Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 11, No.4, November : 2024

TRIBOLOGICAL PROPERTIES OF ALUMINIUM ALLOYS: A REVIEW

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ABSTRACT
The selection of right material is a very difficult task for any design engineer. Light weight material doesn't possess sufficient strength while brittle material will not good in stiffness or toughness also properties of materials greatly affected by the environment in which they are working and the nature of loading. For domestic and manufacturing industries aluminium alloys plays a major role. The successful extraction and the first commercial applications of aluminium took place in the nineteenth century, the period in which the enthusiasm for new materials and their possible uses was immense. Aluminum alloys have unique combinations of properties that make it one of the most versatile, economical, and attractive metallic materials for a broad range of uses—from soft, highly ductile wrapping foil to the most demanding engineering applications. Aluminum alloys are second only to steels in use as structural metals. Aluminum alloys have interesting combinations of properties that make it one of the most versatile, prudent, and appealing metallic materials for a wide extend of uses as it is soft, highly ductile, and find wide industrial engineering applications. In structural applications it finds second place after steel and widely used in automobiles and structural applications. Hence there is a need to study the tribological properties of aluminium alloys.

Keywords:
Aluminium; Aluminium alloy; wear; tribological properties.

I. Introduction

Tribology is an intrigue thinks about of science and innovation that explores wear conduct and includes the plan of key focuses of association surfaces beneath relative movement utilizing the essential standards of contact and oil. Lubrication is one more critical viewpoint of tribology that diminishes the wear rate of a surface in relative movement with another one, and it is characterized by the thickness of the greasing up media. Wear is a dynamic fabric expulsion prepare from contact surfaces amid sliding or rolling [1]. Preservation of vitality and materials is the more self-evident aspect of tribology. Information of tribology is fundamental both in selecting the materials and coatings as well as their assessment. In a few cases, the tribological issue is so imperative that unless it is fathomed, modern innovation cannot be actualized. A curiously case is the streamlined diesel motor. This can be accomplished as it were by creating high-temperature, wear-resistant ceramic materials, and it is not however effective. Another case at a small scale level is micro-electro-mechanical frameworks innovation. In MEMS, any sliding between silicon surfaces comes about in exceptional wear. Thus, MEMS innovation is presently confined to components that do not slide [2].Aluminium for the most part wears since of its lower hardness compared to steel. Understanding these properties is fundamental for optimizing the execution and long life of components made from aluminum combinations in different situations, particularly in car and aviation industries.

1.1. Why Aluminium alloys.

At present situation there is continuous demand for light weight products and it can be achieved by designing smaller component or replacing with lighter materials. The light weight metals include magnesium, titanium, aluminium, beryllium, copper and other similar alloys. While considering light weight material aluminium is always a first choice because of its cost, specific strength, high fatigue strength, corrosion resistance, higher thermal conductivity, low melting point, easily recyclable. As

aluminium has substrate nature it gets wear because of low hardness compared to steel. Wear in mechanical parts or machinery in tribological terms results in poor system performance or machine failure [3].
Aluminum is non-ferromagnetic, a property of importance in the electrical and electronics industries. It is non-pyrophoric, which is important in applications involving inflammable or explosive-materials handling or exposure. Aluminum is also non-toxic and is routinely used in containers for food and beverages. It has an attractive appearance in its natural finish, which can be soft and lustrous or bright and shiny. It can be virtually any color or texture. The ease with which aluminum may be fabricated into any form is one of its most important assets. Often it can compete successfully with cheaper materials having a lower degree of workability. The metal can be cast by any method known to foundry men. It can be rolled to any desired thickness down to foil thinner than paper. Aluminum sheet can be stamped, drawn, spun, or roll formed. The metal also may be hammered or forged. Aluminum wire, drawn from rolled rod, may be stranded into cable of any desired size and type. There is almost no limit to the different profiles (shapes) in which the metal can be extruded [4].
Alloyed aluminum exhibits an excellent strength-to-weight ratio, good corrosion resistance, and good mechanical properties making it highly suitable for a variety of applications. Such alloys perform well in many respects but their tribological performance is worth special mention. The science of movement through friction, wear, and lubrication in mechanical parts is called tribology and directly affects the efficiency, strength, and reliability of moving parts [5-6].

II. Literature

Wear mechanisms in aluminium alloys depends on their microstructure and composition. Common wear mechanisms include: Adhesive Wear, Abrasive Wear and Fatigue Wear.
Among these wear types, adhesive wear where materials transfer between sliding surfaces occurs in softer alloys, followed by abrasive wear which is the scratching or gouging of aluminum surfaces by harder materials and fatigue wear in which repeated loading results to surface cracks leading to material loss. One study concluded that the additive of iron plays a positive role in increasing the wear resistance of aluminum alloys, and using friction tests in lubrication and un-lubricated conditions proves their low surface damage due to the protective layer formed by them [7]. Competition for load-bearing ability between $Al2O3$ particles and the base alloy results in lower wear rates and lower coefficients of friction compared with the AA 7075 matrix [8]. Multilayer graphene (MLG) reinforced composites are reported to show reduced friction coefficients and increased wear resistance with added levels of MLG. Composites with approximately 10% MLG exhibited increased durability [9], as working from abrasive wear mechanisms to self-healing tribo-films. This indicates the need to select reinforcements wisely in order that tribological properties of aluminium alloys can be optimized.
Tribological properties of the aluminium alloys produced will vary in response to manufacturing processes and conditions. Handling like powder metallurgy and stir casting, ultra producing and blasting cooling on holding the surface attributes alongside general performance acceptability: The innovative manufacture methods enhance the dispersal of reinforcements in the matrix and thus helps in stable mechanicals and tribological rankings [10]. One major barrier to the widespread use of standard aluminum alloys has been their low wear resistance, especially in applications where wear resistance is crucial, such engine components [11]. Before being used in industry, it is crucial to comprehend and describe the tribological characteristics of aluminum alloys, which differ greatly from those of steels. The friction and wear behavior of aluminum alloys have been discovered to be significantly influenced by the doping element content, especially silicon.
Recent research has examined how the amount of silicon in aluminum alloys affects their tribological characteristics. It has been noted that the friction coefficient falls and the wear variation becomes less pronounced as the silicon concentration rises [12]. Aluminum metal matrix composites reinforced with TiC particulate are utilized in aerospace, aviation, automotive, and sports industries because of their remarkable properties, including low density, high specific strength, high specific stiffness, good

thermal stability, and high-temperature creep resistance[13].Composites based with aluminium are applicable in aerospace, automobile and sports industries[14]. At higher temperatures the performance of aluminium alloys decreases to resolve this issue aluminium alloys are mixed with ceramic particles termed as aluminium metal matrix composite [15]. The abrasive wear of materials, bound of titanium and aluminum alloys, and has been showed to depend on the hardness of the aforementioned materials. Advances in surface engineering techniques, including the emphasis on surface coatings and treatments, have also been explored to enhance the tribological performance of aluminum alloys. These coatings have been systematically examined from the process-structure-property-performance perspectives which lead to their broader application in different industrial sectors including metal, marine, automotive, aerospace, and electronics. Aluminum combinations have been broadly considered for their tribological properties and riches of inquire about this has been conducted. The mechanical utility of aluminum and its combinations has been of significant consideration due to their appealing portfolio of properties, such as high particular strength, electrical and thermal conductivity, and corrosion resistance. Techniques for making strides the corrosion assurance of non-ferrous metals, counting aluminum, through surface building have been a center of investigate, with basic reviews highlighting the process-structure-property-performance perspectives of these coatings. [16-17]. There has been much investigation into the relationship between the tribological behaviour and the properties of some aluminum alloys like hardness. Some wear studies have been done on aluminum and aluminum silicon alloys using cast as well as powder metallurgy processes, thus emphasizing the significance of the manufacturing process to the wear characteristics of these materials [18]. There has been interest in cast hypereutectic aluminium-silicon alloys, particularly on the effect of the microstructure features such as shape, size, composition and distribution of constituents on the wear mechanisms Wear behaviour of such alloys is measured [19]. The tribological properties of aluminium alloys may be enhanced employing the strategies like developing alloys with optimized compositions to enhance wear resistance and reduce friction, applying surface treatments like anodizing, coating, or ion implantation to create protective layers, minimize friction and wear using appropriate lubricants and incorporating reinforcement materials like ceramic or carbon fibres to improve mechanical properties and tribological performance [20-21].

III. Conclusion

The types of reinforcing, production methods, and alloy composition all affect the tribological characteristics of aluminum alloys. Recent studies highlight the possibility of enhancing wear resistance by using sophisticated processing techniques and carefully choosing reinforcement. Further research into the tribological properties of aluminum alloys will be crucial as industries continue to require materials that can resist challenging operating conditions while retaining performance.

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