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Mechanical and Tribological Characterisation of Sintered Iron and Aluminium based Alloys

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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 nickel and chromium at 600MPa. The die is made of hardened steel and lubricated with zinc-stearate prior to each powder compaction to minimize friction between pwders and die wall and subsequently removal of the compacted samples. Then sintering is done at 1120°C temperature for 7hrs in a furnace. Experimental results are compared to determine best combination of iron, alluminium, nickel and chromium powder preform. The continued growth of ferrous powder metallurgy in automobile and others engineering application is largely dependent on the development of higher density materials and improved mechanical properties. Since density is a predominant factor in the performance of powder metallurgy components, it has been primarily considered for the present investigation. An experimental investigation has been undertaken in order to understand the variation of mechanical and tribological properties of the sintered components with variation of nickel and chromium content.*

I INTRODUCTION

Powder Metallurgy has been used since the 1920s to produce a wide range of structural PM components, self-lubricating bearings and cutting tools. This publication reviews the PM process and describes recent developments in production technology and PM applications. Powder Metallurgy (PM) in the context of this publication encompasses the production of metals in powder form and the manufacture from such powders of useful objects by the process known as sintering. In many cases individual engineering components are produced directly by the process such as components being referred to indiscriminately as sintered components, sintered parts, or PM parts. However, wrought products also can be produced from powder and recently a number of scientifically exciting developments of great industrial potential have taken place. The PM process involves compressing the powder, normally in a container, to produce a compact having sufficient cohesion to enable it to be handled safely, and then heating the compact, usually in a protective atmosphere, to a temperature below the melting point of the main constituent during which process the individual particles weld together and confer sufficient strength on the material for the intended use. It is this heating step that is referred to as sintering. Sintered iron based alloy are increasingly used in light and medium duty gears and bearings because of both technical and economical advantages. For new and wide applications of sintered Iron and alluminium based alloy it is necessary to develop a new material composition to improve the friction and wear resistance characteristic. Sintered materials have inherent porosity and the presence of pores have both beneficial and detrimental role on the part performance. The pores act as stress concentration zones and reduce the mechanical strength and ductility. However, the presence of pores acts also contribute to the reduction in noise and vibration also serve as lubricant pockets in lubricated contacts. Sintered bearings and gears are also used in many applications where the external lubrication is not possible or not preferred. Various elements were added for improved compact ability, hardness and strength. Tribological properties of sintered iron based alloy are studied by few researchers. Under dry sliding conditions there are several mechanisms contributing to the wear behaviour of sintered iron based alloy. Melt wear, oxidation dominated wear and mechanical wear process depending on wear condition, metallurgical structure, composition and porosity of were observed in powder processed iron based alloy. The detached and trapped wear particles present within the contact region influence the wear process. An attempt is made to develop solid lubricant added sintered iron based ternary alloy for tribological applications. The friction and wear characteristics of sintered iron based ternary alloy containing of solid lubricant molybdenum disulphide (MoS_2) studied using a pin-on-disc tribo-meter are reported in this paper. There has been a rapid growth in the development of engineering materials worldwide during the past few decades. The issue of material conservation, energy conservation, longevity, etc. has become a challenging task before designers, engineers and materials scientists in the development of new materials in the research environment. Ferrous materials contain iron as prime constituent and play a significant role in engineering applications due to its low cost, ease of manufacture, better strength, toughness, ductility and availability. These materials can be alloyed and heat treated to achieve desired mechanical properties. Ferrous metals such as mild steel, carbon steel and, stainless steel are in use for a number of engineering applications. Iron is alloyed with other metals like graphite, copper, phosphorus, nickel, etc. in order to

change the microstructure so that the properties for a given application are easily met. Pre-alloyed ferrous powders when used with various additives such as copper, nickel, 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. The Main objective of this paper is to review various ferrous based self- lubricating composites which are developed by adding one or more solid lubricants in order to enhance the tribological properties.

Metal Powders Utilised:

- Iron – 99.5% (200-300 mesh)
- Chromium- 99.5 % pure
- Aluminium- 99% pure
- Nickel

Composition

Serial no.	Iron	Aluminium	Nickel	chromium
1	30%	30%	15%	15%
2	33%	33%	12%	12%

Powder Compaction Die

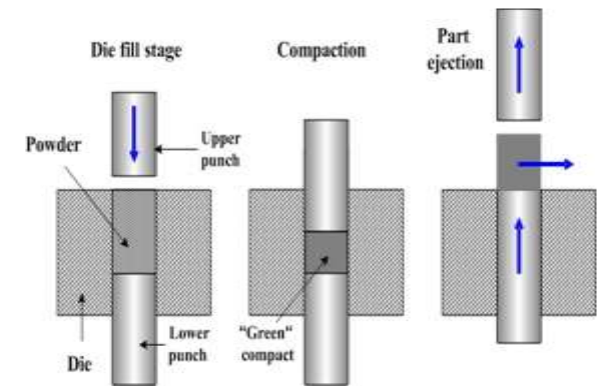
Die Specification Outer

diameter=100mm Inner

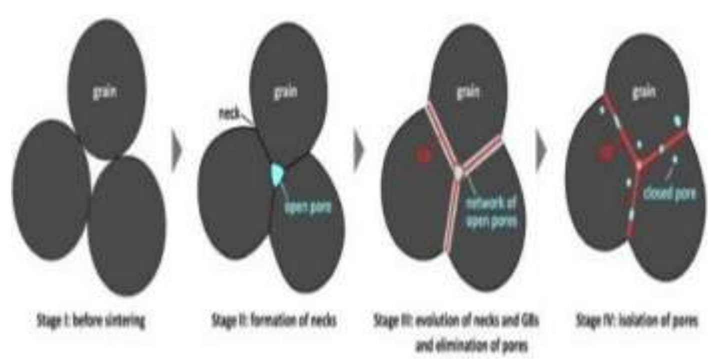
diameter=25mm

Material used= hardend steel

Sintering



This is a process of heat treatment which is mainly used to enhance the metal properties. This process step involves heating of the material, usually in a protective atmosphere, to a temperature that is below the melting point of the major constituent. In some cases, a minor constituent can form a liquid phase at sintering temperature; such cases are described as liquid phase sintering. Sintering is effective when the process reduces the porosity and enhances properties such as strength, electrical conductivity, translucency and thermal conductivity; yet, in other cases, it may be useful to increase its strength but keep its gas absorbency constant as in filters or catalysts. During the firing process, atomic diffusion drives powder surface elimination in different stages, starting from the formation of necks between powders to final elimination of small pores at the end of the process.



Sintering Stages

II LITERATURE REVIEW

[1] "Effect of heating mode on sintering of ferrous compacts through powder metallurgy route"-A. Raja Annamalai, A. Upadhaya1 and D. Agarwal.

Microwave heating is recognized for its various advantages, such as time and energy saving, very rapid heating rates, considerably reduced processing cycle time and temperature, fine microstructures and improved properties. The present paper focuses on preliminary work carried out with the use of microwave radiation applied to sintering of ferrous compacts. The ferrous alloy compacts were sintered in a multimode microwave furnace of 2.45 GHz and 6 kW nominal powers at 1120uC for 60 min in forming gas. Results of densification, mechanical properties and microstructural evaluation of the microwave sintered samples are reported and compared with conventionally sintered ones. In general, it is observed that the microwave radiation generally enhances the properties of the sintered material when compared with conventionally sintered material."Influence of Hardening on the Microstructure and the Wear Capacity of Gears Made of Fe1.5Cr0.2Mo Sintered Steel"-W. Predki, A. Miltenović.

High demands are set on gears made from sintered steel regarding wear, fretting, tooth fracture and pitting load capacity. The hardening obtained after the sinter process will affect the microstructure of the sintered steel so that the wear load capacity can increase to higher values. This report shows the influence of different hardenings methods on crossed helical gears fabricated from Fe1.5Cr0.2Mo sintered steel and the changes induced on the microstructure, the surface and the core hardness and the wear load capacity. The research presented in this paper is aimed at finding the

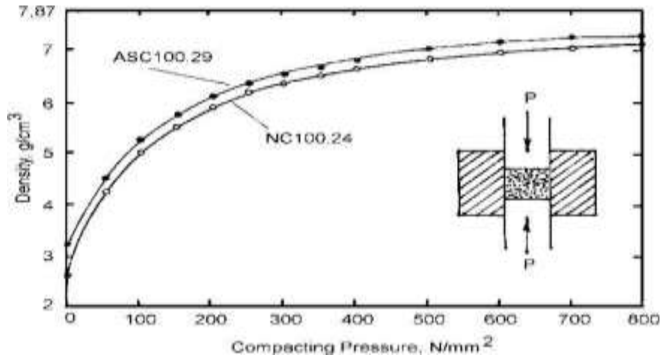


Fig: Density-pressure curves for two commercial iron powders compacted in a carbide die having an inner diameter of 25 mm. Lubricant additions: 0.75% Zn-stearate.most appropriate additional treatment which leads to higher wear load capacity as compared to the wear of sintered steel gears without any additional treatment.

"Tribological Behaviour of Sintered Iron Based Ternary Alloy under Unduplicated and Lubricated Condition"-S.B. Halesh,

P. Dinesh.Lubricated and unlubricated sliding wear tests were carried on sintered iron based ternary alloys produced by powder metallurgy technique. The detailed experiments were carried out on Fe20Al20Al, Fe15Al15Cu and Fe (without alloying elements). Friction and wear behaviour of solid lubricant at four different sliding speeds (1, 1.5m/sec) has been compared with unlubricated sliding condition. Sintered iron based ternary alloy Fe20Al20Cu under lubricated condition shown reduction in mass loss compared Fe15Al15Cu and Fe(without alloying elements) at all sliding speeds. Friction coefficient reduces with increase in sliding speeds for all the conditions. This could also be due to sliding resistance offered by lubricant coated samples with predominant asperities interaction. Sintered iron based ternary alloy Fe20Al20Cu under lubricated condition samples also generated lowest frictional temperature compared to other conditions.

III Methodology

In this process, the mixed metal powder is added into dies and pressure is applied to form a single component. The dominant consolidation process involves pressing in a rigid toolset, comprising a die, punches and, possibly, mandrels or core rods. However, there are several other consolidation processes that are used in niche applications. The strength properties of sintered components increase with increasing density but their economy drops with increasing energy input and increasing load on the compacting tool. Thus, it is most desirable, for both economic and technical reasons, to achieve the highest possible compact density at the lowest possible pressure. Density-pressure curves are generally obtained from standard laboratory tests where a number of compacts are made at different pressures in a carbide die having a cylindrical bore of 25 mm diameter. The densities of the compacts are plotted against compacting pressures.

IV Result

Fe-Cr-Al-Ni sintered materials are developed for application in machine elements such as gears and bearings. Tests was employed to check the mechanical properties of sintered Al-cr-Fe-Ni compact using Vickers hardness testing machine, universal testing machine,,wear testing machine,etc.The harness test was done with a load of 50Kgf for a time limit of 13 sec. several runs were taken and average harness of each sample was calculated. The further result are as follows

Serial no.	Brinell hardness number	Compressive stress N/mm2
1	90	115
2	102	130

V SCOPE OF FUTURE

The project can be always enhanced of its features and its performance; some of the future scope of the project is as mentioned below:

1. Effect of variation in compacting pressure on the properties can be studied.

2. Effect of variation of sintering time on the properties can be studied.

3. Effect of variation in sintering temperature on the properties can be studied.

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[3] "Effect of heating mode on sintering of ferrous compacts through powder metallurgy route"-A. Raja Annamalai, A. Upadhaya1 and D. Agarwal.

[4] "Influence of Hardening on the Microstructure and the Wear Capacity of Gears Made of Fe1.5Cr0.2Mo Sintered Steel"-W. Predki, A. Miltenović.

[5] "Induction Sintering of %3 Cu Contented Iron Based Powder Metal Parts"Uğur ÇAVDAR, Enver ATİK.

[6] "Effect of the Copper Amount in Iron-Based Powder-Metal Compacts"-Uður Çavdar1, BekirSadýkÜnlü, EnverAtýk.

[7] "Tribological Behaviour of Sintered Iron Based Ternary Alloy under Unduplicated and Lubricated Condition"-S.B. Halesh, P. Dinesh.

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