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Surface Texture to Reduce Friction Coefficient

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Abstract:
The Surface texture is crucial amongst different factors that management friction and transfer layer formation throughout slippy. Surface texture of a tougher interacting surface contains an influence on resistance and wear behaviour. The surface look is vital for each the lubrication regime and therefore the level of friction. Associate degree uneven surface in boundary lubrication offers a deformation part to the friction. The friction of well-polished surface in an exceedingly boundary lubrication condition is influence by the adhesive cutting of the interface. In this analysis, we tend to work on the textures and variation in their parameters like diameter, array pattern, lubrication etc. which will be used for the reduction of friction constant

Keywords: interface

I. Introduction

Surface texture is a contributing factor to increase or decrease the friction coefficient. Introduction of a controlled surface texture can decrease the resultant friction and improve tribological properties of sliding surfaces. Typically, surface textures for friction reduction comprise a flat surface interrupted by local depressions. The improving mechanism of the depressions depends on the contact situation.

Surface design can also be utilized to increase the coefficient of friction. High friction amongst interacting surfaces is highly desirable in numerous applications such as fixtures, couplings and bolted joints.

The objective of our Research is to further improve the designing of the surface designs and the relation between surface textures and friction coefficient. Its aim is to design the textures with reduced friction coefficient.

II. Literature Review

We are undertaking this analysis as the current industry trends today call for reduced or controlled friction and wear to improve safety and to be viable cost wise, energy efficient and environmentally friendly. Surface textures and friction coefficient have close relation with each other. As we change surface texture then friction coefficient either increases or decreases. We studied the relation between friction coefficient and surface texture. We referred some research papers of different authors and got more information of different surface textures which are proposed to be used for increasing or decreasing of frictional coefficient.

On the Basis of Surface Texture

In our research we compare various textures and their allied parameters to determine the variation in friction coefficient. While doing the literature survey we come to know that various authors have utilised various surface textures, conducted studies on them and determined from their experimental data, which of the surface was having minimum frictional coefficient. The etching of micro-dimples on the surface of metallic specimens has long been known to have a positive impact on the friction control and wear resistance at the sliding surfaces.

On the Basis of Diameter of Dimples

While doing the literature survey we come across studies conducted by various authors wherein they have assumed various diameters and arrays of dimples and concluded that it

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significantly affects the coefficient of friction according to Xiaolei Wang's research paper.

On the Basis of Array

Texturing patterns etched on the interacting surfaces influence friction under three principle lubrication regimes: Hydrodynamic, Elastohydrodynamic, and boundary lubrication regimes. While conducting literature survey we come across reference papers which suggest that each regime requires specific dimple size, shape, depth and areal density to achieve friction reduction. These multiple parameters in a specific combination, would act as the ideal texturing configuration for every individual regime.

On the Basis of Lubrication

The lubricator once restricted to a considerably tiny volume, very skinny to exhibit any noticeable flow, helps to emphasize the flexibility of the unsmooth surfaces to retain the lubricator inside the contact space. During this manner the lubricator flows over the surfaces when every pass, providing a chance to refill the textures and conjointly to form attainable full film lubrication if speed is enhanced. The clearest results were achieved within the starved boundary lubrication mode. Low friction and smallest wear state of affairs was discovered once the depressions were sufficiently shut and adjusted in order that the total contact circle ofttimes passed these lubricator reservoirs.

On the Basis of Tribological Characteristics

A) Ceramic Tribo Element:

It is observed that ceramics are generally used for tribo element as they have low density, low thermal expansion, good corrosion resistance and high hardness over a wide range of temperatures. Very low coefficient of friction is observed for SiC approx. 0.0038.

B) Steel Tribo Element (Groove Surface Texture)

In the research paper presented by Mr. Wei Wu,Mr. Guiming Chen, Mr. Boxuan Fan, and Mr.Jianyou Liu, different groove surface textures were made on steel by a laser machine, and their tribological behaviours were experimentally studied with the employment of friction and wear tester under distinct high temperature and other working conditions. It was discovered that the majority groove surface textures may scale back the friction constant and alleviate wear, however the extent of reduction is completely different below characteristic experimental conditions.

- **Major Findings from Literature Survey**

From the literature survey, we find various important factors that affect the friction coefficient. Following are some important factors:

- The friction coefficient can be reduced by dimples with an accrual diameter.
- As we increase load for the same speed, then friction coefficient increases with increase in load.
- With increase in dimple to area ratio, coefficient of friction increases with increase in load (N).
- As sliding velocity increases, gradual decrease in friction coefficient takes place for sample with no dimples.
- Proper texturing of micro-dimples can succeed in friction reduction.
- For larger dimples, lower friction coefficients were obtained.
- Friction in cutlery may be controlled by introducing a material and might be any improved by surface texturing the tool.
- As texture performance is maximized in interrupted cutting and at low speeds, the concept is partaking for roaches,

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taps and instrumentality cutting tools, notably among the machining of heat resisting alloys that severely limits the cutting speed.

- Surface texturing may reduce the frictional forces up to 80% and the smaller dimples are more effective at larger velocity gradient.
- In In comparison with untextured surfaces, the results proved that the dimples fashioned by the planned system might effectively cut back the friction constant by up to 23% and weight loss because of wear by up to 50% in each dry and lubricated conditions.
- About 64% friction reduction in boundary and 80% friction reduction in mixed lubrication condition was demonstrated with the elliptical shaped dimple configuration when sliding along its minor axis.
- When a study was conducted on the use of laser surface textures (circular dimples) on mechanical seals 40-50% reduction in friction torques and nearly doubling of the seal service life was found by various manufacturers.

III. Problem Definition

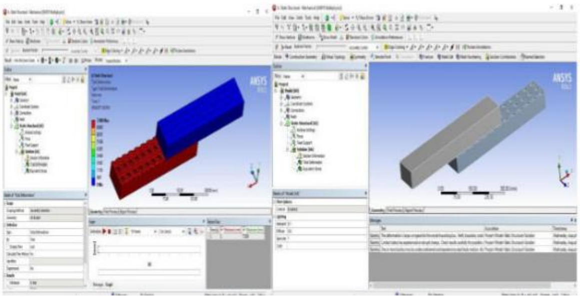
"To design surface texture with reduced friction coefficient by studying different surface textures."

IV. Research Objectives

To study the various surface textures and the relation between surface textures and friction coefficient. The objectives of the present research work are listed as:

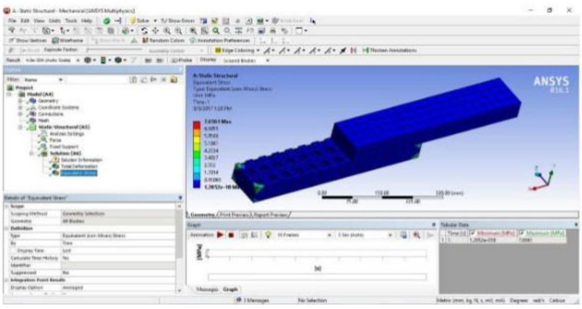
- Aim of present research is to minimize coefficient of friction by using various surface textures.
- To study Analysis and Simulation of various surface textures for friction control and reduction.
- Selection of optimized surface texture design based on of friction reduction.

Texture 2



- To study and evaluate the best techniques of manufacturing optimized surface texture to reduce coefficient of friction.

V. Experimental Details

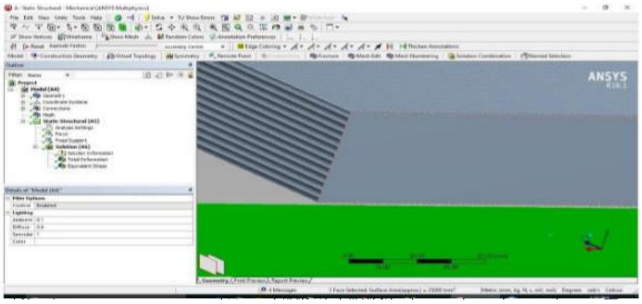


As per the literature survey, there are many researchers who have executed their research on tribological characteristics, solely on experimental setup. Very few researchers have compared their experimental work with simulation results obtained using engineering tools like analysis softwares. Executing the research within software will help reduction of time duration and experimental setup cost. It is difficult to perform large number of iterations using conventional methods due to time, cost, man and power constraints. Hence, we are conducting our research on various analytical softwares like ANSYS, ABAQUS. etc

Methodology

a. Design of various surface Texture for analysis of coefficient of friction.
b. Comparing various surface texture on various analysis tool based on coefficient of friction
c. Manufacturing of best surface texture obtained, from step 1 and 2 by using various manufacturing techniques.
d. Find out best manufacturing techniques for manufacturing of surface texture.
e. Compare Experimental data with analytical data.

Many analysis verticals, as well as mechanical engineering and MEMS, aim to change the behaviour of the system at the surface or at the interface between surfaces. Thus, the topography of the surface could be a crucial issue and should be enclosed in finite component simulations. The ensuing pure mathematics, meshes, and solutions are compared to demonstrate the strengths and weaknesses of the assorted textures.



Following types of surface textures are analysed: Textures will be selected based on reducing coefficient of friction. Till now we have not yet found coefficient of friction for these surfaces. For the analysis purpose, we fixed texture surface and pass on untextured surface by applying following boundary condition Load: -490N

Dimple Density (%):-7.5%, 15%, 30%

Sliding velocity (m/s): - 0.01m/s, 0.1m/s,1m/s

Dimple diameter (um): - 40um, 80um, 120um

Material properties of silicon nitride ceramic for analysis Density (g/cm3) 3.24, Vickers hardness (HV) 1600 Flexural strength (MPa) 1000, Fracture toughness (MPa m1/2) 5.4

The Taguchi Experiment for frictional coefficient:

The Orthogonal array setup:

A L18 orthogonal array was used in the experimental test because it has a good and even distribution of factorial iteration over all factors. Table 1 represent the list of all issue and level utilized in L18 orthogonal array matrix. It's noted that the L18 was changed to possess seven factors elite in representing seven dominant parameter that have an effect on the friction. Besides issue A with 2 levels, all alternative factors have 3 management levels. All levels ar elite for proprietary reasons. As shown in Table 1, a complete of eighteen Taguchi experiments were conducted with totally different levels of management factors explicit in Table 2.

Table 1 control factor and levels for the L18 Array Matrix

Symbol	Description	Level 1	Level 2	Level 3
A	Lubrication method	Wet	Dry	
B	Speed	400 rpm	800 rpm	1200rpm
C	Load	25 N	50 N	75 N
D	Density	7.5 %	10 %	15 %
E	Size	0.01	0.04	0.09
F	Shape	Triangle	Circle	Square
G	Pin material	M.S.	EN 31	SS 304

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Table 2 Experimental Layout and resul

Exp no	Lubrication	Speed	Load	Density	Area	Shape	Material	COF
1	Wet	400	25	7.5	0.01	TRI	MS	0.16
2	Wet	400	50	10	0.04	CIR	EN 31	0.11
3	Wet	400	75	15	0.09	SQRE	SS	0.09
4	Wet	800	25	7.5	0.04	CIR	SS	0.12
5	Wet	800	50	10	0.09	SQRE	MS	0.15
6	Wet	800	75	15	0.01	TRI	EN 31	0.09
7	Wet	1200	25	10	0.01	SQRE	EN 31	0.13
8	Wet	1200	50	15	0.04	TRI	SS	0.1
9	Wet	1200	75	7.5	0.09	CIR	MS	0.06
10	Dry	400	25	15	0.09	CIR	EN 31	0.2
11	Dry	400	50	7.5	0.01	SQRE	SS	0.17
12	Dry	400	75	10	0.04	TRI	MS	0.57
13	Dry	800	25	10	0.09	TRI	SS	0.57
14	Dry	800	50	15	0.01	CIR	MS	0.29
15	Dry	800	75	7.5	0.04	SQRE	EN 31	0.46
16	Dry	1200	25	15	0.04	SQRE	MS	0.63
17	Dry	1200	50	7.5	0.09	TRI	EN 31	0.41
18	Dry	1200	75	10	0.01	CIR	SS	0.49

Evaluation by calculating the S/N ratio:

In Taguchi styles, a live of strength accustomed determine management factors that scale back variability during a product or method by minimizing the consequences of uncontrollable factors (noise factors). Management factors ar those style and method parameters that may be controlled. Noise factors cannot be controlled throughout production or product use, however is controlled throughout experimentation. During a Taguchi designed experiment, you manipulate noise factors to force variability to occur and from the results, determine best management issue settings that create the method or product sturdy, or immune to variation from the noise factors. Higher values of the S/N (S/N) determine management issue settings that minimize the consequences of the noise factors.

Taguchi experiments typically use a 2-step optimisation method. In step one use the S/N to spot those management factors that scale back variability. In step 2, determine management factors that move the mean to focus on and have atiny low or no impact on the S/N. The S/N measures however the response varies relative to the nominal or target price beneath totally different condition. You'll be able to choose between totally different signal/noise ratio ratios, betting on the goal of your experiment. For static styles, Minitab offers four signal/noise ratio ratios:

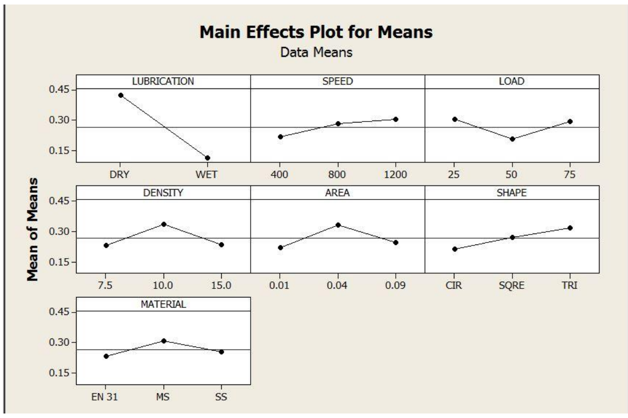
Taguchi has extended the audio thought of the S/N magnitude relation, and to a multi-variable experimentation. The S/N magnitude relation measures the extent of system performance. Its formula is meant specified through the choice of the best price optimises the experiment. However, the tactic of calculative the S/N magnitude relation differs on whether or not an outsized response; a smaller response or AN on-target response is fascinating. In our case wherever the smaller quantity of resistance corfficient is best, the formula is shown as follows:

$$S/N = -10\,Log\left[\frac{1}{n}\sum_{i=1}^{n} Y_i^2\right]$$

Performing the ANOVA :

The analysis of variance (ANOVA) on the experimental results is performed to judge the variation of constant of friction throughout slippery conditions. From the analysis, it's simple to spot that that factors area unit the foremost vital in terms to cut back the constant of friction. Consequently, those vital factors got to be beneath careful management to reduced friction between 2 surfaces.

Results and discussion:



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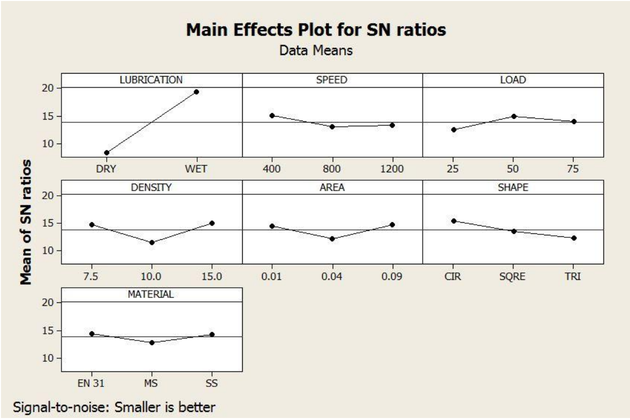

VI. Conclusion

From all the reference papers referred to within this study we conclude that the retention of lubricant film relies on various factors namely density of dimples, area of dimples, topographic area of textured surface, temperature of experimental setup and the variant of lubricant used. The micro-dimples generated by the varied mechanism area unit effective to cut back friction and wear each in dry and lubricated contacts. The presence of micro-dimples on the surfaces has positive impact on friction management. The varied parameters and experimental setups incorporated among the reference papers have helped United States of America analyse the strategies which might be enforced to cut back the constant of friction.

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