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Effect of Casting Parameters on Tensile Strength of Chrome Containing Leather Waste Reinforced Aluminium Based Composite using RSM

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Abstract: The pollution of leather industry contains a wide variety of toxic substance. Many diseases are spread by these viruses, which enter the body through the mouth and nose. Leather industry waste that contains chrome is another sort of trash. Chrome Containing Leather Waste (CCLW) also generates various types of pollution. The study's response parameters are surface quality and energy consumption, while the machining parameters are cutting speed, feed rate, and depth of cut. The ideal set of machining settings, including those for minimal surface roughness and minimum energy consumption, have been determined using the response surface methodology (RSM). CCLW is used as primary reinforcement while for secondary reinforcement particle alumina has been utilized. Stir casting parameters were optimized using Response surface methodology (RSM), collagen was preheated at temperature 177.36°C, weight percent of collagen 1.43, stirring duration of stir casting is 180 s, alumina preheat temperature of 300°C and alumina weight percent of 5 has been determined to be best amalgamation of casting parameters. At optimal combination of characteristics, tensile strength of prepared composite was determined to be 162.45 MPa, composite tensile strength was increased by around 20.33 %.

Keywords: Collagen powder, Alumina particles, CCLW, Leather waste, Tensile strength

1. Introduction

Wastes generated by industries are causing much environmental pollution. These wastes lay outside. If they are not dumped somewhere else at the right time, they give rise to various types of pollution¹⁾. These wastes rotted lying outside. Different types of viruses are also caused due to rot. These viruses sometimes prove to be very harmful to human health. These viruses enter the human body and give rise to many diseases²⁻³⁾. Therefore, it becomes very necessary to use them properly. However, today there are many industries which are trying to recycle the wastes⁴⁾.

Leather industry generates chrome-containing leather waste (CCLW). As result of this trash, the environment is contaminated with a wide range of pollutants. This waste causes a lot of air pollution after rotting. Different types of viruses mix with air after CCLW decomposes. Through the lips and nose, this virus enters the human body. It has a negative impact on human health since it enters the body⁵⁻⁷⁾. Which causes a wide range of illnesses to develop in the human body. This disease can also prove to be fatal at times. Therefore, the re-use of CCLW becomes very important. Apart from because the researchers were

interested in using CCLW as a reinforcement with aluminium because of the existence of this element. Following the extraction of the Cr from CCLW in this work, a composite was established^{8,9)}.

The demand for aluminium has increased everywhere in today's time. The main reason for increasing its demand is its lightweight and high specific strength. Furthermore, it has been observed that its hardness and strength are lower than among iron. In this situation, it becomes necessary to increase its strength and hardness¹⁰⁻¹²⁾. However, sometimes by combining different alloying elements, the mechanical properties of aluminium such as hardness and tensile are enhanced^{13,14)}. Cr is used as an alloying element to increase hardness and corrosion resistance of aluminium. With the addition of various ceramic particles, the characteristics of aluminium can also be improved. Cr with alumina powder has been used as a reinforcing particle for aluminium alloy in this study¹⁵⁾.

generate aluminum-based composite materials from a literature review. There are, however, only a few researchers who have used collagen powder and alumina

to make composites. Although composite has been made using collagen and alumina in previously published work¹⁶⁻¹⁸⁾, some defects have been observed in the developed composite. In this article, firstly optimized the casting parameters were then composite was fabricated at optimum casting parameters to improve mechanical properties¹⁹⁾. In the current study, a composite made of Al-4032 and 6% SiC by weight was created using a stir casting apparatus. The morphology, surface topography, and fracture behaviour of composites have been studied using optical micrographs (OM) and scanning electron microscopy (SEM) with energy dispersive x-ray analysis (EDXA)²⁰⁾. The composite has also been mechanically characterized by conducting tests to determine its tensile strength, micro-hardness, and impact strength²¹⁾. The cutting characteristics of interest—surface finish and energy consumption—are as a result of this investigation, cutting speed, feed rate, and depth of cut²²⁾. To determine the optimal set of parameters for accomplishing the set goals, a desirability approach based on the response surface methodology (RSM) has been used.

While the mechanical qualities benefit by reinforcing, ductility suffers greatly as a result. Fabrication of SiC reinforced aluminum composites have made use of the liquid route technology (casting). Cutting speed, feed rate, and depth of cut are only few of the input parameters that have been manipulated to complete the machining process. Surface quality and efficiency have been measured using the roughness parameter (Ra) and the MRR, respectively²³⁾. There has been no thought given to any other rough machining condition except MRR

2. Investigated Materials and Experimental Methods

2.1 Matrix Material

Aluminium is the material of choice for the matrix in this investigation. Today, aluminium alloy is widely used. Because of its low weight, aluminium is increasingly being employed in the automotive industry²⁴⁾. Doors and windows can also be made from aluminium, which is another common building material. Select aluminium alloy was discovered to have 135 MPa of tensile strength²⁵⁾.

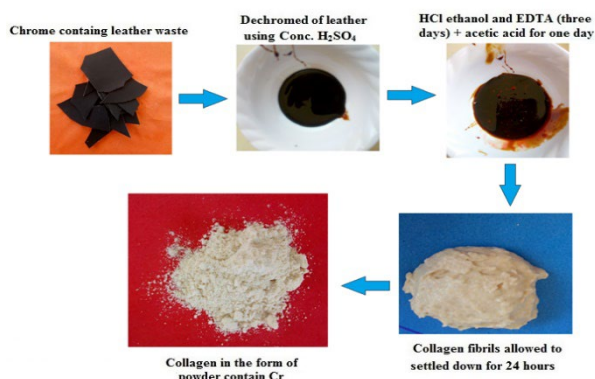


Fig. 1: Collagen powder developed from CCLW

2.2 Formation of Collagen Powder form CCLW and its Ball-milling

Fig. 1 depicts process of converting CCLW into collagen powder. First, CCLW had to be cleansed and washed to extract collagen powder in Cr-form. After washing, it was exposed to sun's rays to dry. After that, the CCLW was submerged in a solution of conc. H_2SO_4 . For the next three days, it was maintained in solution of HCl and EDTA. After another day in acetic acid, it could dry. Ball milling was used to produce collagen fibrils as a powder^{26,27)}.

2.3 Secondary Reinforcement Material

Alumina particles have been selected as second reinforcement. The good wettability of alumina with aluminium shows that it is a good reinforcing material. Any material's hardness, tensile strength, and wear resistance can be improved by incorporating with alumina. In this study, attempt has been made to increase tensile strength of aluminium by mixing alumina with collagen powder¹⁰⁻¹¹⁾.

2.4 Experimental Procedure

Stir casting technology has been utilized to generate aluminium-based composite material reinforced agent collagen powder and alumina. Fig. 2 depicts the casting setup in a simplified form. The composite was created by melting aluminium in electric furnace. At same time, reinforcement particles were preheated²⁸⁾. Stirring the molten aluminium with preheated reinforcing particles resulted in a homogenous mixture. Developed composite was left to cool in the furnace itself. Table 1 shows the casting parameters at which the composite was developed. Tensile strength various Input parameters is shown in Table 2.

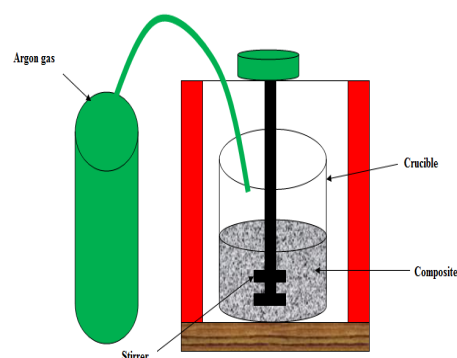


Fig. 2: Fabricated of Collagen and alumina composite material

Table 1: Ranges of Casting parameters

S. No.	Input parameters	Range
A	Stirring Time (Seconds)	60- 180
B	Collagen (wt. %)	1.25 – 5
C	Alumina (wt. %)	1.25 – 5
D	Alumina preheat temperature (Degree centigrade)	300 – 500
E	Collagen preheat temperature (Degree centigrade)	100 - 200

Table 2: Tensile strength various Input parameters

Standard Order	Run	A: Stirring Time (Seconds)	B: Collagen (wt. %)	C: Alumina (wt. %)	D: Alumina preheat temperature (Degree centigrade)	E: Collagen preheat temperature (Degree centigrade)	Tensile Strength (MPa)
3	1	180	5	5	300	100	165.75
18	2	120	3.125	3.125	217.884	150	154.38
23	3	120	3.125	3.125	400	150	153.01
25	4	120	3.125	3.125	400	150	153.24
2	5	180	1.25	1.25	500	200	135.2
21	6	120	3.125	6.53	400	150	169.65
13	7	120	3.125	3.125	400	241.058	145.6
20	8	120	3.125	-0.28	400	150	130.85
9	9	180	1.25	5	300	200	165.75
24	10	120	3.125	3.125	400	150	153.21
16	11	10.73	3.125	3.125	400	150	151.97
1	12	60	5	1.25	500	200	134.88
17	13	229.26	3.125	3.125	400	150	158.08
7	14	180	1.25	5	500	100	160.55
5	15	60	5	5	300	200	166.4
26	16	120	3.125	3.125	400	150	152.91
15	17	120	6.53	3.125	400	150	156
4	18	180	5	1.25	300	200	141.38
14	19	120	-0.28	3.125	400	150	152.75
8	20	60	5	5	500	100	158.6
12	21	120	3.125	3.125	400	58.94	141.05
22	22	120	3.125	3.125	400	150	153.14
6	23	60	1.25	5	500	200	159.25
10	24	180	5	1.25	500	100	142.35
19	25	120	3.125	3.125	582.116	150	146.64
11	26	60	1.25	1.25	300	100	130.65
3	1	180	5	5	300	100	165.75
18	2	120	3.125	3.125	217.884	150	154.38
23	3	120	3.125	3.125	400	150	153.01
25	4	120	3.125	3.125	400	150	153.24

3. Results and Discussion

3.1 Mathematical Modeling

For stir casting composites, the ANOVA table is shown in Table 3. The ANOVA table shows that all input parameters are statistically significant. In contrast, a

deficiency of fit is of no relevance. There is no doubt that all the input factors have a major impact on the response if they are significant (Tensile strength)^{29,30}. Fig. 3 shows the model graph predicted and actual. However, non-significant of lack of fit proves that model fits well in experiment.

Table 3: ANOVA Table

Source	Sum of Squares	DF	Mean Square	F Value	Prob > F	
Model	2991.842858	20	149.5921429	4257.498323	< 0.0001	significant
A	10.35125	1	10.35125	294.6039054	< 0.0001	
B	5.28125	1	5.28125	150.308115	< 0.0001	
C	18.66605	1	18.66605	531.2490017	< 0.0001	
D	29.9538	1	29.9538	852.5063603	< 0.0001	
E	752.72	1	752.72	21422.94425	< 0.0001	
A2	184.8818791	1	184.8818791	5261.869208	< 0.0001	
B2	2.466147944	1	2.466147944	70.18831692	0.0004	
C2	6.064422088	1	6.064422088	172.5977472	< 0.0001	
D2	13.94876686	1	13.94876686	396.991783	< 0.0001	
E2	16.74190854	1	16.74190854	476.486573	< 0.0001	
AB	11.28214279	1	11.28214279	321.0977733	< 0.0001	
AC	23.77364888	1	23.77364888	676.6148828	< 0.0001	
AD	15.28738562	1	15.28738562	435.0898208	< 0.0001	
AE	0.774446318	1	0.774446318	22.04129065	0.0054	
BC	1.270053877	1	1.270053877	36.14663275	0.0018	
BD	0.198144383	1	0.198144383	5.639329471	0.0636	
BE	1.488161399	1	1.488161399	42.35412727	0.0013	
CD	0.68184675	1	0.68184675	19.40584135	0.0070	
CE	0.172523022	1	0.172523022	4.910127379	0.0775	
DE	1.203829099	1	1.203829099	34.26182868	0.0021	
Residual	0.175680801	5	0.03513616			
Lack of Fit	0.098200801	1	0.098200801	5.069736744	0.0875	not significant
Pure Error	0.07748	4	0.01937			
Cor Total	2992.018538	25				
Std. Dev.	0.187446419	R-Squared	0.999941284			
Mean	151.2784615	Adj R-Squared	0.999706418			
C.V.	0.1239082	Pred R-Squared	0.976309775			
PRESS	70.88159193	Adeq Precision	230.5442694			

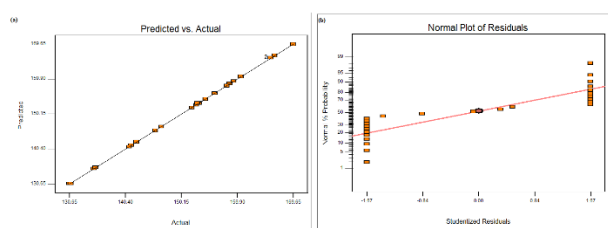


Fig. 3: Model graph; (a) Predicted v/s actual, (b) Normal % probability graph

3.2 Microstructural Investigation at Optimum Casting Parameters

To determine whether or not the matrix material's distribution of reinforcing particles is good, the microstructure of the composite was examined. Microstructure pictures of collagen powder and alumina

reinforced aluminum-based composite material are shown in Fig. 4. When composites have been grown beyond the range of casting parameters, several agglomerations of reinforcing particles have been noticed. The proper distribution of reinforcing particles was demonstrated by microstructure of composite that generated at optimal casting settings^{31,32}. Mechanical qualities like as hardness and tensile strength will be improved by the well-distributed reinforcing particles.

3.3 Tensile Strength Analysis

3.3.1 Measured Tensile Strength on Preheat Temperature Collagen Powder

The influence that collagen powder preheating temperature has on tensile strength is illustrated in Fig. 5. Tensile strength of collagen powder was improved by

raising the temperature at which it was preheated. However, when the value of the preheat temperature was increased to more than 177.36°C, tensile strength began to decrease.

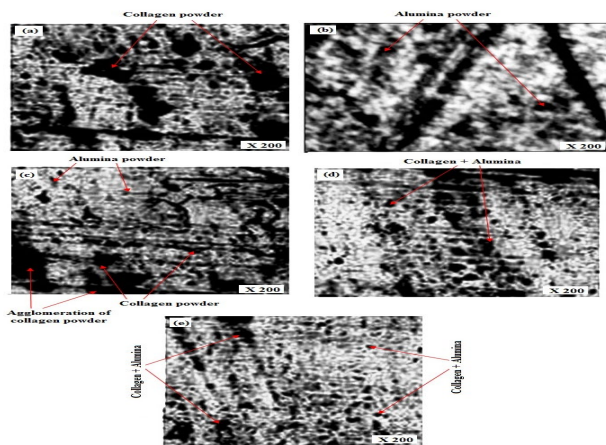


Fig. 4: Microstructure images of collagen and alumina Al-based composite

In this research, ceramic Al_2O_3 particles were incorporated into a collagen extract from chrome-containing leather waste (CCLW). In collagen, the Al_2O_3 particles were evenly dispersed, as seen in the microstructure picture. In terms of tensile strength, Collagen/6.25 wt% Al_2O_3 Bio-Composite performed best at 18 MPa³³). The powdered collagen was heated before being mixed with the aluminum to make it more wettable. However, tensile strength of composite material was significantly reduced due to excessive preheating of the collagen powder.

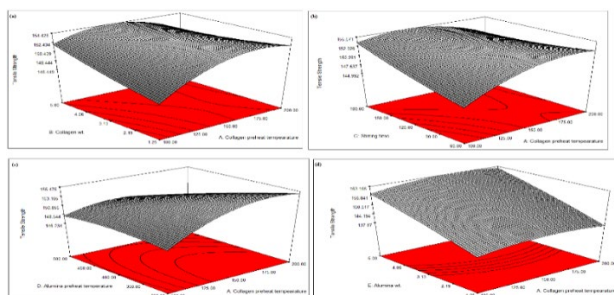


Fig. 5: Preheat temperature Collagen powder interact with other parameters and effect of Tensile strength

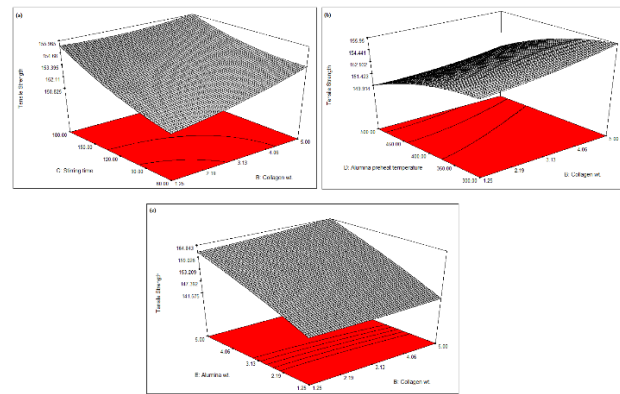


Fig. 6: Collagen weight percentage Interact with other parameters and impact on Tensile strength

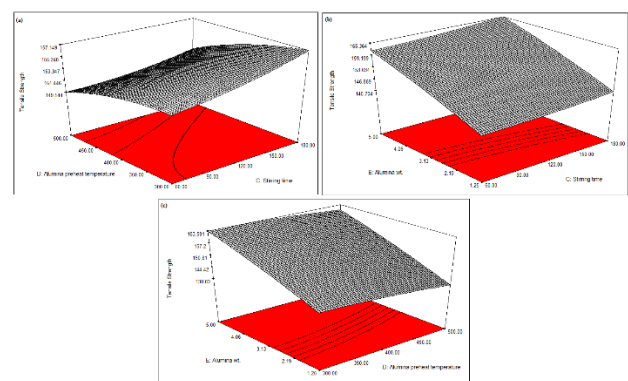


Fig. 7: Stirring time Interact with other parameters and impact on Tensile strength

3.3.2 Measured Tensile Strength on Collagen Powder (wt. %)

Fig. 5 demonstrates effect of collagen content on composite's tensile strength. Tensile Strength properties by increasing collagen content. But the best tensile strength came when collagen's weight percent was 1.43 % and alumina's 5 wt. %. Tensile strength of composite increased due to presence of Cr in collagen³⁴). However, collagen proved to be good as reinforcement when it was combined with alumina particles into Aluminum.

3.3.3 Effect of Stirring Time on Tensile Strength

To demonstrate influence of stirring time on tensile strength of collagen and aluminum-based composite material, see Fig. 6. enhances in tensile strength were string length grew³⁵). The dispersion of reinforcing particles with matrix material was improved by increasing Stirring time. When the distribution is optimal, the composite's strength is enhanced.

3.3.4 Measured Tensile Strength on Preheat Temperature Alumina

The effect of preheating the alumina to a certain

temperature may be seen in Fig. 7. When the Fig. was examined, it was discovered that the alumina had the highest tensile strength after being warmed to a temperature of 300°C. The tensile strength of composite material reduced while preheat temperature was maintained at 500°C. This study demonstrated that the wettability of alumina was satisfactory when its preheating temperature was maintained at 300°C.

3.3.5 Measured Tensile Strength on Alumina (wt. %)

The tensile strength of prepared composite material with reinforcing agent collagen and alumina reinforced is shown in Fig. 7 as function of alumina weight percent. When alumina weight percentages were increased, as seen in Fig. 7, the composite's tensile strength grew steadily. Aluminum-based composites' tensile strength drops off when the excess weight % of alumina increases, as has been found numerous times. Even though the weights of alumina and collagen were held at 5 percent and 1.43 percent respectively, the composite's tensile strength rose significantly.

3.4 Confirmation Experiment

The composite material's tensile strength ramp function graph is shown in Fig. 8. According to ramp function graph, when collagen is preheated at 177.36°C, collagen weight percent is 1.43, stirring time is 180 seconds, alumina is preheated at 300°C, the composite's strength should be 166.42 MPa. The ideal stir casting parameters were used for the confirmation experiment. At optimal conditions, tensile strength was found to be 162.45 MPa. Developed and experimental model has a remarkably low margin of error of 2.38 percent.

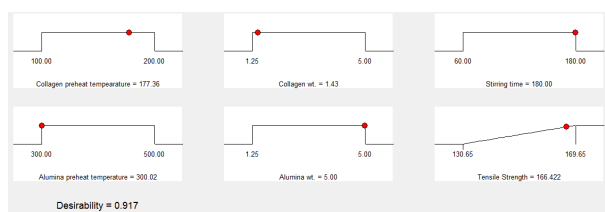


Fig 8: Ramp Function graph

4. Conclusions

The following conclusions can be drawn Based on this study:

- It is concluded that the most effective combination of stir casting parameters are the collagen and alumina preheat temperature of 177.36°C, 300°C and weight % 1.43, 5 respectively and stirring time of 180 seconds.
- The tensile strength is increased by 20.33% by utilizing uniformly distribution of CCLW.
- Pollution will be reduced by using CCLW, and leather industry can sell their waste.

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