To Study the Influence of Slight Additions of Chromium and Copper on Surface Roughness of Al-Si Alloy

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ABSTRACT.

In present work the aluminum alloy (Al-9.1%Si Alloy) with minor addition of chromium and copper powder have been casted in rectangular size by adding different amount of chromium and copper powder by weight. The surface roughness of the alloys after machining was evaluated using Surface roughness tester TR100 (Made by TIME High Technology Ltd, BEIJING). Result shows that surface roughness (Ra) of machined surface of all the alloys decreased with increase in copper content and micro hardness. Melt treatment of all the alloys with the addition of chromium reduced the surface roughness.

1. INTRODUCTION.

Al-Si alloys have received considerable attention due to their machining and casting features. Both hypoeutectic and hypereutectic alloys are used for tribological applications like internal combustion engines, pistons, liners, clutches, pivots, hydraulic pumps etc. Addition of alloying elements is made principally to improve mechanical properties such as tensile strength, hardness, rigidity and machanibility, and sometimes to improve fluidity and other casting properties of aluminum [1]. The term "surface texture" refers to the fine irregularities (peaks and valleys) produced on a surface by the forming process. By convention, the texture comprises two components; roughness and waviness. Roughness consists of the finer irregularities characteristics of the process itself, such as the grit spacing of a grinding wheel or the feed of a single-point tool. Waviness consists of the more widely spaced irregularities that are often produced by vibration in the machining process. Usually, however, the terms "surface texture" and "roughness" are used interchangeably, because roughness is specified and measured much more often than waviness [2]. Reference [3] focused on improving the wear resistance of Al-Si alloy for engine block material by decreasing casting effects like porosity etc. After a study of the microstructure of an Al-9wt. %Si-3wt.%Cu alloy reveals that pore can nucleate along the long side of the β-Al_5FeSi needles. Third alloying elements can form a low melting point phase and cannot be filled when solidifying between dendrites. A study of an Al-Si-Mg alloy modified with Sr found that a Cu content over 0.2% resulted in a 7-fold increase of the dispersed micro porosity. It also found that the level of porosity with the addition of Cu up to 4wt. % remains constant.

Reference [4] studied the effect of minor additions of chromium on wear resistance and machanibility of Al-15%Si alloy" the wear resistance and machanibility for cast Al-Si alloys containing up to 0.4% chromium and 15% silicon (LMX) under the condition of abrasive wear against a hardened steel disc and using standard lathe tool dynamometer indicating forces in x, y, z directions respectively. The abrasive wear rate of the LMX (new alloy) dispersions was similar to that of Al- 24.56Si (LM 29) hypereutectic alloy and more than Al-11.73Si (LM 13) eutectic alloy and the cutting forces for machining LM 29 alloy is higher in comparison with LM 13 and LMX (new alloy). Whereas the difference between the cutting forces of LM 13 and LMX is almost negligible. The hardness of LMX was done on the Brinell hardness tester with 5mm ball diameter 250 Kg. load which is higher than that of LM13 and LM 29 Al-Si alloys. The possible reason for high hardness LMX could be attributed to the combined effect of primary silicon cuboids and Al-Si-Fe-Mn-Cr intermetallic formation.

Ravindra Thamma [5] has discussed the various turning parameters on the surface roughness in his paper "Comparison Between Multiple Regression Models to Study Effect of Turning Parameters on the Surface Roughness". He evaluated that Cutting speed, feed rate, and nose radius have a major impact on surface roughness. Smoother surfaces will be produced when machined with a higher cutting speed, smaller feed rate, and nose radius. Depth of cut has a significant impact on surface roughness only in an interaction. The interactions of the cutting speed, nose radius, and feed rate also have a more significant impact on surface roughness than the individuals. T. Tanaka et al. [6] have discussed the machanibility of high silicon aluminum alloys made by a P/M process and by casting were compared. He also discussed the effect on machanibility and surface roughness by adding 2wt% Cu and 1wt% Cu with 1%wt Mg in to Al-20Si alloy in their paper. “Machanibility of Hypereutectic Silicon-Aluminum alloys”. During machining of Al20%Si-2%Cu-1%Mg alloys the total wear (flank wear width) increases with increase in the depth of cut and feed rate. The effect was much smaller in turning P/M alloy than the casting alloy. The addition of Cu or Mg to hypereutectic casted Al-Si alloys has improved the surface roughness in turning with carbide tool. Under the condition of a speed of 300m/min, a feed of 0.05mm/rev and depth of cut of 0.5mm.the surface roughness of the P/M alloy was better than that of casted alloys with Cu and Mg addition.

2 EXPERIMENTATION

2.1 Alloy preparation

Aluminum alloys are used in both the cast and wrought conditions. Whilst the mechanical properties of many of them can be improved by precipitating hardening and addition of other elements. With the expansion of aluminum market many of new compositions has been introduced. Aluminum alloy LM-26 was selected as a parent alloy with Si content 9.1%, Cu content 1.2% and Cr content 0.03% is prepared by using two commercial alloys. Alloy 1 has silicon 14%wt and copper 1%wt and alloy 2 has silicon 0.88%wt and copper 0.29%wt. These alloys are melted in furnace with the addition of copper and chromium by sand casting to make of different alloys of different compositions for study. Chemical compositions tests are conducted to find out the chemical composition of alloys.

In present thesis work the aluminum alloy LM 26 with minor addition of chromium and copper powder have been casted in rectangular size by adding different amount of chromium and copper powder by weight. The procedure for preparing the specimens:

- Alloy 1and Alloy 2 of aluminum was taken in a graphite crucible by weight and alloying elements chromium and copper in powder form was added to it.
- After this mixture was melted in a furnace.
- Before pouring the liquid metal in to the mould cavity, it was mixed properly in a crucible by stirring.
- Then it was poured into the green sand mould and castings obtained as shown in fig.1.
- After casting, different specimens with different ratios of copper and chromium specimens were, machined to obtain equal dimensions for smoothing the surfaces for further testing. Ten rectangular specimens were prepared to check surface roughness

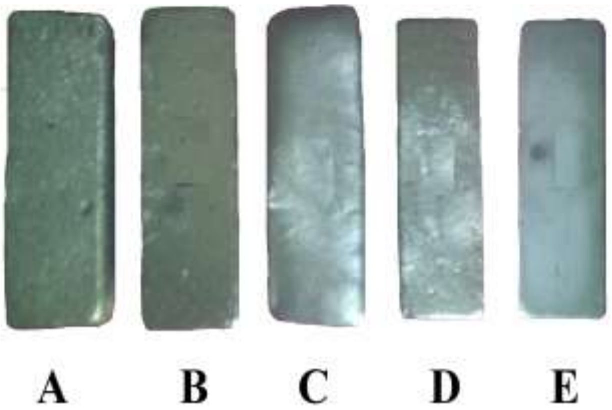
. Fig.1 Casting specimens of aluminum alloys after addition of Cu and Cr

2.2 Specimen Preparation

Casting specimens were prepared in sand casting, the parent alloy without any addition of Cu and Cr and other three new test alloy specimens with different ratios of copper and chromium powders. Other alloy specimen of different Si content than parent alloy is also prepared for comparison with parent and other three alloys. Table 1 shows the compositions of different alloys and variation in copper and chromium contents. The parent aluminum alloy LM-26 with Si 9.1%, Cu 1.2%, Cr 0.03% and Al 86.67% was the base alloy. The new alloy (Alloy A, Alloy B, Alloy C and Alloy E) having different amount of silicon, copper and chromium contents have been developed as shown in fig.1. The amount of copper have been increased in Alloy B, C and A gradually. Contents of silicon was same in Alloy A, B, C and D but higher in Alloy E. The amount of other elements like Mg, Zn, Fe, Sn, and Ni present in alloys has been shown in table 1. Fe is present as an impurity in the present work the focus is only on the variation of Cu and Cr content in aluminum alloy LM-26. It has been observed that different amount of Cu and Cr (keeping other elements composition fixed approximately).

3 SURFACE ROUGHNESS MEASUREMENTS

Samples required for roughness testing were turned on all geared head stock lathe without coolant. The cutting parameters used to study the machining behavior are



following:

Feed rate - 0.049 mm/rev, Cutting speed - 35 m/in-depth of cut - 2 mm

Roughness of machined samples of various alloys under different conditions was evaluated using Ra surface roughness. Average value of properties was taken for study. The roughness of the alloys was evaluated using roughness tester (TR100 Surface roughness tester, made by TIME High Technology Ltd., Beijing) as shown in figure 2, under the following conditions: Standard: ISO 1999,Traversed length: 6mm,Cut-off length: 0.8mm, Radius of the Stylus: 10.0 ± 2.5µm, Speed: 0.25mm/s

Fig.2 TR100 Surface roughness tester

Table 1 Chemical composition (wt.%) of parent alloys and new alloys

	Chemical composition (wt. %)								
Alloy	**Si**	**Mg**	**Zn**	**Cu**	**Fe**	**Cr**	**Sn**	**Ni**	**Al**
A	9.09	0.27	0.23	4.06	0.7	0.15	0.14	0.81	84.55
B	9.1	0.38	0.13	2.5	1.3	0.25	0.055	1.06	84.22
C	9.08	0.3	0.12	1.1	0.75	0.35	0.72	1.07	86.51
D	9.1	0.32	0.13	1.2	0.78	0.03	0.72	1.05	86.67
E	12.1	0.95		1.06	0.75			1.85	

Table 2 shows the roughness of various alloys

Alloy	R_1	R_2	R_3	R_4	R_5	Average (Ra) µm
A	2.34	2.23	2.2	2.17	2.23	2.23
B	2.67	2.60	2.62	2.53	2.57	2.6
C	2.85	2.82	2.78	2.85	2.76	2.81
D	3.03	3.07	2.95	2.82	2.88	2.95
E	4.12	4.18	4.26	4.31	4.18	4.21
R_1, R_2, R_3, R_4 and R_5 are readings of surface roughness of samples A,B,C,D and E respectively in µm						

4 Result and discussion

The variation in Surface roughness with Cu and Cr contents in parent and new alloys has been shown in table 2. The average surface roughness of the alloys was found between 2.23 and 4.21 µm. Fig. 2 show the variation of surface roughness with increase in copper contents during machining of different alloys alloy. It can be observed that surface roughness (Ra) of machined surface of all the alloys decreased with increase in copper content and micro hardness. Melt treatment of all the alloys with the addition of chromium reduced the surface roughness. The alloy A has lower surface roughness as compared to the parent or other new alloys.The possible reason for lower surface roughness in new alloys could be attributed to the combined effect of fine Al2Cu particles and Al-Si-Fe-Mn-Cr intermetallic formation.

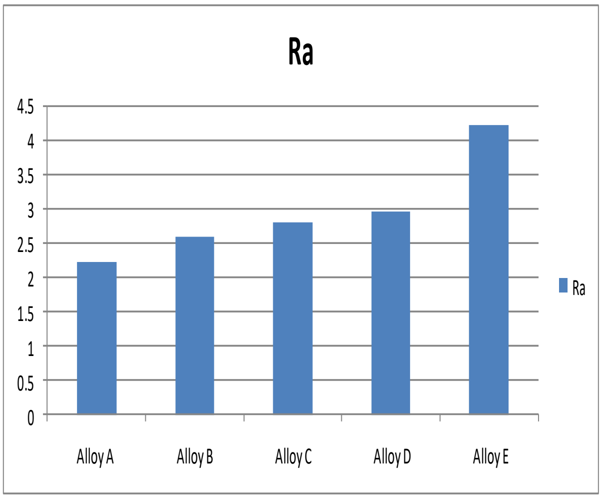


Figure 2 Shows the surface roughness of different alloys.

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