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Preparation of the Experimental Set-Up and Study of The Friction Coefficient for Different Pairs of Metals

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Abstract -Burr and roughness are interlocked by making movements impossible when two surfaces are in contact with each other. A force that opposes this movement is created on the contact surface when the body moves or tries to travel over another body. The force that determines the motion or tendency of motion is called friction or friction. Frictional force has the property of altering the degree of force in order to attempt to cause motion to the body in such a manner as to stop motion. The degree of friction cannot be increased beyond the limit specified as the limitation or ultimate friction force if the force applied is greater than the limitation of friction, the body moves.

In this construction, the hydraulic jack is used to evaluate the angle, the protractor is used to measure the angle and the weights are used to adjust the load. The result obtained from the experimental setup was consistent with the actual coefficient of friction. This demonstrated a good accuracy with an adequate error deviation. Results have demonstrated that the coefficient of friction is independent of the load and depends solely on the material and the smooth surface

Keywords: Friction, Coefficient of Friction Hydraulic Jack, Protractor

I. INTRODUCTION

The friction coefficient is a value that indicates the relationship between the friction force between the two surfaces and the natural response between the objects involved. It is a value that is often used in physics to find the usual force or frictional force of an object where other approaches are not available. The friction coefficient is shown by $F_f = \mu F_n$. In that equation, Ff is the friction force, μ is the friction coefficient, and F_n is the normal force.

The μ coefficient can be two different things. This is either the coefficient of static friction μ_s or the coefficient of dynamic friction μ_k. The coefficient of static friction is the friction force between two objects when neither object is moving.

The coefficient of friction is dimensionless and has no unit. It is a scalar, meaning that the orientation of the force does not influence the physical quantity. The coefficient of friction depends on the artifacts that generate friction. The meaning is normally between 0 and 1 but can be greater than 1. A value of 0 means there is no friction between objects at all. It is only technically feasible. Both objects in the physical world are going to have some tension when they meet each other. A value of 1 means that the friction force is equal to the usual force. It is a fallacy that the friction coefficient is limited to values between zero and one. A friction coefficient that is greater than one clearly implies that the friction force is higher than the usual force. For example, an entity such as silicone rubber may have a friction coefficient far greater than one.

The friction force is the force exerted by a surface as an object passes across it-or attempts to travel across it. The inclined plane can be defined as any plane surface situated at an angle to the horizontal plane. At the moment of sliding, the friction force must be the same as the factor of weight acting down the plane.

The friction coefficient and the interfacial isolation of the sliding surfaces due to the trapped wear particles were measured on a variety of sliding pairs in both the dry and the lubricated sliding. The findings showed that the particle size did not remain unchanged, except during a single sliding test, but grew as the sliding continued. This rise in the size of the wear particles was found to be attributable not to the creation of larger wear particles but to the agglomeration of small wear particles formed during sliding. The formation of large wear particle agglomerates induced an increase in the amount of plowing and also a simultaneous increase in the coefficient of friction. [1]

The mechanism of electrical contact resistance between lightly loaded sliding surfaces has been investigated. The improvement in contact resistance of non-noble or base metal contacts, such as S_n-P_b, was found to be due to the oxidation of metallic wear waste, which is caught in sliding contacts. It was believed that even non-noble or base metals (e.g. copper, nickel and S_n-P_b) show poor

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contact resistance as wear debris is constantly separated from the sliding surfaces. Experimental testing on the modulated touch surface of the base metal contact found that the electrical contact resistance was poor so the debris was essentially stuck, supporting the validity of the theory. The implications of these results for the use of base metals in electrical contacts are explored.[2]

Experimental data and a physical model of the effect of the natural load and the rigidity of the system on the friction and wear processes of water lubrication. Transformation from mild to severe friction and wear was found to be independent of the rigidity of the system but to be dependent on normal load. If the normal load is further raised, it achieves another critical value, which depends on the rigidity of the system that generates high-frequency, self-excited vibrations. This oscillations show a connection between frictional and normal degrees of freedom. Mild wear rates are seen to increase with regular load and even rigidity of the device.[3]

Variation of friction and rate of wear depends on interfacial conditions such as normal load, geometry, relative surface motion, slipping speed, surface roughness of friction surfaces, substrate shape, unit stiffness, temperature, stick slip, relative humidity, lubrication and vibration. Among these factors, sliding speed and normal load are the two main factors that play a key role in friction and wear rate variations.[6]

II. MANUFACTURING

2.1. Manufacturing of setup for calculating friction coefficient

Pulley of Wood:

A pulley is a wheel on an axle or shaft intended to facilitate the rotation and changing of direction of the taut cable or belt, or the transfer of force between the shaft and the cable or belt. In the case of a pulley supported by a frame or shell that does not move power to a shaft, but is used to direct the cable or exert force, the supporting shell is called a block, and the pulley may be called a shaft.

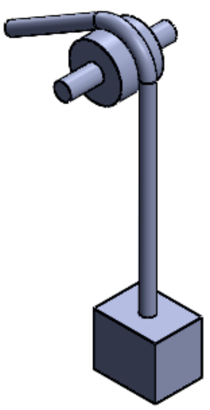

Figure 1: Pulley of Wood

A pulley may have a groove or groove between the flanges along its circumference to position the cable or belt. The driving feature of the pulley system may be a cord, a cable, a belt or a chain.

Hinges:

The hinge is a mechanical bearing that connects two stable objects, normally having only a small rotation angle between them. Two objects bound by an ideal hinge rotate relative to each other on a fixed axis of rotation.

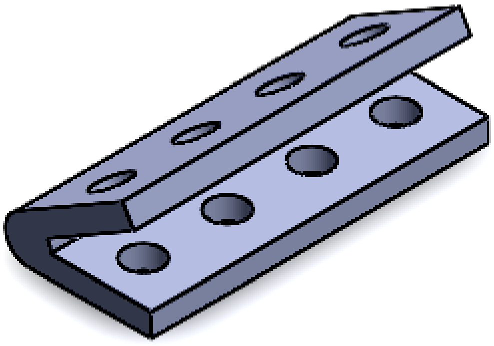

Figure 2: Barrel Hinge

Many further translations or rotations are prohibited, and therefore the hinge has a degree of independence. The hinges can be constructed of lightweight material or moving parts. In biology, certain joints act as hinges, like the joint of the elbow.

Slotted Weights:

Slotted masses are used to teach physics and other sciences in undergraduate lab courses. The slotted mass and weight-hanger combination helps a student to easily build any desired volume of mass, to be used in experiments involving force, acceleration, and mass. There are also several other experiments in other areas where the vector hanging mass is handy.

Figure 3: Slotted Weights

Hydraulic Jack:

A jack is a mechanism that uses force to lift a heavy load. The primary mechanism by which the force is exerted varies depending on the particular type of jack, but is generally a screw thread or a hydraulic cylinder. Jacks can be classified according to the type of power they use: mechanical or hydraulic. Mechanical jacks, such as car jacks and house jacks, lift heavy machinery and are graded on the basis of lifting power (for example, the number of tons they can lift). Hydraulic jacks tend to be larger and

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can carry heavy loads higher, including bottle jacks and floor jacks.

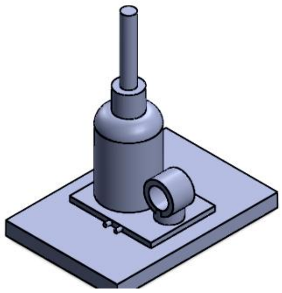

Figure 3: Modelled Hydraulic Jack

Protractor:

The bevel protractor is a graduated circular protractor with one pivoted arm used for weighing or labelling angles. Often Venire scales are attached to provide more reliable readings. It has wide use in architectural and mechanical drawing, but its use is declining due to the availability of modern drawing tools or CAD.

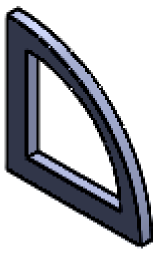

Figure 3: Modelled Protractor

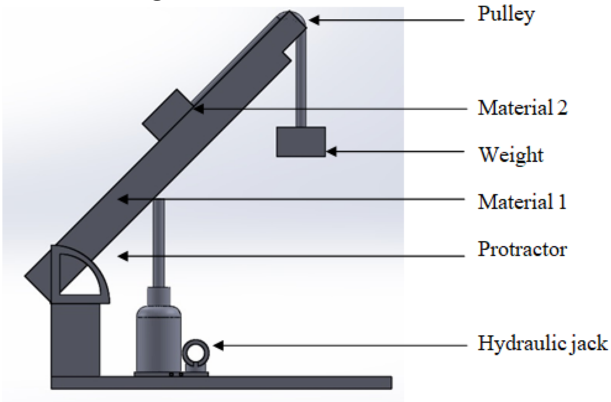

Figure 4: 2D Model of Setup

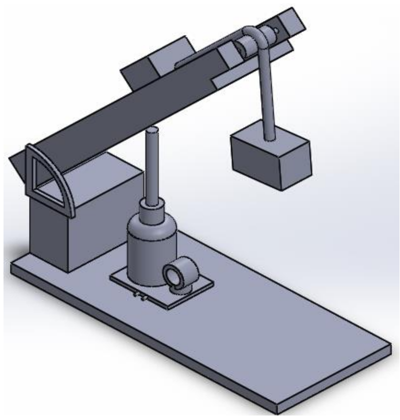

Figure 5: 3D Model of Setup

Figure 4: Final Setup of Manufactured

III. TEST PROCEDURE AND RESULT

3.1.TEST PROCEDURE

Case -1: When weights are constant

1. First of all set the plane of Material 1 at 0º slope by ensuring that it is in horizontal plane.
2. Afterwards, set the cube of material 2 at the end of right edge of Material 1 plane.
3. Increase the tilt angle.
4. Note the angle of inclination when cube starts to slide.
5. Now evaluate static deflection (μ) by substituting the values in the equation.

$$\mu = \frac{(mg\sin\theta - P)}{(mg\cos\theta)}$$

6. Repeat the same procedure three times and take the average.

Sample calculations

$$\mu = \frac{(mg\sin\theta - P)}{(mg\cos\theta)}$$

$$\mu = \frac{(953.59 * 9.81 * \sin 39 - 250 * 9.81)}{(953.59 * 9.81 * \cos 39)}$$

$$\mu = 0.47$$

Case -2: When angles are constant

1. First of all set the plane of Material 1 at some angle
2. Place the cube in the middle of plane of Material 1
3. Apply weight at the end of plane by weight hanger
4. Note the loads when cube starts to slide
5. Now evaluate static deflection (μ) by substituting the values in the equation

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$$\mu = \frac{(P - mg \sin\theta)}{(mg \cos\theta)}$$

6. Repeat the same procedure three times and take the average.

Sample calculation

Material 1

Weight of Brass = 570gms
Weight of MS = 480gms
Weight of GI = 405gms
Weight of cube = 800gms

$$\mu = \frac{(P - mg \sin\theta)}{(mg \cos\theta)}$$

$$\mu = \frac{(1150 * 9.81 - (953.59 * 9.81 * \sin 45)}{(953.59 * 9.81 * \cos 45)}$$

$$\mu = 0.70$$

Material 2

Weight of Brass = 42.04gms
Weight of MS = 60.9gms
Weight of GI = 50.65gms

3.2. RESULTS:

Table 1: Determination of Friction Coefficient at Constant Weight

S.No.	Material 1	Material 2	Load at which motion starts (P) (gms)	Angle (θ°)			Coefficient of Friction μ			Average coefficient of friction μ_{avg}
				θ_1	θ_2	θ_3	μ_1	μ_2	μ_3	
1	GI	GI	250	36	40	39	0.40	0.49	0.47	0.48
2	Brass	Brass	250	30	31	33	0.27	0.29	0.33	0.29
3	MS	MS	250	41	44	43	0.52	0.60	0.57	0.56
4	GI	Brass	250	40	43	45	0.49	0.57	0.62	0.56
		MS		36	39	37	0.40	0.47	0.42	0.43
5	Brass	MS	250	29	31	30	0.25	0.29	0.27	0.27

Table 2: Percentage Error of Friction Coefficient at Constant Weight

S.No.	Material 1	Material 2	Actual coefficient of friction(A)	Average coefficient of friction(B)	Error |B-A|	%Error [|B-A|/A]*100
1	Brass	Ms	0.35	0.27	0.08	22
2	Ms	Ms	0.5-0.8	0.56	0.09	13

Table 3: Determination of Friction Coefficient at Constant Angles

S.No.	Material 1	Material 2	Load at which motion starts (P) (gms)			Angle (θ°)	Coefficient of Friction μ			Average coefficient of friction μ_{avg}
			P_1	P_2	P_3		μ_1	μ_2	μ_3	
1	GI	GI	1200	1250	1280	45	0.77	0.85	0.89	0.83
		MS	1100	1150	1300		0.63	0.70	0.96	0.76
		Brass	1270	1350	1350		0.88	1.002	0.95	0.94

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2	MS	GI	1050	1150	1210	30	0.73	0.73	0.88	0.78
		MS	960	1050	1130		0.58	0.59	0.79	0.68
		Brass	1170	1250	1330		0.83	0.87	1.03	0.91
3	Brass	GI	920	950	1000	35	0.47	0.51	0.57	0.51
		MS	820	850	900		0.34	0.38	0.45	0.39
		Brass	1030	1050	1080		0.61	0.64	0.67	0.64

Table 4: Percentage Error of Friction Coefficient at Constant Angle

S.No.	Material 1	Material 2	Actual coefficient of friction(A)	Average coefficient of friction(B)	Error (B-A)	%Error [(B-A)/A]*100
1	Brass	Ms	0.35	0.39	0.04	11
2	Ms	Ms	0.5-0.8	0.68	0.03	4.6

Table 5: Percentage Error of Friction Coefficient at Constant Weight

S.No.	Material 1	Material 2	Actual coefficient of friction(A)	Average coefficient of friction(B)	Error |B-A|	%Error [|B-A|/A]*100
1	Brass	Ms	0.35	0.33	0.02	5
2	Ms	Ms	0.5-0.8	0.62	0.03	4

IV. CONCLUSION

The following results can be taken from the study: the coefficient of static friction of various materials under different conditions has been determined. It can be inferred from the exam that the co-efficient of friction depends on contact surface condition of material.

I. It is found that the percentage of error decreased in Case-II relative to Case-I. This is a friction coefficient that depends on the load.

II. The result obtained from the experimental setup was compared with the true friction coefficient and the standard value. This showed a reasonable precision with an acceptable error deviation.

The overall test outcome is satisfactory with 5 percent difference.

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