EXPERIMENTAL INVESTIGATION OF MACHINING BEHAVIOUR OF ALUMINIUM ALLOY

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Abstract: Fiber-reinforced aluminum alloy composites were fabricated by squeeze casting, and the effects of the fiber reinforcementll on thell machinability ofl the alloy werell investigated. Machinability isl the mostll important property of a material. There are variousl waysl toll check the machinabilty of a material. The large number of machinability tests developed in the pastll is limitedll by their ability tol compare materials of differentll classes, eg. Ferrousll vs. non-ferrousll metals, Thell considerationsll involved in thell successful machiningll ofl aluminumll andll its alloysl have sprungll intoll particular prominence duringll the lastll year or soll with the greatly increased usel of these materialsll under the armaments expansion program. Numerousl firmsll who havel hithertoll confinedll their attentions toll steels and non-ferrous metalsll like brass andll copper are now engaged in the mass production ofl partsll machined fromll extruded, rolledll andll cast aluminumll andll aluminumll alloys. These light metals are by noll means difficultll toll machine butll their particular properties require all special technique if full advantage is to be taken of the economy resulting from the high Speed at which they may be worked

Therell are a lot of factor whichll affects the machinability andll other properties of the material. Inll currentll research work itl isl experimentally studiesl andll investigatedll thell effectl of such parameters (depth of cut, feed rate, cutting speed, cutting force etc) on the properties of Aluminiumll base alloy.

Keywords: Aluminum Alloy, Machinability

I. INTRODUCTION

The reinforcement of aluminum alloys withll ceramicl fibers has been proposed to improve the strengthll and rigidity at high temperature, andll wear resistance of the alloys. The aluminall fiber wouldl be mostl suitablel for improving the properties of the alloy, because itsl high temperature strength andll hardness are superior. The aluminall fiber-reinforcedl aluminum alloy composites havell not only been fundamentally studied [1-5] but alsoll made in trials or put intol practicalll use [6]. However, there is a concern aboutll all decrease in machinability ofl the aluminum alloy by reinforcing withll alumina fibers, because alumina isl difficultll tol machine. Although Saga etll al. [7] reportedll the machinability of anll alumina fiber- reinforcedll aluminumll alloy composite, the effects of the fiber on thell cuttingll mechanismll of thell aluminum alloy and tool wear characteristicsll when thel composites were machined have not yet been sufficiently clarified.

In the present study, short alumina fibers having different properties were used as the reinforcements of the aluminum alloy, and all fiber perform was infiltrated with thell aluminum alloy melt by squeeze castingll inll order toll fabricate the composite. Thel effectsl of thell fiber reinforcement on thel machinability of thell aluminum alloy were then clarified.

II. OBJECTIVE AND SCOPE OF PRESENT INVESTIGATION

Al-Fe-V-Sill alloys, which have the potential to use inll high temperature applications. Al-Fe-V-Si alloys are generally produced throughll rapid solidificationll process, which exhibit comparable better mechanicalll properties tol conventional castll aluminum alloys. Thel better performance of these alloysl at elevatedl temperature have made them strongll candidates for all variety of future aerospace applicationsll suchll asl aircraft fuselage, missile finsll and winglets, rocketl motor cases, andll various gas turbinell engine components. Al-Fe-V-Si alloys producedll throughll RSP route is also al costll intensive. Sahool etll al. havell produced these alloys by meltingll and castingll route.

Thell entirell experimental programme may be groupedl under thell following heads:-

1. Preparation of Al-Fe-V-Si alloys of differentll composition.
2. Casting the alloys in variousll moulds.
3. Determination of mechanical propertiesll of the as cast alloys.
4. Machinability ofl alloys.
5. Heat treatmentll ofl alloys.

wasl respectively 112 HV and 130 HV, while thatll of AC8A alloy wasl 90 HV.

B. Machinabilityll of Composites

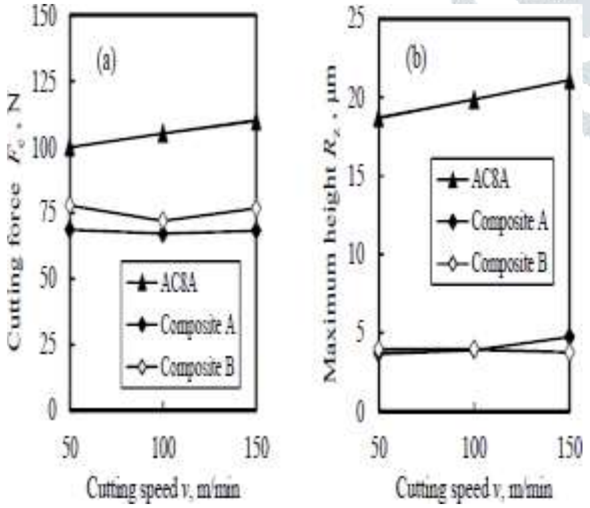
Figure 2(a) showsl thell effect ofl thell cutting speed v onl thell cutting forcell Fc of thell AC8A alloy and composites. Since the serrations (variation in Fc) werell observed during the cutting, the mean values of Fc were shown in Fig. 2(a). Under every cutting condition, Fc decreased due to the fiber reinforcement.

Itll isl reported thatll dispersing the hardll phasesll inll thel aluminum alloy facilitatesll the shear deformation of thell alloy due tol thel stressl concentration in the hard phases during thell cutting process [7]. Thell results that occurredll in thell present study can bel expressed by thel same mechanism; thell fibers inll thell composite actl as stress-concentration sitesl andll facilitatell thell shear deformation ofl thel alloy. Furthermore, the Fcl of composite A wasl lower than that ofl compositel B under every condition. Thisll is probably duel tol thel fact thatll the hardness of fiber A wasl lower thanll that of fiber B. Figurell 2(b) showsl thell effect of the cutting speedl v on the surface roughness (maximum height), Rz, of the AC8A alloy and composites. For every cutting condition, the Rz values of composites were lower than those of the AC8A alloy.

The cuttingll forcel andll the surface roughness have all relationshipll with the formation of the built-up edge [9]. Therefore, we investigatedll the formationll of thel built-up edge when the AC8A alloy and composites

III. RESULTSll ANDl DISCUSSION

A. Microstructure and Hardness of Composites Figure 1 isl anll optical micrograph of the parallelll section of composite A. Thell dark phases observedl inll thell micrographll arell the short alumina fibers. Noll agglomeration ofl the fibers or porosity is observed inll the composite, indicatingll thatll thell meltl infiltrationll intoll the fiber preform was perfectly accomplished. Thell fibers werell in all random planar arrangementll asl well as the fibersll in the preform. The matrixll of every composite was αl aluminum (bright area observed inll the micrograph) in which the finell eutecticl silicon particles werell mainly dispersed. As al resultll ofl the fiber volumel fractionll measurementll in the composites using the Archimedianll principle, it wasl 15 vol%, which is thell samel as the fiber volume fraction inll the preforms. Vickers hardness of the composite A and B werell machined. Figurell 3 shows the cross-sectional optical micrographs of the AC8A alloy andll composite B in the vicinity of the cutting part where they hadll contacted the tool edge. These photos were taken after thell machining was quickly stopped andll the tool wasl removed.



For the AC8Al alloy, the built-upll edgel was obviously observed (Arrow in Fig. 3(a)). The Vickersll hardnessl of thell built-upll edgell wasll approximately 140 HV, whilell that of the chipll area was approximately 105 HV andll that of the unmachinedll areall was 90 HV. Inl addition, thell machinedll surfacell and the chip surfacel in contact withll the built-up edge were rough and seemed to bel pluckedll by thell machining. In contrast, thell built-up edgell in composite Bl was slight (Fig. 3(b)),ll andll thell machinedll surface and the chip surfacel in contact withll thell tool were smoother than thatll of thell AC8Al alloy.

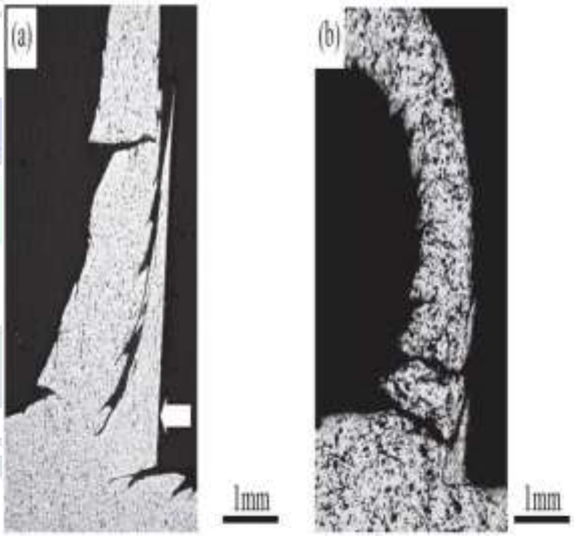


Figure 1. Optical micrographll of composite A.

Figure 2. Effect of cutting speedl on (a) cutting force andll (b)l surface roughness (maximumll height)ll of the AC8A alloy and composites (t = 1.0 mm, f =ll 0.1mm/rev).

Figure 3. Cross-sectional optical micrographs of (a)l AC8A alloy and (b) composite Bl inll thel vicinity of thell cutting partll where they had contacted thell tool edge (t = 1.0 mm, f = 0.1mm/rev, v = 50 m/min). Arrow inll Fig. 3(a) indicates built-up edge.

Figure 4l shows the chipll formsll of thell AC8A alloy and composites obtained when the feed rate f is 0.1mm/rev. For every cutting speed, continuousl chipsll were formedll after cuttingll the AC8All alloy, whereas the sheared or serratedll chips were formedl after cutting the composites. This tendency was alsoll observed when f isll 0.2 mm/rev. These resultsl indicate thatll thell fibers arell fractured by the shear stressll duringll thell machining process which facilitated thell shear deformationll andll division of the chips.

Generally, thel formationll ofl the built-upll edge decreases the cutting force and the tool wear, while itl increases the surface roughnessll [9]. Some findings obtainedll in the presentll study arell consistentll with thesel general findings; the build-up edge andll thel surface roughness ofl the AC8A alloy were greater thanll those of the composites. Thell decrease in surface roughnessll by the reinforcementll isll probably due toll thell factl that thell fibers or whiskers suppressedl thel formation of the built-up edgel and the accretions onl the rake face. However, for the cutting force, the data in the presentll study conflict withll thell general findings; the cuttingll force of the compositel was lower than thatll ofl AC8Al alloy in thell present study.

As stated, it is reportedll thatll dispersing the hardll phasesll inll thell aluminumll alloy facilitates thell shear deformation ofl the alloy due toll thell stressl concentration in the hardll phase during the cuttingll [7]. Thell resultsll thatll obtainedll in the presentll studyl canll be expressed by the same mechanism; the fibersl inll the composite facilitate the shear deformation and division of the chips because the fibers are easily sheared by the cutting.

Figure 5 shows thell effect of the cutting distance xl on the width of the flank wear (*VB*) after cutting the composites (*t* =0.1 mm, *f* = 0.1mm/rev). For the composite B, *VB* reachedll 0.2 mm,ll which isl thell tool lifell valuell for the finishing cut of nonferrousll metalsll establishedll in JIS, when the cuttingll distance was 2.3-km. On thell other hand, for thell composite A, *VB* reachedll 0.2 mm when thell cutting distance was approximately 6 km. Thisll result indicatesll that thell reinforcement withll lessl harder fibers decreasesl the tool wear.

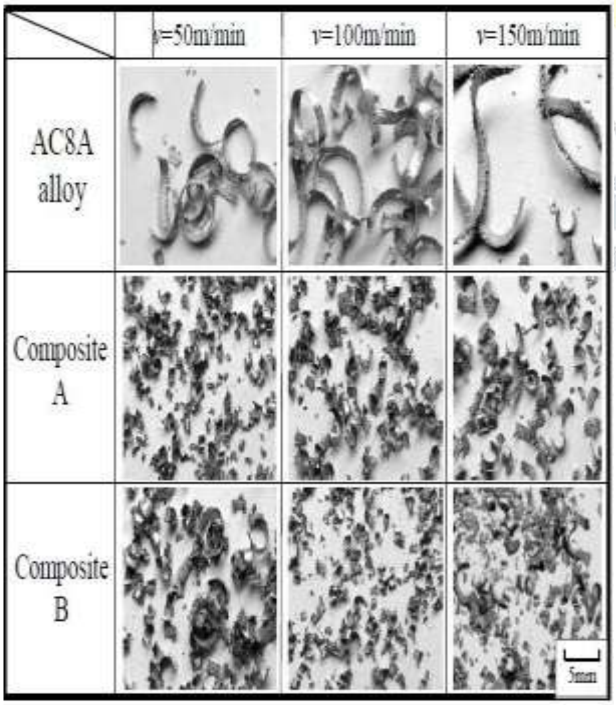


Figure 4. Chipll forms of thell AC8All alloy andll composites (*t* = 1.0 mm, *f* = 0.1 mm/rev).

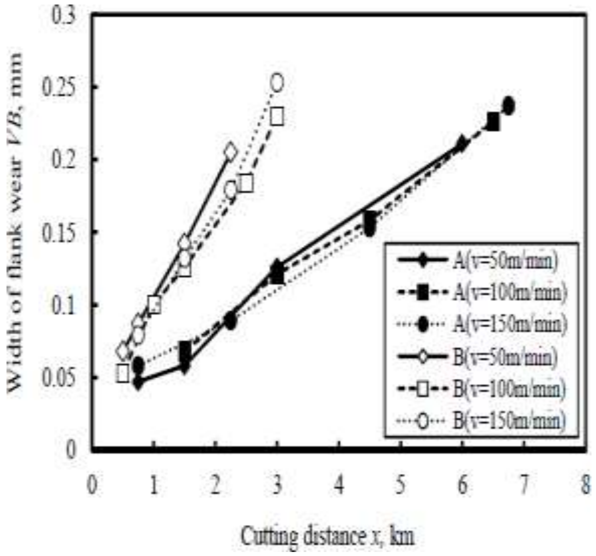


Figure 5. Effectl of cutting distancell on width of flank wear after cutting the composites (t = 0.1 mm,ll fl = 0.1mm/rev).

CONCLUSION

- Hardness isll increases asll ironll content increases fromll 4 to 5 %
- As ironll % increases, UTS sharply increasesl but %l elongationll decreases.
- The mechanical propertiesll of the alloy arel improvedl through hotll rolling of the castl samples. 80% reductionll gives the bestll ultimate tensilell strength.
- Hardness isl almostl constantll atl 250˚C up toll 240 hours.
- From the experiments itll hasll beenll seen that thesel alloys is having good machinability.
- As Depthll ofl cutl andll Feedl ratell increases, cutting force is requiredll more but with increase of cuttingll speed, cutting force decreases.
- At different Cuttingll speed, Depth of Cutl andll Feed, itl produces Discontinuous chips.
- Onll increasing of Depth of Cut, roughnessll of surface increases during machining.

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