Proceedings of the Institute of Acoustics

A STUDY OF STICK SLIP FOR SELECTED MATERIALS

G J McNulty(1), G R Symmons(1) and Zhang Ming(2)

(1)Sheffield City Polytechnic, Pond Street, Sheffield S1 1WB
(2)Chengdu University, P.R. China

SUMMARY

Several selected materials used for brakes and clutches were tested for stick-slip motion as part of a long term investigation into the source of acoustic output and its associated friction relationship.

Published work (1-5) provides tentative relationships between stick slip and acoustic output. However, no definite reason why some material combinations have an acoustic output can at this juncture be rigorously postulated.

This paper concentrates on the specific details of the relationships between friction torque, friction and stick slip velocity for several material combinations in stick slip motion.

A brief outline of the stick slip apparatus is given for completeness.

INTRODUCTION

A detailed description of stick-slip motion has already been described with results in (1-5), but in the interests of completeness a brief outline of the method of inducing the stick-slip and the mechanism of the motion is described.

Stick slip is a vibrational motion set up between two slow moving bodies in frictional contact when one is, or both are, driven through an elastic member. When two bodies are in contact there exists a static friction force between them which opposes any motion. The generation of stick-slip is induced when one of the members is driven elastically, as a consequence this elastic member when vibrated induces movement in the hitherto static combination of the two contracting bodies. This motion is the result of the forces in the elastic member reaching a magnitude greater than the static frictional force between the two bodies. The slip phenomenon is the result of the driven body being rotated as a result of this force. Since the bodies are moving against each other, the frictional force between them is reduced to a lower level called the kinetic friction force. The drop in the frictional force means that the elastic member still has enough stored energy to overcome it, so rotation continues. When this is not the case, rotation ceases and the friction goes back to the static level. This is the stick phase. The whole process is now repeated as long as one member continues to be driven.

This paper will show the result of an investigation of the noise and vibration arising during stick-slip motion using a hardened steel disc and two different fibrous materials as the contacting bodies.

There has been a dearth of published work relating stick-slip friction to acoustic output. Speculation as to why certain materials produce acoustic output is still being investigated (1-5). In this paper several materials of a high coefficient of friction have been tested in an attempt towards a qualitative solution to the problem. It is shown here that a high value of friction energy is consistent with an acoustic output. The dearth of suitable materials to provide a wide range of friction together with the protracted time it takes for each test has allowed only two specimens to be tested, at this stage of the work.

The aim of this paper is:

(i) To test commercial brake and clutch materials for stick-slip motion.

(ii) To identify the factors from these tests which result in acoustic signals.

DESCRIPTION OF APPARATUS

The stick-slip machine was made and used to provide variable, drive speeds, normal loads and contacting materials. Direct instrumentation then provides outputs of stick-slip amplitudes slip velocity, and dynamic friction forces. A real time analyser gives frequency scans of the noise and vibration outputs.

Figure 1 shows a sketch plan of the arrangement.

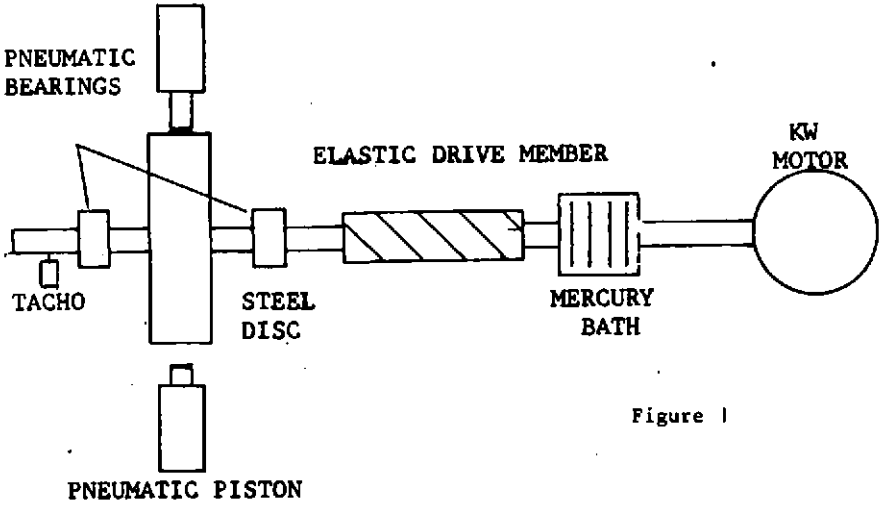


Figure 1

RESULTS

The results will discuss a number of combinations of stick-slip contacts in which special commercial brake and clutch fibrous material are tested with mild steel. Each fibrous material is described in broad terms relating to its specification.

Material DM6 in contact with Mild Steel

DM6 is a material used for clutches. It has a random fibre asbestos base and contains metallic inclusions in the form of brass chippings. The material possesses high mechanical strength and a medium co-efficient of friction (approx 0.28), with a low rate of wear.

The results for DM6 exhibit similar characteristics to that of two metals in stick-slip contact observed in (1-5). This is surprising, as fibrous materials display a more rapid oscillating characteristic for Friction Torque. Such a behaviour seems to indicate that the brass inserts in the DM6 may have an influence on the results. It would be reasonable therefore, to test brass against steel in order to study any possible similarities.

Brass on Steel Stick-Slip

The results for the DM6 actuated the testing of brass as material in its own right. Of all the materials tested, brass is the most difficult and provides the least interest and information. For the first twenty minutes of the motion brass did not stick-slip, it just turned. Finally when the pistons were worn in, it gradually began to stick for small values of torsion.

Even when stick-slip motion did occur, the slips were very small and irregular. The information from the traces of torsion, velocity and friction was not intelligible. This dearth of information was also consistent with the acoustic signal. It took over one hour of consistent stick-slip motion before any acoustic signal was observed. The frequency varied so much from one stick-slip to the next that no definite frequency pattern could be distinguished. The only useful information that could be detected was that there was generally two dominant frequencies of about the same amplitude. Thus brass was considered to be unsuitable for the study of stick-slip motion.

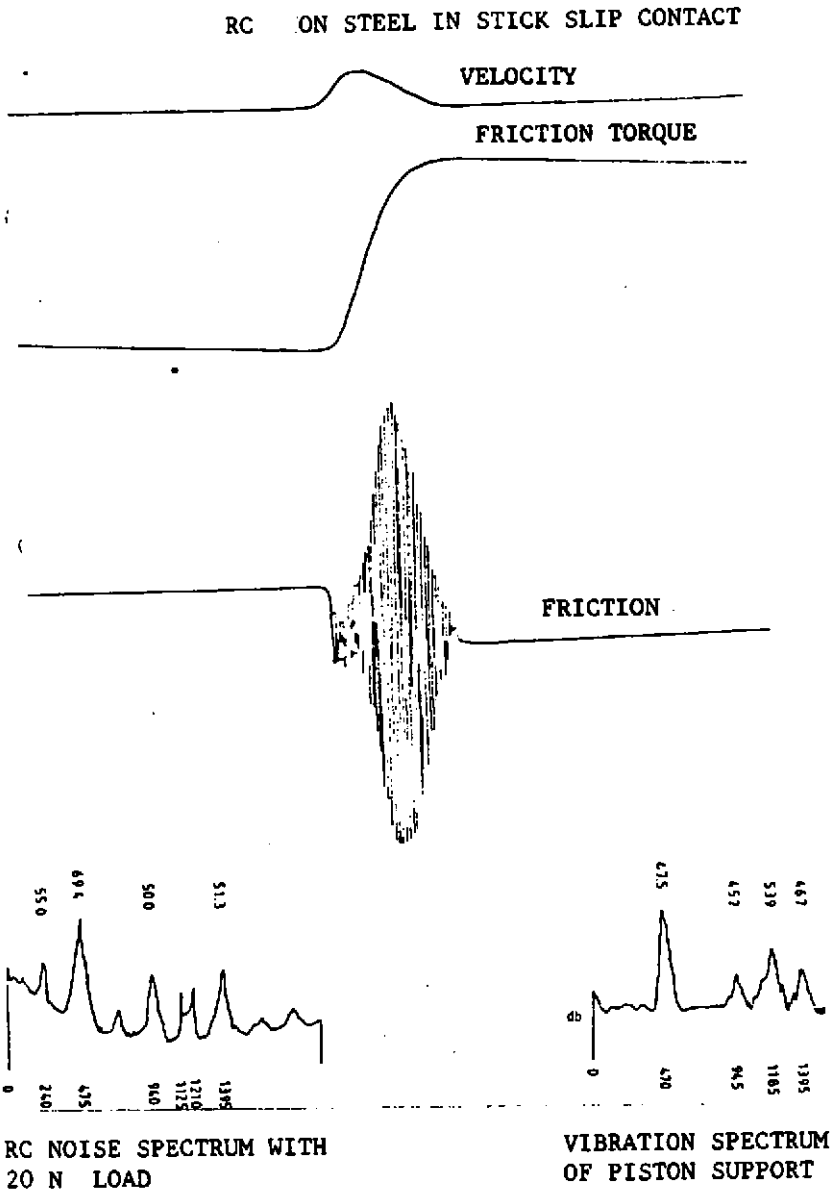
It would therefore seem reasonable that the consistency in the torque-friction and velocity result for DM6 was dominated by its fibre content rather than the brass.

Material RC in Contact with Mild Steel

RC is a non-metallic, moulded friction material with a synthetic rubber base, containing a special ingredient for resisting water and mud film. The purpose of this is for braking to be possible throughout a wide range of climatic conditions.

Figure 2 shows that the friction curve exhibits a highly active excursion about the mean line, whose peak value does not coincide either with a peak torque or peak velocity. The high frequency content within the friction domain shows this energy to be consistent with rapid movement approaching instability. Such a performance is observed to produce an acoustic signal as shown. The prolific number of peaks in these spectra is peculiar to this material and have not hitherto been observed in other material combinations.

The curve of sound pressure level against change in friction is given in Figure 3. This curves suggests that the acoustic output increases with the change in friction. Such a test is not conclusive but the trend poses the question, when the change in friction is reduced, is there a diminution in acoustic output with a concomitant absence of brake squeal. The investigation is continuing to investigate this question, which may prove to have useful commercial possibilities.



RC NOISE SPECTRUM WITH 20 N LOAD

VIBRATION SPECTRUM OF PISTON SUPPORT

Figure 2

CURVE OF SOUND PRESSURE LEVEL AGAINST CHANGE IN FRICTION LEVELS FOR RC FIBRE MATERIAL IN CONTACT WITH STEEL DURING STICK SLIP MOTION

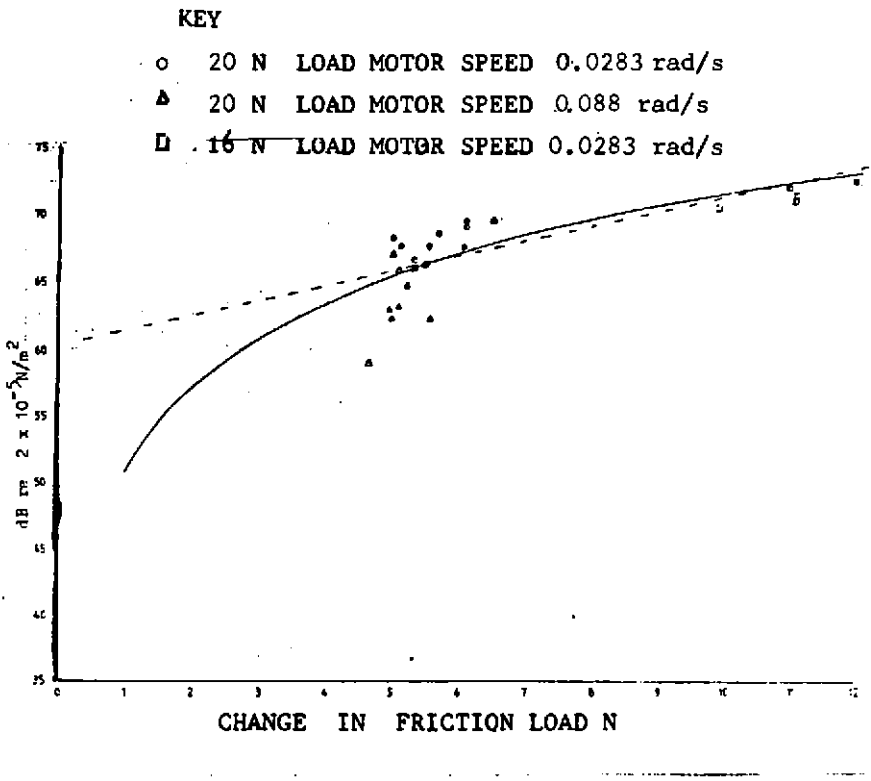


Figure 3

CONCLUSIONS

Two commercial braking materials have been tested for stick slip characteristics in relation to their associated acoustic output. It has been noted that a special friction force output has been observed which exhibits a rapid oscillation not hitherto observed in the work-to-date. When this characteristic existed it was observed that an acoustic output resulted from the combination of materials against the mild steel in stick slip motion.

REFERENCES

(1) G R Symmons and G J McNulty (1985) Stick-slip friction characteristics and noise emission. Seminar on friction and contact noise techniques, Hughesschool, Delft, Holland, 20 to 22 June 1985.

(2) G R Symmons and G J McNulty (1986) Acoustic output from stick-slip friction, International Journal of Wear 113 1. pp 29-82 December 1986.

(3) G R Symmons and G J McNulty (1986) Relationship between stick-slip friction and its acoustic signal. proc INTERNOISE M.I.T. Cambridge Mass, USA pp 365-370.

(4) G J McNulty and G R Symmons (1987) Acoustic output from stick-slip motion. Proc. I.O.A. December 1987.

(5) G J McNulty, G R Symmons (1989) Stick slip and acoustic output. 8th Symposium on Environmental Acoustics April 24th to 28th 1989. Paper accepted for inclusion in Conference proceedings.