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A study on friction and wear characteristics of Fe–Cu–Sn alloy with MoS_2 as solid lubricant under dry conditions

S MUSHTAQ[1,*], M F WANI[1], M NADEEM[3], K A NAJAR[2] and M MURSALEEN[2]

[1]Tribology Laboratory, Mechanical Engineering Department, NIT Srinagar, Hazratbal, Srinagar 190006, India
[2]Mechanical Engineering Department, NIT Srinagar, Hazratbal, Srinagar 190006, India
[3]Metallurgical and Materials Engineering Department, NIT Srinagar, Hazratbal, Srinagar 190006, India
e-mail: shuhaibmushtaq@gmail.com; mfwani@nitsri.net; nadeem.nit.06@gmail.com; najar.kaleem@gmail.com; mursaleen@nitsri.net

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Abstract. Iron-based alloys are materials of choice for engineering applications such as bearings and gears owing to their low cost, ease of manufacture, high strength, availability, and good wear resistance and low coefficient of friction. In this study, Fe–Cu–Sn composite containing varying percentage of molybdenum disulfide (MoS_2) is developed using simple single stage compaction and sintering. The friction and wear behaviors of these composites were studied ball-on-disc tribometer in which EN8 steel ball was used. It was found that with the increase in percentage of MoS_2 from 0 to 3 wt% the coefficient of friction and wear rate substantially decreases from around 0.85 to 0.25. The wear mechanism in base composition (0% MoS_2) is observed to be adhesive and abrasive, whereas mild abrasive wear was observed in the 3 wt% MoS_2 composite. The hardness of composite was also found to improve with the increase in MoS_2 weight fraction.

Keywords. Fe–Cu–Sn alloys; MoS_2; coefficient of friction; wear; dry lubrication; bearing materials.

1. Introduction

Cost effectiveness is need of the hour in every industry and particularly in bearing and gears industries, and iron is one cheapest metals in addition to its excellent mechanical properties. Bearing materials can be produced economically by using Powder metallurgy (PM) techniques. PM produced parts are near-net shape which offers low cost production, and results in tight dimensional tolerances. In recent years, iron-based sintered tribomaterials have been considered over copper-based tribomaterials due to their lower cost and easy availability of iron powders [1]. Since a decade, high performance sintered iron-based self-lubricating composites have been developed [2] as a solution for combining a low friction coefficient with improved mechanical and wear resistance. Sintered composites contain high porosity, which reduce the mechanical strength and load-bearing capacity as compared to dense materials [3], however, according to Lim *et al* [4] porous materials have an ability to retain lubricants and release during use. In addition, wear debris produced during sliding interfaces may also be retained by pores and avoid further aggravation of wear and subsequently improves the tribosystem [5].

The tribological characteristics of sintered iron-based materials have been investigated by many researchers like Sudhakar *et al* [6] and Liu *et al* [7]. It has been observed that the friction and wear resistance is substantially affected by the composition of material, percentage porosity, surface treatments and lubrication. It was also found by Khorsand *et al* [8] that the dense materials wear less. Under untreated conditions, the coefficient of friction ranges from 0.7 to 0.9 [9]. Sometimes additives are also used in iron-based sintered alloys in order to improve the friction and wear resistance [10] such as the addition of WS_2 nanoparticles to bronze graphite nanocomposite lead to low coefficient of friction [11]. The addition of graphite also improves the wear resistance in iron-based materials. Copper being a pearlite promoter is also added to improve the strength of iron and ultimately the strength of sintered composite [12]. The most used solid lubricants nowadays are MoS_2 and graphite worldwide [13, 14]. The mineral Molybdenite, having a metallic shine and dark blue coloration, occurs naturally as a compound in the earth crust [15]. It can be found commercially in the form of powder, suspensions, mixed in greases, as films or in composites with different matrices after proper processing and refining. The lubricant effect is based on its lamellar crystalline structure, where the Sulphur lamellae are bonded only by weak interaction (van der waals), which eases the shear [14]. The crystalline layers of MoS_2 will easily slide and orient parallel to the direction of relative movement in the occurrence of sliding, which provides the lubricating effect. The strong ionic bond

*For correspondence