CHAPTER-7

PRACTICAL APPROACH AND SCOPE FOR FUTURE RESEARCH

7.1 PRACTICAL UTILIZATION Al-MMCs

Hundreds of parts are required in the aircraft; conceivably the most of them are of aluminium. The Airbus A380 is considered to have the lowest percentage (by weight) of aluminium; it still contains 61 per cent of the aluminum element [Carey et al., (2009)]. The main grounds for this widespread use are its low weight, density being about one third of copper or steel alloys [Avner, (1997)] and its specific gravity being 2.72 [Lakhti, (1998)]. Due to the weight advantage of MMCs, they have potential to be used in aircraft structures, aircraft engines and naval weapons systems. The Toyota Motors considerably uses aluminium MMCs for pistons and other automotive parts. Other components include connecting rods, cam followers, cylinder liners, brake parts and drive shafts.

The alloying of metal and heat treatment improves the strength of material. The tensile strength of wrought aluminum (99.5%) is around 100 MPa. With the alloying of Cu upto 4%, the tensile strength is increased by 100%. The phenomenon of precipitation hardening may be the main cause behind this huge increment in strength [Askeland,(1994)]. Furthermore, with heat treatment like aging, the tensile strength reaches to 300 MPa [Tisza, (2001)]. The Al-Cu alloy is popularly used and designated as 2000 series by Aluminum Association. It has penalty of applications like aircraft structures, rivets, hardware, truck wheels, screw machine products, auto body panels, die and hand forgings, pistons and rotating aircraft engine parts for operation at elevated temperatures, heavy-duty forgings, plates, extrusions for aircraft fittings, wheels and major structural components, space booster tanks and structures, truck frame and suspension components etc [Wikipedia, (2016)].

Hybrid MMCs (means the addition of two or more ceramic according to tailored properties requirement) are more common and current area of research in the field of MMCs. But still for strengthening of aluminum alloy matrix in MMCs are rare in literature. The present work emphasizes on strengthening of MMC through SiC in Al-Cu alloy matrix. The precipitation hardening phenomenon occurs with an addition of 4% Cu in Al6061. Copper is dispersed homogenously without any mechanical mixing which prevents dislocation movement at the molecular level [Askeland,(1994)]. Moreover, the previous researchers advocated the chances of enhancement in strength through aging due to the presence of copper in aluminium alloy MMC [Suresh et al., (1989), Kim et al., (1992) and Harris et al., (1993)]. This is also taken in consideration for present work.

7.2 CONCLUSIONS OF PRESENT WORK

Results of the present work are useful in low-cost production of Al6061-Cu-SiCp MMC. This may be the replacement of copper alloys and steel alloys. Hence, this work provides the prospects for growth to a new and improved technology with vibrant commercial sector delivering an improved quality of life, stronger technology base possessing, the dexterity and awareness to support commercial needs and exploring the potential of a new material for a given application.

The machining of MMCs is very expensive that requires diamond tools because the MMCs with abrasive ceramic reinforcements are very hard. As machining is a major cost factor, development of improved methods tailoring to the unique properties of MMCs would help to make these MMCs more competitive.

Therefore it is concluded as:

i) The Al6061-Cu-SiC_p metal matrix composites are produces successfully as per intended casting process parameters.

ii) The SEM analysis reveals that at 2.5 cm/s pouring speed homogenous dispersion of SiC in Al6061-Cu achieved. The material losses homogeneity in mixing of SiC with composite at high temperature and higher stirring speeds. Likewise, manual blending of SiC in alloy matrix (Al6160- 4% Cu) is not viable. Similarly for wear test, at high temperature and higher stirring speed deep grooves, severe damage and plastic deformation on surface are noticed.

iii) Experiments are conducted as per the intended design of experiment and data are shown in Appendix I, Appendix II and Appendix III.

iv) The effect the type of material is highly significant for the output variables (hardness, impact strength, ultimate tensile strength and material removal rate). Pouring speeds are highly influencing factor for output hardness and impact strength, but ultimate tensile strength and material removal are not found significant for Pouring speed. However, the interaction of Material Type and Pouring speed on output variables are not found significant.

The stirring speed is highly significant for hardness, impact strength and material removal rate but found insignificant for ultimate tensile strength. Similarly pouring temperature is a highly significant for hardness, impact strength and material removal rates but except ultimate tensile strength. The combine interaction affect of stirring speed and pouring temperature is also significant for hardness, impact strength and material removal rate but again ultimate tensile strength is not significant.

The effects of input variables stirring speed and pouring temperature on output property material abrasive wear rate are tested. The effect of pouring temperature and stirring speed are highly significant for the material wear rate. However the interaction effect of stirring speed and pouring temperature on wear rate not found significant.

v. The optimum value of hardness, impact strength and material removal rate are at pouring speed of 2.5 cm/s for both material 1(matrix alloy) and material 2 (metal matrix composites). They are respectively 66 BHN, 38 J and 82 BHN, 45 J respectively.

The mean values of ultimate tensile strength are 151.1 N/mm^2 and 153.7 N/mm^2 for material 1 and material 2 respectively.

The maximum value of material removal rate for material 1 and material 2 are 0.265 g/min at 3 cm/s pouring speed and 0.278 g/min at 3.5 cm/s pouring speed respectively.

The optimum value of hardness (87 BHN) and impact strength (52 J) and material removal rate (0.434 g/min) are at a stirring speed of 400 rpm and at pouring temperature 725°C.

Material removal rate increases with an increase in pouring temperature up to 725˚C and then decreases abnormally in all levels of pouring temperatures. The least rate of material removal of MMC is at a pouring temperature of 675˚C.

vi. The stirring speed ranging from 200 rpm to 600 rpm and pouring temperature ranging from 700˚C to 750˚C gives the least wear rates of Al6061-4%Cu-5%SiC MMCs. The MMCs obtained at low pouring temperature 675˚C, close to the melting point of metal have higher wear rates. Al6061-4%Cu-5%SiC MMC obtained at pouring temperature (775˚C) has higher wear rates.

vii. The dependent variables are mathematically modelled. To validate the model normal regression standardized residual plots are drawn respectively.

Control over the particulate ceramic /matrix inter phase in MMCs is critical to both cost and performance of these materials. At high temperatures, particulate ceramic/matrix interactions degrade mechanical and machining properties of MMCs. Expansion in the areas of pouring temperature, stirring speed and pouring speed are desirable, not only to prevent these deleterious reactions but also to promote the proper degree of wetting to form a good particulate ceramics/matrix bond. Researches to optimize the processing costs of MMCs for the production are vital.

7.3 SCOPE FOR FUTURE WORK

There are numerous industrial machinery parts that should be promoted for superior specific strength and stiffness of MMCs. Still fabrications of MMCs of aluminium are not mature. There is a lot of potential for researches especially to optimize the process route, time and cost of production. The following may be the scope of research in the field of Al-SiC MMCs:

1. These results are only valid for Al6061-4%Cu-SiC MMCs or Al2000- SiC MMC. To generalize the result, some more experiments are required with a variety of matrix combinations.
2. The gravity casting technique is adopted for investigation of mechanical, machining and wear properties. However improved result can be obtained with better gating system.
3. The prime challenge is controlling the temperature of the melt in the open hearth furnace. Hence the effect of the type of furnace and its temperature control mechanisms are the area of research.
4. In the present work mechanical properties, hardness and impact strength of MMC are investigated. Other mechanical properties as required by the designer for selection of material are to be investigated.
5. Effects of different filler material on the matrix alloy are the areas which are still to be investigated.
6. The effect of mold design, riser design in the production of metal matrix composites may be an interesting field of investigations.
7. The future area of research can include hybrid metal matrix process parameters.
8. Nano SiC MMCs may attract the future researchers.