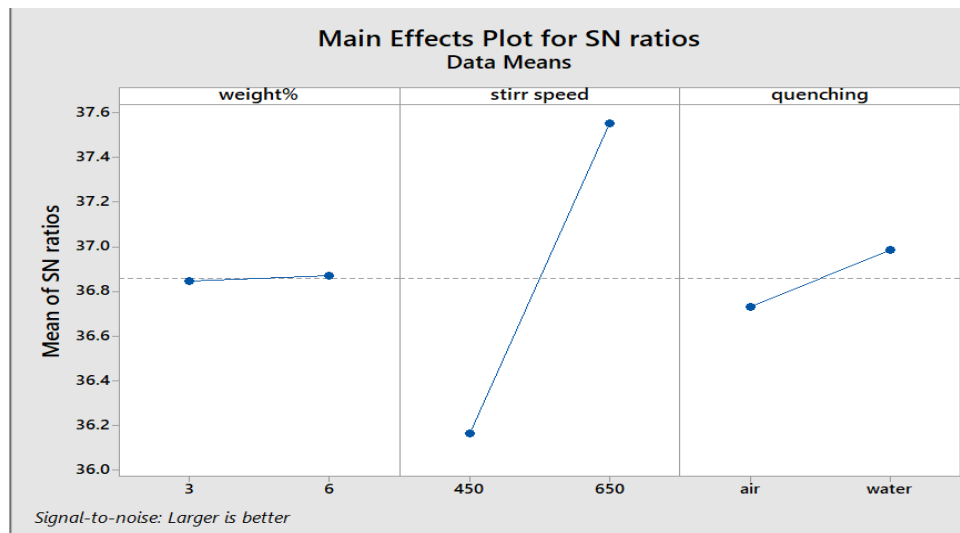


Figure 3: Main Effects plot for SN ratios of hardness v/s factors

Table 5: Response Table for Means

Level	Weight%	Stir speed	Quenching
1	70.27	65.20	69.31
2	70.47	75.53	71.42
Delta	0.20	10.34	2.11
Rank	3	1	2

Wear Test:

Wear resistance testing was done on Pin-On-Disc machine at load of 10N and rotational speed of disc of 477.46rpm. Standard cylindrical pin wear testing sample was prepared on the lathe machine having dimensions of 8mm diameter and 1inch length as shown in Figure 4

Following parameters were used to perform wear test.

Load (N)-10 Newton,

Disk Rotation speed-477.46rpm.

Track radius-60mm,

Time-11.10minutes.



Figure 4: wear test work pieces

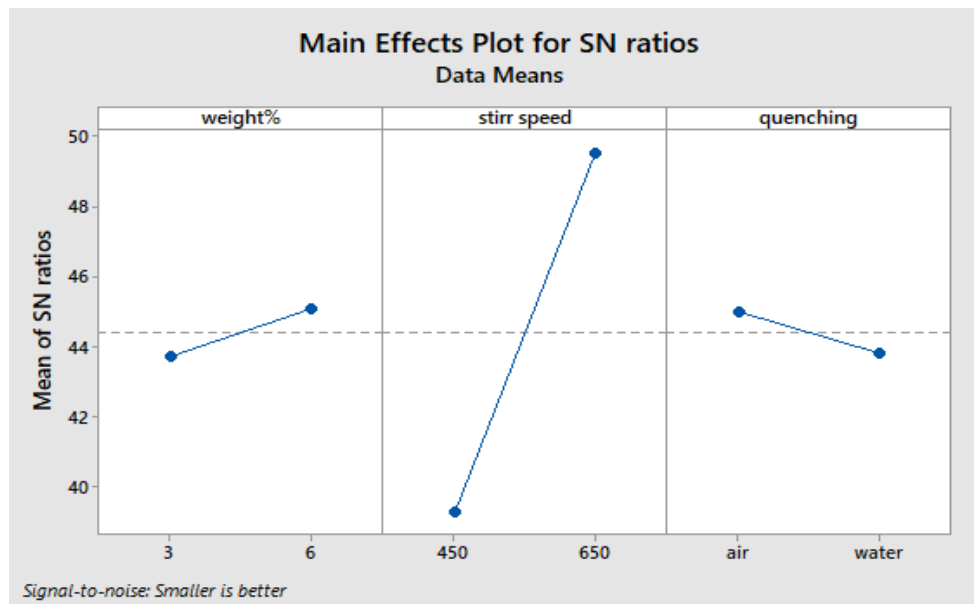


Figure 5: Main Effects plot for SN ratios of wear v/s factors

Table 6: Response Table for Means

Level	Weight%	Stir speed	Quenching
1	0.008275	0.016925	0.007025
2	0.012870	0.004220	0.014120
Delta	0.004595	0.012705	0.007095
Rank	3	1	2

The effect of input parameters on the wear resistance can be studied by analysing the data in MINITAB17 and can obtain the response table, response graph by which the effects of input parameters can be studied. From the response table the wear rate minimum at sic 3% stir speed 450rpm and work pieces cooled at air temperature. From the response table the wear resistance mainly effected by stir speed, quenching type, weight% of sic.

V. CONCLUSION

This study determined the effects of SiC weight%, quenching type and mechanical stirring on hardness and wear resistance of Al5083 composite. The robust L8 orthogonal array of Taguchi method with two levels of main factors was used to optimize the fabrication parameters. Analysis of signal-to-noise (S/N) ratio of the responses was also conducted to quantify the variations in hardness and wear.

Al 5083 composite was successfully fabricated using L8 processing considering the homogeneous distribution. These observations were critical in as suming the effective load transfer between the two materials. The highest hardness values of 79.77BHN obtained from the DOE run 6 sample containing of 6% of SiC, stirring speed 650rpm and quenching type is water. minimum wear 0.0016mm³/m were obtained from the DOE run 4 sample containing of 3% of SiC, stirring speed 650rpm and quenching type is water. Thus, the hardness (79.77%) and wear (0.0016) of the composite improved compared with those of the Al5083 alloy. Based on the Taguchi analysis, the speed of mechanical stirring was the major factor that influenced the improvement in the

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Vol. 8, Issue 8, August 2019

mechanical properties of the composite. The speed of the stirring played a more important role in improving the hardness of the material. The amount of SiC% exhibited the least effect on both properties of the composite.

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