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INVESTIGATING THE SLIDING WEAR CHARACTERISTICS OF ZAMAK 5 ALLOY UNDER DRYAND WET LUBRICATING CONDITIONS

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Abstract - Zamak refers to a category of alloys that include zinc as the base metal and various alloys like aluminium, copper and Magnesium etc. Despite the fact that Zamak alloy belongs to the ZA alloy family, it contains 4% aluminium. Electroplating and wet painting of Zamak alloys is easy. As a result, ZAMAK alloy can be used in a number of automotive applications to replace aluminium alloys.

The tribological properties of Zamak alloy were investigated in this study using a weight loss method and a Pin-on Disc apparatus. Mechanical moulding and machining is used to create Zamak 5 samples.The experiment is carried out under different loads, displacements, and speeds under dry and wet lubrication conditions.

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Key Words: *ZAMAK 5 Alloy, Weight loss Method, Pin on Disc, Dry and Wet Lubrication, Wear rate, Coefficient of friction*

1.INTRODUCTION

Pot metal and white metal alloys are commonly used in zinc composites. When higher hardness, strength, and creep resistance are needed, Zamak 5 is preferred over other Zamak alloys. Zamak 5 has a similar composition to Zamak 3 with the addition of 1% copper to increase hardness and destructive resistance (by about 10%), but it reduces pliability.

Zamak 5, also known as Zinc Compound 5, is the most commonly used Zinc alloy in Europe. As compared to Zamak alloys, it has more strength and less pliability. As compared to Aluminum alloy, the wear rate of Zamak 5 alloy was extremely high.

The tribological properties of Zamak5 alloy in both dry and lubricated conditions are investigated in this paper. A pin-on-disc apparatus is used to investigate the sliding wear test with various loads and sliding speeds.

Zamak5 alloy has the highest damping character of any zinc alloy, with a damping strength nearly ten times that of A380 aluminium. The smoothness of zinc's phenomenon allows for a more slender blade and cooling pin configuration to better dissipate heat. Because of their high hardness (Table 1) and natural lubrication properties, all zamak alloys, especially Zamak-3 and Zamak-5, have excellent wear resistance qualities.

Table 1 : Mechanical properties of Zamak 5 alloy

S.No	Property	Metric Value
1	Ultimate tensile strength	331 N/mm^2
2	Yield strength (0.2% offset)	295 N/mm^2
3	Shear strength	262 N/mm^2
4	Compressive yield strength	600 N/mm^2
5	Fatigue strength (reverse bending 5x10^8 cycles)	57 N/mm^2
6	Impact strength	0.052KJ
7	Elongation at F_{max}	2%
8	Elongation at fracture	3.6%
9	Hardness	91 BHN
10	Modulus of elasticity	96 GPa

2.PROPERTIES OF ZAMAK 5

The Zamak 5 castings are slightly more grounded and tougher than the Zamak 3 castings. In either case, these improvements are compensated by a lack of pliability, which may affect formability during auxiliary twisting, riveting, swaging, or pleating operations. The addition of 1% copper to Zamak 5 (Table 3) accounts for these fluctuations in properties.

The alloy is usually die cast in Europe and has excellent castability and creep performance as compared to Zamak 3. Material specifiers also strengthen components through design adjustments rather than using Zamak 5 because Zamak 3 is so readily available. When extra tensile strength is required, Zamak 5 alloy castings are recommended.

Table 2: Physical properties of Zamak 5 alloy

S.No	Property	Metric Value
1	Density	6.6 g/cm^3
2	Melting point	383ºC
3	Thermal conductivity	109W/mK
4	Coefficient of thermal expansion	27.4µm/m°C
5	Electrical Conductivity	26µm/mºk
6	Thermal conductivity	109 W/mK

3. EXPERIMENTAL STUDY

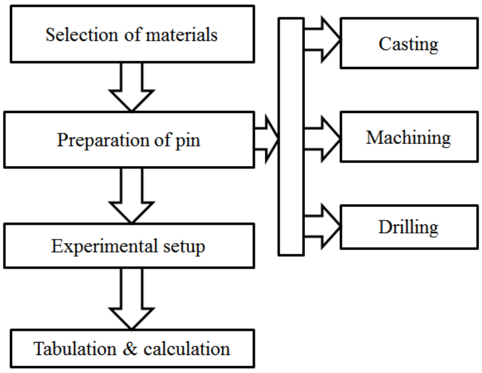


Figure 1 Methodology

3.1 Specimen Preparation

The specimen material used in this analysis is Zamak 5 alloy, which has the chemical composition described in **Table 3**. Mechanical moulding is used to make it. In a temperature-controlled electrical crucible furnace, the melting process for Zamak5 alloy was carried out.

Table 3
Chemical composition of the ZAMAK 5

S.No	Materials	% of weight
1	Aluminum	3.5-4.3
2	Copper	0.75-1.25
3	Magnesium	0.03-0.08
4	Iron (max)	0.1
5	Lead (max)	0.005
6	Cadmium (max)	0.004
7	Tin (max)	0.003
8	Zinc	Balance

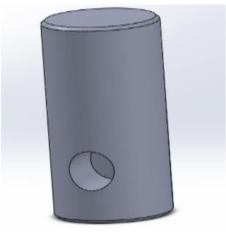


Fig 2(a) 3D view of specimen

Fig 2(b) Tested specimen

The specimen was machined to 6mm dia and 35mm length using CNC turning to meet the appropriate size of pin on disc apparatus. Figures 2(a) and 2(b) provide a sample of the pins.

3.2 Experimental Procedure

This study looked into the dry and wet sliding wear properties of the ZAMAK 5 alloy. Sliding wear experiments in both dry and wet lubricated environments were performed using a pin-on-disc apparatus.

The weight loss method and the **PIN ON DISC** apparatus will be used to calculate the **ZAMAK-5** alloy's wear rate. The working of PIN ON DISC apparatus is depicted in Figure 3a and 3b.

Fig 3(a) Pin on Disc Apparatus

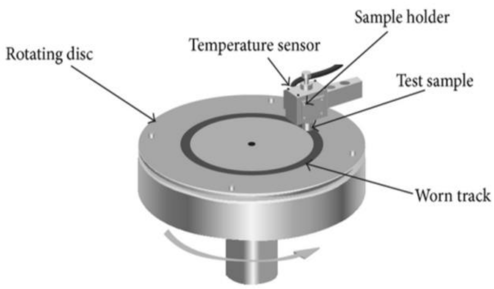


Fig 3 (b) working of Pin on Disc Apparatus

Friction and wear experiments are carried out with pin-on-disc equipment. The cylindrical shape ZAMAK-5 material sample pin has a diameter of 6mm and a length of 30mm. Different loads and speeds were used during the experiments. The tribometer is used to measure frictional forces. A Mettler weighing balance unit was used to assess the specimen's weight loss. The wear rate and coefficient of friction of the zamak-5 material is determined using the formulas below.

Sliding velocity = $\pi DN/60$

Let

D = diameter of the track in m,

N = speed of a disc in rpm

$$\text{Time} = \frac{\text{Distance}}{\text{Sliding Velocity}}$$

$$\text{Volume loss} = \frac{\text{Weight Loss}}{\text{Density}}$$

$$\text{Wear rate} = \frac{\text{Volume Loss}}{\text{Distance}}$$

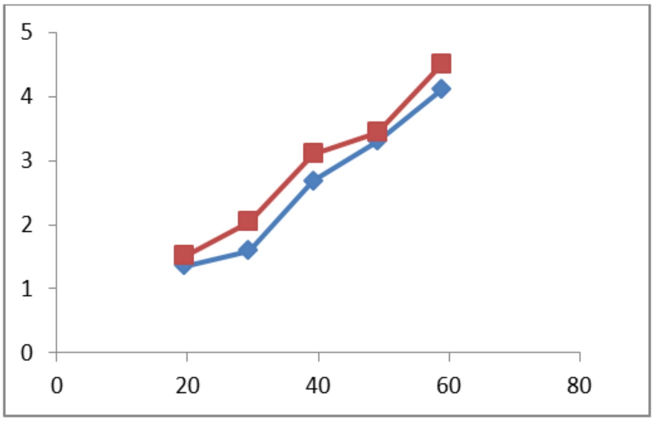
$$\text{Co-efficient of friction} = \frac{\text{Frictional force}}{\text{Applied load}}$$

4. RESULTS AND DISCUSSIONS

On the basis of the measurements taken during the experiment, the following parameters' effects on the wear rate and the coefficient of friction were examined

Table 4
Wear rate of Zamak 5 under Dry Lubrication

LOAD (N)	SPEED (RPM)	WEAR RATE OF ZAMAK-5 ALLOY (mm^3/m)	WEAR RATE OF ALUMINIUM ALLOY (mm^{3}/m)
19.62	600	$1.361x10^{-06}$	$1.51x10^{-06}$
29.43	600	$1.597x10^{-06}$	$2.04x10^{-06}$
39.24	600	$2.681x10^{-06}$	$3.10x10^{-06}$
49.05	600	$3.306x10^{-06}$	$3.41x10^{-06}$
58.86	600	$4.108x10^{-06}$	$4.50x10^{-06}$

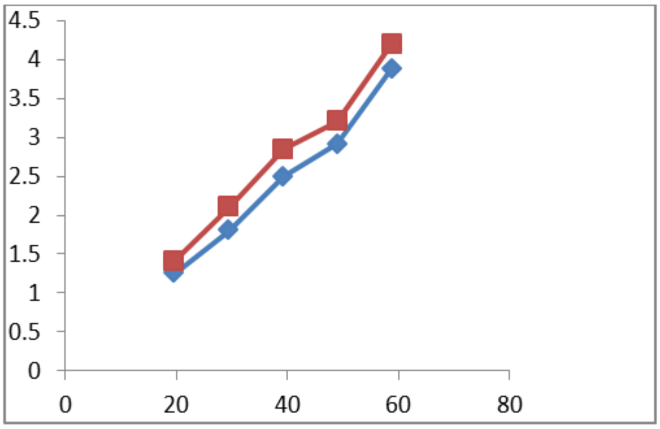


Graph 1 Wear rate of Zamak 5 and Aluminum under without Lubrication

Table 4 and Graph 1 demonstrate that ZAMAK 5 alloy has an 8% to 10% lower wear rate than Aluminum alloy in without lubrication.

Table 5
Wear rate of Zamak 5 under Wet Lubrication

LOAD (N)	SPEED (RPM)	WEAR RATE OF ZAMAK-5 ALLOY (mm^3/m)	WEAR RATE OF ALUMINIUM ALLOY (mm^3/m)
19.62	600	$1.251x10^{-07}$	$1.41x10^{-07}$
29.43	600	$1.807x10^{-07}$	$2.104x10^{-07}$
39.24	600	$2.501x10^{-07}$	$2.85x10^{-07}$
49.05	600	$2.91x10^{-07}$	$3.21x10^{-07}$
58.86	600	$3.88x10^{-07}$	$4.20x10^{-07}$

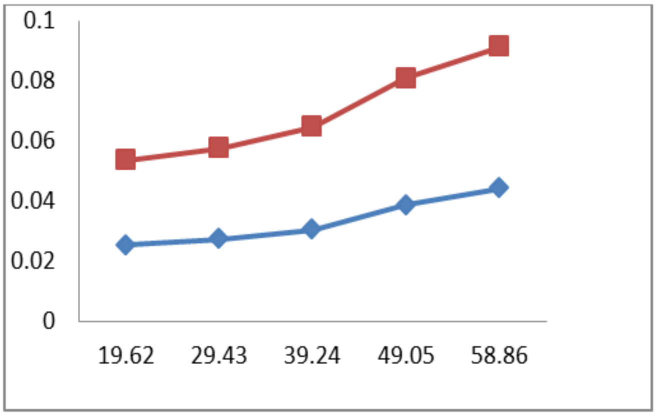


Graph 2 Wear rate of Zamak 5 under Wet Lubrication

In lubricated condition the wear rate of ZAMAK 5 alloy is 7.5% to 10.3% lower than that of aluminum alloy, as shown in Table 5 and Graph 2.

Table 6
Coefficient of Friction of Zamak 5 under Dry Lubrication

LOAD (N)	SPEED (RPM)	COEFFICIENT OF FRICTION OF ZAMAK-5	CO-EFFICIENT OF FRICTION OF ALUMINIUM ALLOY
19.62	600	0.132	0.172
29.43	600	0.163	0.201
39.24	600	0.193	0.242
49.05	600	0.234	0.276
58.86	600	0.278	0.304

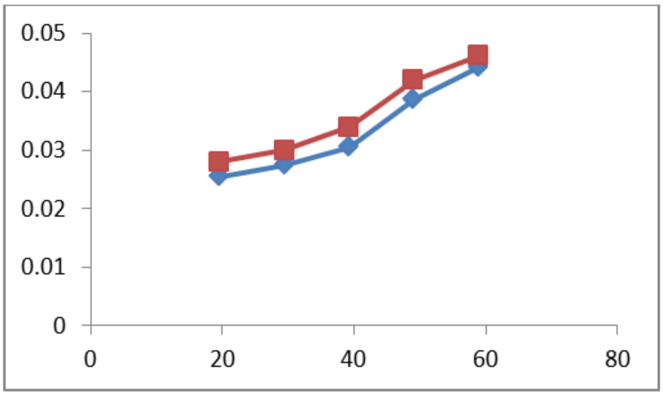


Graph 3 Coefficient of Friction of Zamak 5 under Dry Lubrication

Table 5 and Graph 3 show that the Zamak 5's Coefficient of Friction is 0.026 to 0.049 less than that of Aluminum alloy in the absence of lubrication.

Table 7
Coefficient of Friction of of Zamak 5 under Wet Lubrication

Load (N)	Speed (RPM)	Coefficient of Friction of Zamak-5	Co-Efficient of Friction of Aluminium Alloy
19.62	600	0.0255	0.028
29.43	600	0.0275	0.030
39.24	600	0.0306	0.034
49.05	600	0.0387	0.042
58.86	600	0.0442	0.0461



Graph 4 Coefficient of Friction of Zamak 5 under Wet Lubrication

Zamak 5's Coefficient of Friction is 0.0019 to 0.0034 less than that of Aluminium in lubricated conditions, as demonstrated in Table 6 and Graph 3.

5. CONCLUSION

The use of ZAMAK-5 alloy reduces the rate of wear and increases lubrication. The zamak-5 alloy has a 9 to 11 percent lower wear rate and co-efficient of friction than the current Aluminum alloy in both dry and wet lubrication conditions. It's also ideal for use at high temperatures. Even though the zamak-5 alloy is more costly, it has a longer life cycle in both wet and dry conditions.

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