Investigation of Effect of Alloying Elements on Tribological And Mechanical Properties of Sintered Iron

Hanamant Yaragudri[1], Rahul[2], Tarun R[3], Sravya K[4]
[1]Assistant Professor, Dept of mechanical engineering
[2, 3, 4]Dept of Mechanical Engineering
[1, 2, 3, 4] New Horizon College of Engineering, Bangalore

Abstract- *In this present work effect of alloying elements on tribological and mechanical properties of sintered based iron alloys are to be evaluated using powder metallurgy techniques. Test specimens of iron based alloy compositions are prepared by varying graphite at 306 MPa.The powder mixture is transferred to the die which is well lubricated with zinc-stearate to minimize the friction between powders and die wall. The mixture is compacted and samples were ejected. Then sintering is done at 580°C temperature for 30 min in a furnace. Experimental results are compared to determine best combination of graphite and iron powder preform.*

Keywords- Mechanical and tribological properties, powder metallurgy, sintering.

I. INTRODUCTION

Powder Metallurgy is a branch of manufacturing in which various parts are produced from metallic powders with or without addition of nonmetallic constituents. Powder metallurgy find its wide applications in manufacturing of various components such as gears, bushes, bearings, sprockets, rotors, cutting tools etc. The basic steps involved in powder metallurgy are shown in figure 1(a) below.

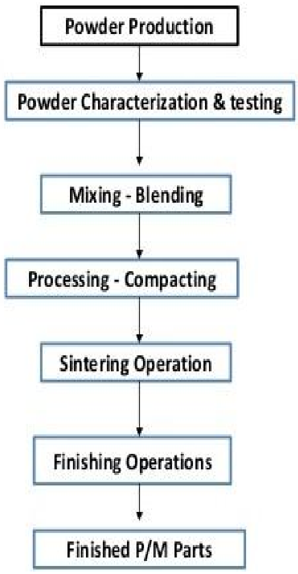

Figure 1(a) Basic steps involved in powder metallurgy.

Pre-alloyed ferrous powders when used with various additives such as copper, nickel, graphite, etc. results in high strength martensitic microstructures. In this paper, various compositions of iron which are widely being used for various engineering applications are discussed. Solid lubricants and their behaviour have also been comprehensively reviewed.

II. EXPERIMENTAL PROCEDURE

(A).Die making and component production

Material used for making die is hardened steel. The die used was 80mm long and 100mm in diameter with a 25mm hole in the centre. The punch is also made from hardened steel and purchased as 80 by 40 mm rod. The die separates one in from the bottom, so the specimen may be pushed out. Figure 1(b) shows the die used in production of specimens.

Figure 1(b): Die.

(B) Sintering furnace

Green compacts are placed in the furnace to carry out the sintering operation. Sintering is carried out in an well controlled environment i.e. hydrogen to prevent the oxidation of parts. Figure 2 shows sintering furnace used in this project.

Figure 2: Sintering furnace used in this project.

The material used for the present study was partially pre alloyed mixture of following composition as given in table 1. After mixing appropriate amount of powders, test specimens were pressed using a uniaxial semi-automatic hydraulic press of 100 ton capacity at 600MPa. The die made of hardened steel was cleaned with acetone and was lubricated with zinc-stearate prior to each powder compaction to minimize friction between powders and die wall and subsequently removal of the compacted samples.

Table 1: Chemical compositions .

Element Content	Raw Powder			
	Fe	Al	Cu	C
Contents %	Balance	20	20	0-10

The sintering furnace was tube washed with dry and clean hydrogen to remove atmospheric air inside the furnace. The green compacts were dewaxed in a furnace under hydrogen atmosphere. The hydrogen stream was maintained slightly above the atmospheric pressure. Then sintering has been carried out at temperature 1120^{0}C for 30min in a furnace with varying compositions of graphite. Figure 5.3 shows components manufactured through powder metallurgy technique.

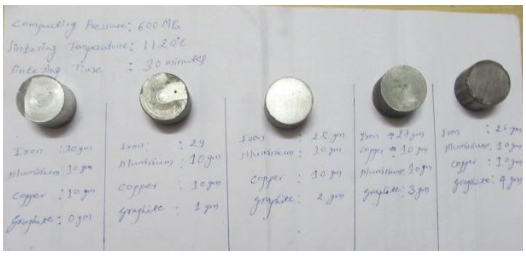

Figure 3: Components manufactured through powder metallurgy technique, here components from left to right refer to components containing 0% graphite,2% graphite,4% graphite,6 % graphite and 8% graphite respectively.

(C) Mechanical properties measurement:

Hardness was measured with an applied load of 5Kg. Compressive strength of the sintered samples was measured using the universal testing machine.

The addition graphitet increases the compressive strength of sintered materials leading to a decrease in density. The average of hardness values measured in the as-sintered samples is shown in Table 2. The hardness of 4% graphite added material is very high compared with the base composition. The increase in the hardness can be attributed to the presence of hard phase on graphite added compositions. However the hardness of 6% and 8% graphite added materials are less than that the 4% graphite added material. Addition of graphite improves the compressive strength of the material. Similar to hardness variations, the compressive strength of 4% graphite added composition is higher than that of the base composition. Presence of a large amount of interconnected pores in base composition yields a low hardness and strength comparing to the materials with low density. But, when the added graphite are more than 4%, the strength reduce contribute to the reduced hardness. Figure 4, Figure 5, Figure 6 and Figure 7 show variation in density, hardness, percentage porosity and compressive strength with variation in graphite content.

Table 2: Mechanical and tribological properties of test materials

Content of graphite	Density (gm/cm^3)	Hardness (HRC)	Porosity (%)	Compressive strength (MPa)
Graphite-0%	6.25	52.5	1.320	415
Graphite-2%	7.12	61.6	1.245	515
Graphite4%	7.38	68.5	0.545	550
Graphite6%	6.79	66.0	0.613	460
Graphite8%	6.45	63.5	0.845	434

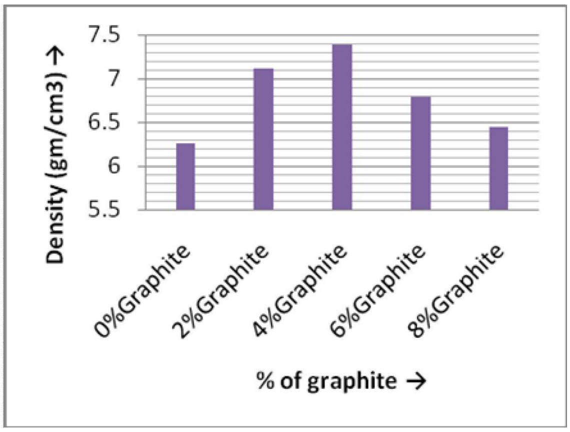

Figure 4: Variation of density with graphite content

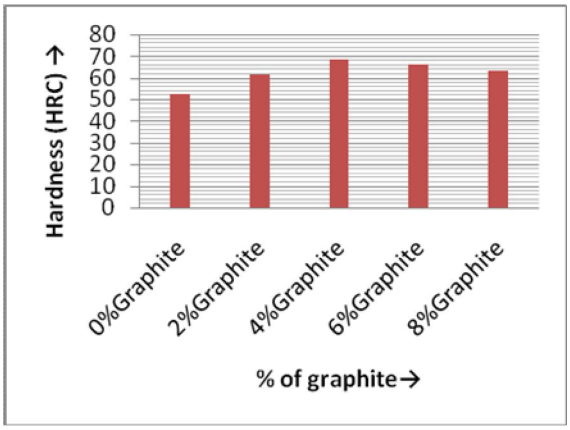

Figure 5: Variation of hardness with graphite content

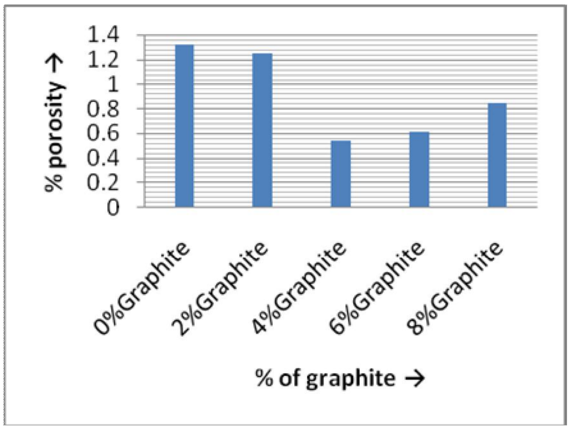

Figure 6: Variation of porosity with graphite content

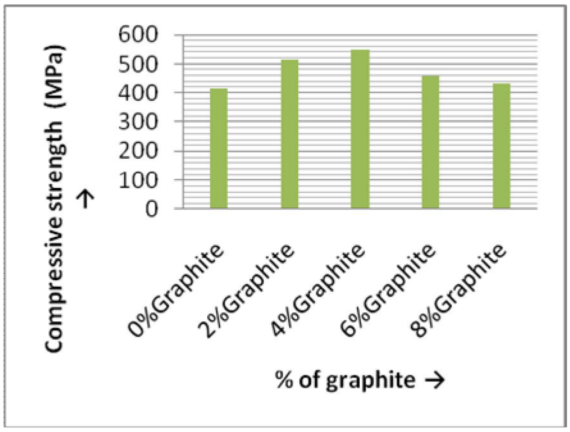

Figure 7: Variation of compressive strength with graphite content

(D) Friction and wear test process:

The frictional coefficient and wear rate were tested by tribometer.Figure 8(a) and (b) show variation of coefficient of friction measured during the dry sliding tests at load of 50N and load 100N for the materials investigated.

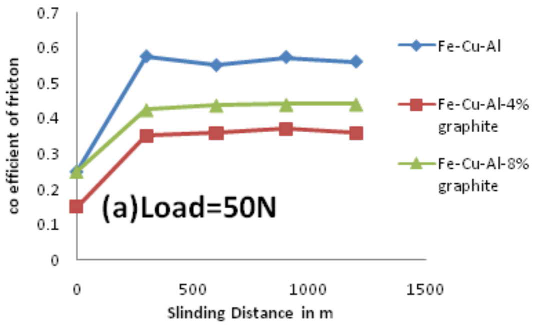

Figure 8(a):Coefficient of friction variation for materials investigated at applied load of 50N

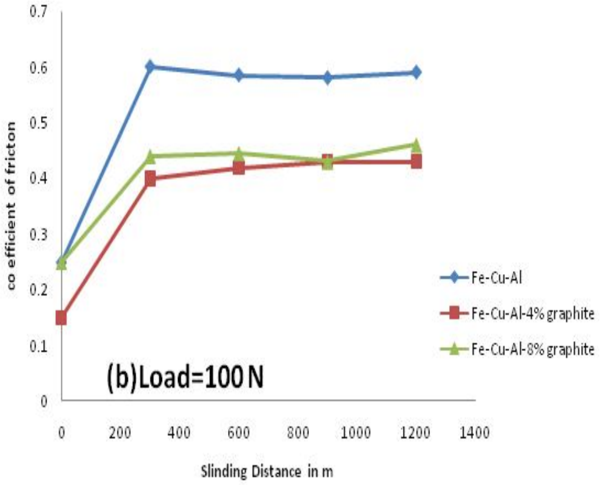

Figure 8(b): Coefficient of friction variation for materials investigated at applied load of 100N

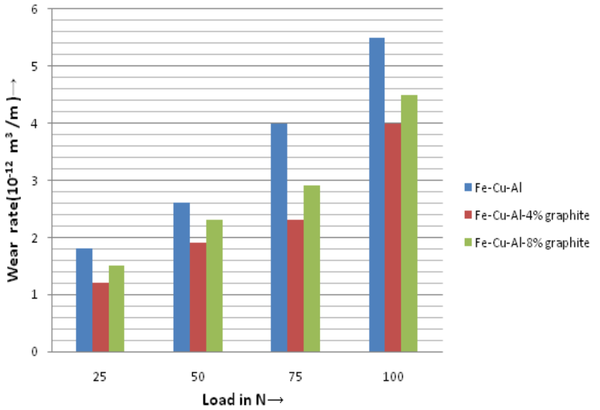

Figure 9: Wear rate of materials investigated at different applied load.

III. CONCLUSIONS

Fe-Cu-Al sintered materials containing solid lubricant graphite are developed for application in machine elements such as gears and bearings. Additions of solid lubricant increase the compressibity and contribute to the improved part density. In the dry sliding, the materials containing graphite formed the glaze layer improve friction and wear properties. Materials containing 4% graphite exhibited significant reduction in friction coefficient compared to the base alloy. However excessive addition of graphite resulted in the increase in the coefficient of friction. High hardness and strength of the 4% graphite added material contribute to the reduction in wear rate. When the graphite as solid lubricant are added in the Cu-Fe-Al alloy, the adhesive wear decreases largely. Meanwhile, wear behavior presents self-lubricating grain wear due to glaze layer.

REFERENCES

[1] "Effect of heating mode on sintering of ferrous compacts through powder metallurgy route"-A. Raja Annamalai, A. Upadhaya1 and D. Agarwal
[2] "Influence of Hardening on the Microstructure and the Wear Capacity of Gears Made of Fe1.5Cr0.2Mo Sintered Steel"-W. Predki, A. Miltenović.
[3] "Tribological Behaviour of Sintered Iron Based Ternary Alloy under Unduplicated and Lubricated Condition"-S.B. Halesh, P. Dinesh.
[4] G. S. Upadhyaya, "Powder metallurgy Technology," Cambridge International Science Publishing, Cambridge, 1997
[5] K. S. Naransimhan, "Sintering of Powder Mixtures and the Growth of Ferrous Powder Metallurgy," Materials Chemistry and Physics, Vol. 67, No. 1-3, 2001, pp. 56-65.
[6] D. Chatterjee, B. Oraon, G. Sutradhar and P. K. Bose, "Prediction of Hardness for Sintered HSS Components Using Response Surface Method," Journal of Materials Processing Technology, Vol. 190, No. 1-3, 2007, pp. 123-129.
[7] G. E. P. Boxes and N. R. Draper, "Emperical Model Building and Response Surfaces," Wiley, New York, 1987