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Tribological Behavior of Aluminum Alloys (Al2014, Al7075, Al2025)

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***Abstract**: Aluminum based alloys are appropriate materials for structural applications in the aircraft and automotive industries because they are ductile, highly conductive, lightweight and have a high strength to weight ratio. Wear test was made by using pin on disc apparatus on the prepared specimen. It was found that, under mild wear conditions, the alloy conditions like wear rate and friction coefficient analyzed compared to aluminum. In this the wear rate and coefficient of friction are considered with different type of aluminum alloy, with different speed of the disc and temperatures. However, for severe wear conditions, the composite displayed higher wear rate and friction coefficient and it was clarified that the friction and wear behavior of aluminum alloy is largely influenced by the applied load and there exists a critical load beyond which could have a negative impact on the wear resistance of aluminum alloy, in this present work it is proposed to optimize the experimental analysis by using TAGUCHI L9 method. This simplifies the tribological behavior of aluminum alloys by reducing the number of experiments from twenty seven to nine*

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I. INTRODUCTION

Aluminum (Al) is the second-most plentiful element on earth and it became an economic competitor in the engineering applications as early as the end of the 19th century. The emergence of three important industrial revolutions would, by demanding material characteristics consistent with the unique qualities of Aluminum and its alloys, greatly benefit growth in the production and use of the metal. Among the most striking characteristics is its versatility. The range of physical properties that can be developed
from refined high-purity Al to the most complex alloys-is remarkable.

Aluminum and its alloys are extensively used as the materials in transportation (aerospace and automobiles), engine components and structural applications [1].Thus it becomes all the more vital to study the tribological characteristics of Aluminium and its alloys. Addition of Silicon to Aluminum gives high strength to weight ratio, low thermal expansion coefficient, and high wear resistance. These alloys also show improved strength and wear properties as the silicon content is increased beyond eutectic composition. Such properties warrant the use of these materials as structural components in automotive industries [2]. The wear properties of three Aluminium alloy samples have been studied viz. Al -7wt% Si, Al- 10%Si and Al-14%Si here. The principal wear mechanisms in these alloys and abrasive andsliding wear which have been dealt with in the later part of this work.

II. ALUMINUM ALLOYS

Aluminium alloys are alloys in which aluminium (Al) is the predominant metal. The typical alloying elements are copper, magnesium, manganese, silicon, tin and zinc. There are two principal classifications, namely casting alloys and wrought alloys, both of which are further subdivided into the categories heat-treatable and non-heat-treatable. About 85% of aluminium is used for wrought products, for example rolled plate, foils and extrusions. Cast aluminium alloys yield cost-effective products due to the low melting point, although they generally have lower tensile strengths than wrought alloys. The most important cast aluminium alloy system is Al–Si, where the high levels of silicon (4.0–13%) contribute to give good casting characteristics. Aluminium alloys are widely used in engineering structures and components where light weight or corrosion resistance is required.

Alloys composed mostly of aluminium have been very important in aerospace manufacturing since the introduction of metal-skinned aircraft. Aluminium-magnesium alloys are both lighter than other aluminium alloys and much less flammable than alloys that contain a very high percentage of magnesium [2].

II.I Aluminum 2024 Alloy

Aluminium alloy 2024 is an aluminium alloy, with copper as the primary alloying element. It is used in applications requiring high strength to weight ratio, as well as good fatigue resistance. It is weldable only through friction welding, and has average machinability. Due to poor corrosion resistance, it is often clad with aluminium or Al-1Zn for protection, although this may reduce the fatigue strength. In older systems of terminology, this alloy was named 24ST.

Basic properties:

Aluminium alloy 2024 has a density of 2.78 g/cm³ (0.1lb/in³), electrical conductivity of 30% IACS, Young's Modulus of 73GPa (10.6Msi) across all tempers, and begins to melt at 500 °C (932 °F). 2024 aluminium alloy's composition roughly includes 4.3-4.5% copper, 0.5-0.6% manganese, 1.3-1.5% magnesium and less than a half a percent of silicon, zinc, nickel, chromium, lead and bismuth.

Ii.Ii Aluminum 2014 Alloy

2014 Aluminum Alloy is an aluminum-based alloy often used in the aerospace industry. It is easily machined in certain tempers, and among the strongest available aluminum alloys, as well as having high hardness. However, it is difficult to weld, as it is subject to cracking.2014 is the second most popular of the 2000-series aluminum alloys, after 2024 aluminum alloy. It is commonly extruded and forged. The corrosion resistance of this alloy is particularly poor. To combat this, it is often clad with pure aluminum. If unclad 2014 aluminum is to be exposed to the elements, it should be painted as a corrosion protection measure Prior to the adoption of The Aluminum Association alloy designations in 1954, 2014 was known by the industry conventional designation "14S"

Basic properties:

Typical material properties for 2014 aluminum alloy are, Density: 2.80 g/cm^3, or 175 lb/ft^3, Young's modulus: 73 GPa, or 11 Msi, Electrical conductivity: 34 to 50% IACS, Ultimate tensile strength: 190 to 480 MPa, or 28 to 70 ksi, Thermal Conductivity: 130 to 190 W/m-K, Thermal Expansion: 23 μm/m-K

II.III Aluminum 7075 Alloy

Aluminum alloy 7075 is an aluminum alloy, with zinc as the primary alloying element. It is strong, with a strength comparable to many steels, and has good fatigue strength and average machinability. It has lower resistance to corrosion than many other Al alloys, but has significantly better corrosion resistance than the 2000 alloys. Its relatively high cost limits its use to applications where cheaper alloys are not suitable.7075 aluminum alloy's composition roughly includes 5.6–6.1% zinc, 2.1–2.5% magnesium, 1.2–1.6% copper, and less than a half percent of silicon, iron, manganese, titanium, chromium, and other metals. It is produced in many tempers, some of which are 7075-0, 7075-T6, 7075-T651.

Basic properties:

Aluminium 7075A has a density of 2.810 g/cm³[1] (0.1015 lb/in³)

III. Experimental Details

Sample preparation:

In this study, Aluminum alloys refined with Al-5%Ti-1%B master alloy was prepared by strain-induced melt activated (SIMA) process. The main variables of the SIMA process were cold working, holding time and temperature in semi-solid state. Cold working was applied on specimens by upsetting technique to achieve 10%, 20% and 30% height reduction. Cold worked specimens were heat treated in semi-solid state at 585 °C, 595 °C, 605 °C, 615 °C, 625 °C and 635 °C and were kept in these temperatures for different times (20 and 30 min). Observations through optical and scanning electron microscopy were used to study the micro structural evaluation. The results revealed that fine and globular microstructures are obtained by applying 30 % height reduction percentage and heat treating in 625 °C for 30 min. Comparison between refined and unrefined Al2014 alloy after applying SIMA process showed that Al-5%Ti-1%B master alloy has no significant effect on average globule size but makes the final structure more globular. This is how the Aluminum alloys were prepared but we bought the rods of in the market of30mm diameter and using the lathe machine with different lathe operations we reduced them into 10mm diameter pieces

Fig.: Samples Work Pieces of AL Alloys (Al2014, Al7075, Al2025)

Surface finishing and weights of Aluminum alloy specimens

These are the weights of the specimen taken by using the digital weight machine after the surface finishing process of the alloy specimens

Fig.: Surface finishing of Aluminum alloy Specimens

Fig.: weighing of aluminum alloy specimens

Table: Weights of the alloy specimens before starting the experiment

S.No	Name of the specimens	Material piece number	Weight of pieces before experiment in gms	Weight of pieces after experiments in gms
1.	Al7075	3	6.628gms	6.607 gms
2.	l7075	5	6.297gms	6.290 gms
3.	Al7075	4	6.569gms	6.563gms
4.	Al2014	1	6.165gms	6.159gms
5.	Al2014	4	6.436gms	6.428gms
6.	Al2014	3	6.540gms	6.537gms
7.	Al2024	5	6.590gms	6.570gms
8.	Al2024	4	6.200gms	6.196gms
9.	Al2024	2	6.385gms	6.383gms

Hardness test

The Rockwell scale is a hardness scale based on indentation hardness of a material. The Rockwell test determines the hardness by measuring the depth of penetration of an indenter under a large load compared to the penetration made by a preload.[1] There are different scales, denoted by a single letter, that use different loads or indenters. The result is a dimensionless number noted as HRA, HRB, HRC, etc., where the last letter is the respective Rockwell scale (see below). When testing metals, indentation hardness correlates linearly with tensile strength. This important relation permits economically important nondestructive testing of bulk metal deliveries with lightweight, even portable equipment, such as hand-held Rockwell hardness testers

Wear test

A pin on disc tribometer consists of a stationary "pin" under an applied load in contact with a rotating disc. The pin can have any shape to simulate a specific contact, but spherical tips are often used to simplify the contact geometry. Coefficient of friction is determined by the ratio of the frictional force to the loading force on the pin.

The pin on disc test has proved useful in providing a simple wear and friction test for low friction coatings such as diamond-like carbon coatings on valve train components in internal combustion engines

Taguchi L-9:

Taguchi has envisaged a new method of conducting the design of experiments which are based on well defined guidelines. This method uses a special set of arrays called orthogonal arrays. These standard arrays stipulate the way of conducting the minimal number of experiments which could give the full information of all the factors that affect the performance parameter. The crux of the orthogonal arrays method lies in choosing the level combinations of the input design variables for each experiment.

A typical orthogonal array

While there are many standard orthogonal arrays available, each of the arrays is meant for a specific number of independent design variables and levels. For example, if one wants to conduct an experiment to understand the influence of 4 different independent variables with each variable having 3 set values (level values), then an L9 orthogonal array might be the right choice. The L9 orthogonal array is meant for understanding the effect of 4 independent factors each having 3 factor level values. This array assumes that there is no interaction between any two factors. While in many cases, no interaction model assumption is valid, there are some cases where there is a clear evidence of interaction. A typical case of interaction would be the interaction between the material properties and temperature.

Table: Taguchi L-9 orthogonal array

$L_9(3^4)$ Orthogonal array				
	Independent Variables			Performance Parameter Value
Experiment	Variable1 (materials)	Variable 2 (speed)	Variable 3 (loads)	Time
1	1	1	1	p1
2	1	2	2	p2
3	1	3	3	p3
4	2	1	2	p4
5	2	2	3	p5

6	2	3	1	p6
7	3	1	3	p7
8	3	2	1	p8
9	3	3	2	p9

In this we considered 3 Aluminum alloys 2014,2024,2075 and these are test on pin on disc apparatus under these variables.

Variable1	**Variable2**	**Variable3**
Alloy-1	300rpm (1)	10kg (1)
Alloy-2	350rpm (2)	15kg (2)
Alloy-3	400rpm (3)	20kg (3)

IV. Resuls And Discussion

The below table shows the values of the hardness test done on the aluminum alloys Al2024, Al2014, Al7075 by using Rockwell hardenss method in hardness test.

Table: Resuls for Hardness Test

S. no.	Material	Intender Used	Trail (1)	Trail (2)	Trail (3)	Trail (4)	HRB Rockwell B Hardness
1	AL2014	1/16inch ball	B65	B18	B98	B98	R_B 69.75
2	Al2024	1/16inch ball	B87	B8	B16	B10	R_B 30.25
3	Al7075	1/16inch ball	B2	B96	B91	B99	R_B 72

Generally considered as the most accurate among the three tests performed, this test also supports results obtained from the previous two tests, thereby confirming the increase in hardness.

REFERENCES

[1]. Rosa, Jorge Luiz; Robin, Alain; Silva, M. B.; Baldan, Carlos Alberto; Peres, Mauro Pedro. "Electrodeposition of copper on titanium wires: Taguchi experimental design approach". Journal of Materils Processing Technology. **209**: 1181–1188. doi:10.1016/j.jmatprotec.2008.03.021.

[2]. Rao, Ravella Sreenivas; C. Ganesh Kumar; R. Shetty Prakasham; Phil J. Hobbs (March 2008). "The Taguchi methodology as a statistical tool for biotechnological applications: A critical appraisal". Biotechnology Journal. **3** (4): 510–523. doi:10.1002/biot.200700201. PMID 18320563. Retrieved 2009-04-01.

[3]. Rao, R. Sreenivas; R.S. Prakasham; K. Krishna Prasad; S. Rajesham; P.N. Sarma; L. Venkateswar Rao (April 2004). "Xylitol production by Candida sp.: parameter optimization using Taguchi approach". Process Biochemistry. **39** (8): 951–956. doi:10.1016/S0032-9592(03)00207-3.

[4]. Selden, Paul H. (1997). Sales Process Engineering: A Personal Workshop. Milwaukee, Wisconsin: ASQ Quality Press. p. 237. ISBN 0-87389-418-9.

[5]. Logothetis, N.; Wynn, H. P. (1989). Quality Through Design: Experimental Design, Off-line Quality Control, and Taguchi's Contributions. Oxford University Press, Oxford Science Publications. pp. 464+xi. ISBN 0-19-851993-1.

[6]. Wu, C. F. Jeff; Hamada, Michael (2002). Experiments: Planning, Analysis, and Parameter Design Optimization. Wiley.

[7]. Box, G. E. P. and Draper, Norman. 2007. Response Surfaces, Mixtures, and Ridge Analyses, Second Edition [of Empirical Model-Building and Response Surfaces, 1987], Wiley.

[8]. Atkinson, A. C.; Donev, A. N.; Tobias, R. D. (2007). Optimum Experimental Designs, with SAS. Oxford University Press. pp. 511+xvi. ISBN 978-0-19-929660-6.

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