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Effect of Energy flow and Transmitted power in the Degrading wet friction

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ABSTRACT

Experiments and simulations performed within the framework of accelerated-life tests of wet friction clutches reveal that with the progression of degradation of clutches, the transmitted power decreases along with a modification within the energy flow behavior, principally within the pre-lockup section. Additionally, the engagement length will increase and therefore the relative rate fluctuation in post-lockup section changes. These degradation effects area unit thanks to the reduction in friction force and therefore the modification in the relative rate profile caused by the dynamic friction characteristics of the clutch friction material with degradation. Simulations area unit performed AN exceedingly in a very bond graph methodology incorporating an tailored type of the Generalized Maxwell Slip (GMS) friction model, that calculates the friction force taking under consideration the dynamic variation in relative rate and the normal load.

1. INTRODUCTION

A wet-friction clutch could be a robot that transmits power from one element to a different through resistance and viscous effects. In recent years, increasing use of wet-friction clutches for varied applications has junction rectifier researchers and engineers across the globe to review and improve the ability transmission capability and energy flow behavior of the wet friction clutches. Power transmission capability is outline because the most worth of mechanical power that a wet clutch is in a position to transmit, (which is a product of the transmitted torsion and therefore the relative velocity), from a driver member to the driven member with efficiency and effectively.

Basically, wet friction clutches comprises components sort of a hub, a drum, setup and friction disc. The friction disc is formed of steel with a friction material guaranteed on each side, and therefore the setup disc is made of plain steel. To produce the cooling to the clutch whereas it's operative, the discs are immersed in associate automatic drive fluid (ATF). The use of ATF reduces the ability transmission capability of the wet friction clutches, owing to the reduction in coefficient of friction as compared to the dry clutches [1]. Therefore to achieve the specified power transmission capacity, typically the wet friction clutches are assembled with many pairs of friction and setup disc. The look power transmission capability is calculated by engineers considering the parameters of a contemporary clutch, however because the clutch progresses towards its service life, it degrades. The degradations occurring in wet friction clutches are primarily caused by each friction material and ATF degradation [2]. The objective of this paper is to analyze the results of degradation of wet clutch on the transmitted power and corresponding energy flow behavior through experiments and simulations. Accelerated life tests (ALTs) distributed on wet friction clutches, reveal that with the progression of the clutch degradation, the transmitted power and therefore the corresponding energy flow behavior changes. In addition the engagement length will increase and therefore the relative speed fluctuation in post-lockup part (once the clutch is totally engaged) changes [3]. To simulate the above-named degradation effects, a clutch system is sculptured, during a bond-graph methodology. The bond-graph approach is taken into account because of its ability to represent the ability and energy flow variables between any 2 connected components during a simulation setting. An appropriately tailored style of the Generalized Maxwell Slip (GMS) friction model [4] is employed within the simulations, during which the dynamic friction torsion is not solely a perform of relative speed between the hub and {also the} drum of the clutch however also on the pressure engaged on the piston. Moreover, as the degradation progresses, the Stribeck behavior and therefore the tangential contact stiffness amendment [3], along side their several parameters, this warrants a modification of the corresponding parameters within the friction model in associate reconciling manner. The simulation results show that the transmitted power decreases and the corresponding energy flow behavior changes mainly within the pre-lockup part. The explanations for these effects are make a case for here.

Owing to the degradation of clutch, the friction characteristics of the clutch friction material changes, inflicting a discount in friction torsion and a amendment in relative speed profile as a perform of engagement length. Due to these changes the ability transmission capability decreases and therefore the corresponding energy flow behavior primarily in pre-lockup part changes.

2. Experiment Setup

2.1 Check setup and accelerated life check description

An elevation of wet clutch is conducted with the support of the economic partner, Danu Spicer Off Highway Belgique, on the SAEII check setup. The schematic illustration of the check setup is shown in Fig.1, that consists of 3 main sub-systems: the driveline, the management and also the mensuration system.

The driveline consists of six components: input electric motor, input regulator, the wet clutch assembly that consists of a drum, a hub, separator and friction discs, force sensing element, output regulator and output motor. The system is employed for both dominant the input force per unit area to the clutch and for the rate management of the input and output flywheel. 2 electrical motors with freelance velocity controllers square measure used as main drivers. Both motors square measure connected to the input and also the output flywheel by a temporal order belt transmission. The block scheme and bond graph model of the mechanical and hydraulic a part of the SAEII check setup is absolutely described in [5].

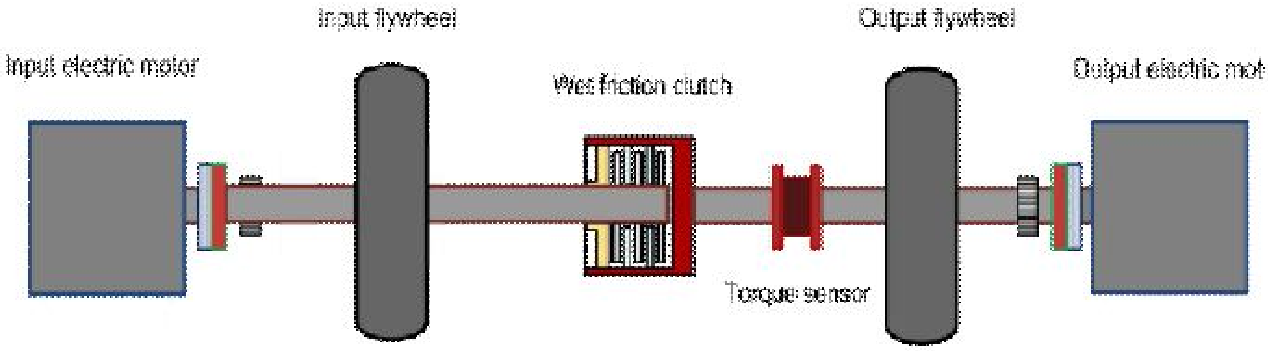

Fig. 1. Schematic illustration of the SAEII check setup

The elevation is allotted as follows. Initially, while each input regulator (hub side) and output flywheel (drum side) square measure rotating at identical speed in opposite direction, the motors square measure powered-off and the pressurised law enforcement agency is at the same time applied to the clutch pack. The oil so actuates the clutch piston, pushing the friction and setup discs towards every other. whereas the applied pressure is increasing, contact is bit by bit established between the setup and friction discs. As a result, the transmitted force starts to extend to succeed in its most worth, and the relative rate decreases on the opposite hand. The clutch is totally engaged once the relative velocity reaches zero worth for the primary time. Finally, at the tip of the duty cycle, the applied pressure is reduced to zero. This procedure is recurrent till a given range of duty cycles square measure earned. A multi channel knowledge acquisition system is employed to accumulate the signal of interest.

2.2 Experimental results

An elevation is allotted on a paper based mostly wet friction clutch. Law enforcement agency is unceasingly filtered to preserve the law enforcement agency from degradation throughout the tests.

Moreover, the body of water temperature of the law enforcement agency throughout the tests is controlled to be constant at eighty ^{o}C. The pressure signal is unbroken constant for every duty cycle, since solely the impact of the friction material degradation on the transmitted power and corresponding energy flow behavior is that the subject under investigation. With given inertias of the input and output regulator, the sole method through that we have a tendency to can apply higher energy to the clutch system is by having a better magnitude of the initial relative velocity. we've got chosen Associate in Nursing initial relative rate of 4000 revolutions per minute, a lot of beyond the traditional in operation conditions such important degradation of the friction material may be ascertained in a very restricted number of duty cycles. This primary rate is additionally kept constant for every duty cycle. Figure 2(a) show the engagement period ascertained throughout the check. I to IV degradation levels square measure recorded at one, 3300, 6600 and ten thousand duty cycles. Note that in Fig.2 (a) the signals square measure premeditated with reference to identical reference time instant that's set to zero, i.e. the time instant at which the pressure is applied whereas in Fig.2 (b) the signals for degradation level II, III and IV is shifted to the moment once the relative rate reaches zero for the primary time for degradation level I, that is about to zero. One will clearly see in Fig. 2 that the engagement period will increase and also the post-lockup relative rate fluctuation changes. Post-lockup refers to the time span, ranging from the time instant

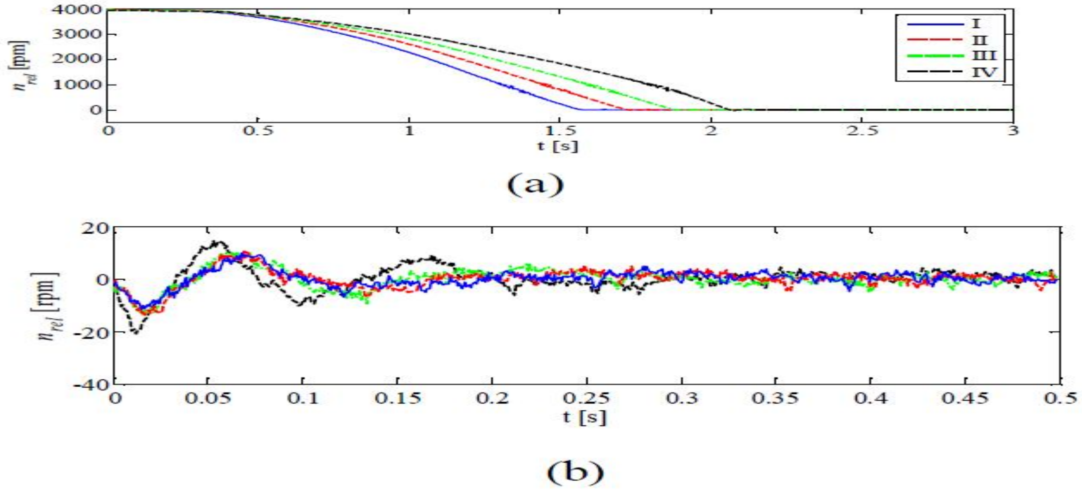

Fig. 2(a). Engagement duration, (b). Post-lockup relative velocity fluctuation for the degradation levels (Experiments).

3. ANALYSIS OF RESULT

In order to check the result of the degradation process of wet friction clutches on the ability transmission and corresponding energy flow behavior, the clutch system model is built as explained earlier in section III. The friction model parameters for four degradation levels square measure listed in Table II. the extent I, II, III and IV corresponds to one, 3300, 6600 and ten thousand duty cycles. The parameters at level I square measure correlative with the experiments allotted on the contemporary clutch severally, whereas all the parameters at different degradation levels square measure assumed. This assumption is formed like to understand the parameters at every degradation level. an obsessive set of experiments square measure need for parameter extraction, which isn't possible within the bestowed experimental case. The pressure signal is unbroken a similar for all degradation levels, that consists of a ramp input starting from zero to eight bar in one.43 sec, thenceforth command constant till the top of the duty cycle. It is also important to notice that though the mechanical structure of the SAEII check setup and also the clutch system model below investigation square measure totally different, the dynamical parameters, particularly relative speed (nrel) and pressure (p) that square measure the inputs to the friction model square measure obtained equally in each the cases and hence the process as explained earlier in section II.

TABLE II.

Parameters	Value at level			
	I	II	III	IV
k_t [Nm/rad]	230	220	210	200
a_M [Nm/bar]	40	35	27	18
b_M [Nm]	0.1	0.1	0.1	0.1
a_C [Nm/(rad/s)^3/bar]	1.65	1.63	1.58	1.56
b_C [Nm/(rad/s)^3]	0.01	0.01	0.01	0.01
β_∞ [-]	0.25	0.15	0.10	0.07
p_0 [bar]	0.6	0.6	0.6	0.6
V_s [rad/s]	75	70	65	60
C [s^{-1}]	100	100	100	100
γ [-]	0.50	0.50	0.50	0.50

Simulation results show that the clutch engagement length (Fig. 5(a)) and also the relative velocity fluctuation within the post-lockup section (Fig. 5(b)) square measure qualitatively correlative to the experimental results (Fig. 2) at four degradation levels. Note that in Fig.5 (a) the signals square measure aforethought with relation to the same reference time instant that's set to zero, i.e. the time instant at that the pressure is applied whereas in Fig.5 (b) the signals for degradation level II, III and IV square measure shifted to the time instant once the relative speed reaches zero for the primary time for degradation level I, that is ready to zero. This time represents the beginning of post-lockup time. The simulation results clearly show that the engagement duration will increase and also the post lockup relative velocity fluctuation changes. the explanations for these changes square measure explained earlier in section I.

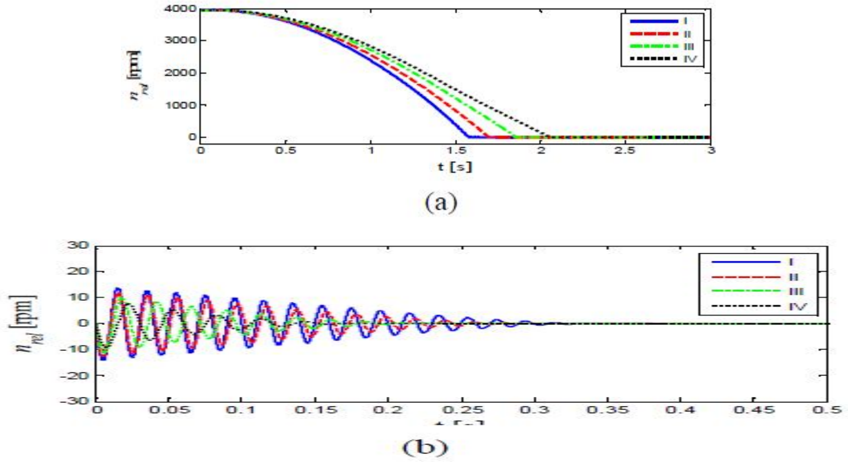

Fig. 5(a). Engagement duration, (b). Post-lockup relative velocity fluctuation for the degradation levels (Simulations).

Fig. 5. shows the engagement length (te) in function of the duty cycles obtained from the experimental and simulation results. Similar observation through simulations and experiments is also rumored in [7]. The markers within the figure represent the degradation level I to IV as seen from left to right. The plot shows that a decent correlation is achieved between the experimental and simulation results. conjointly it's clear that the engagement length increases because the range of duty cycle will increase or as the wet clutch degrades. The power transmission capability of the clutch decreases in the main due to the reduction in friction torsion, that is thanks to the amendment within the friction characteristics of the clutch friction material.

4. CONCLUSIONS

Experiment and simulation of the accelerated life tests of the wet clutch are bestowed. The results showed that with the degradation of wet friction clutch, the transmitted power decreases and the corresponding energy flow behavior within the prelockup phase changes. Additionally the engagement duration will increase and therefore the relative speed fluctuation in post-lockup section changes. Due to degradation, the friction characteristics of the clutch friction material changes, inflicting a discount within the friction torsion and a amendment in relative speed profile as a operate of engagement length. Due to these changes the facility transmission capability decreases and therefore the corresponding energy flow behavior principally in pre-lockup section changes.

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