Physical and Mechanical Properties of Ni-Cr based composites with addition of solid lubricants produced through powder metallurgy process

Wan Farhana Mohamad[1,a], Amir Azam Khan[1], Faiz Ahmad[2] and Abdullah Yassin[1]

[1]*Department of Mechanical and Manufacturing, Faculty of Engineering, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia*
[2]*Mechanical Engineering Department, University Technology PETRONAS, 31750 Tronoh, Perak, Malaysia*

Abstract. Ni-Cr based composites with and without the addition of solid lubricants (MoS_2, silver and CaF_2) were prepared by powder metallurgy method. The samples were sintered at two different temperatures, 1000 ^oC and 1200 ^oC. The physical properties such as shrinkage, sintered density and porosity were studied. The microstructures of the Ni-Cr based composites were observed by using SEM analysis while the mechanical properties of the composites were measured by Rockwell Hardness Tester. The results revealed that the increased in sintering temperature improved the shrinkage, sintered density and hardness of the composites while less porosity produced. Ni-Cr based composites with the addition of silver and MoS_2 exhibited better shrinkage, density and porosity. Besides, 5% of MoS_2 addition in the composites improves the hardness of the composites at sintering temperature 1200^oC.
Keywords: solid lubricants, Ni-Cr composites, powder metallurgy, MoS_2, silver, CaF_2

1 Introduction

Giant industries such as automotive and aerospace are having an economical loss due to high maintenance cost for mechanical components. Failure of mechanical components such as bearings and bushings used in the advanced jet engines are caused by friction and wear as subjected to wide temperature range. As for example, the operation temperature of nozzles for turbojet propulsion system is reaching the temperature of 1650^oC [1]. At this high temperature, the liquid lubricant is unstable and tends to lose its lubricating properties. Thus, solid lubricant is preferable compared to the liquid lubricant. Besides, solid lubricant also has advantages compared to liquid lubricants either under the extreme pressure conditions, radiation environment or cryogenic temperature [2].

The incorporation of the solid lubricant in the composites is called self-lubricating composites. The composite is able to form a lubricating film to reduce the effect of friction and wear. The examples of metal used in the self-lubricating composites are iron based, copper based and nickel based composites. Iron based self-lubricating composites are mostly used in the automotive application such as piston ring, clutch, brake system and engine liners [3]. While copper based composites are used for the application of thermal management application due to excellent properties thermal and heat conductivity [4]. Among the metal composites, nickel based composites have become the most attention of researchers for high temperature application. The high cost of refractory metals and complex manufacturing process also make the metal nickel as an option for high temperature application [5].

Nickel Chromium (Ni-Cr) has become one of the leading materials for high temperature application due to its excellent performance at high temperature. A series of nickel based composites has been developed in order to achieve the great need of high temperature solid lubricating system produced through powder metallurgy process [6]. Ni-Cr matrix also acted as a binder and offered excellent high temperature oxidation/corrosion resistance and essential mechanical strength [7], [8]. Nickel itself offers good mechanical properties and anti-oxidizing properties when exposed to air atmosphere at high temperature while chromium offers anti-wear and lubricating properties at high temperature [9] . The strength of the Cr particles can determine the strength and bonding between the matrix and Cr reinforcement.

Efforts have been made in order to enhance the performance of self-lubricating composites with solid lubricants addition. The work is continued in order to develop a perfect combination of matrix and solid lubricant for high temperature system to meet the requirement of advanced technology. In this research work, the author is working on Ni-Cr based composites with the addition of single, dual and multiple solid lubricants in order to obtain an excellent mechanical as

[a] Corresponding author: wanfarhana88@gmail.com