

CLUTCH JUDDER IN AUTOMOBILE DRIVELINES

R. P. Jarvis, PhD, CEng, MIMechE*

R. M. Oldershaw, BSc(Eng), MEng, CEng, MIMechE*

A review of experience and records from a car enables a realistic simulation to be developed on an analogue computer, demonstrating clutch judder in a driveline system. Possible causes of judder are discussed.

1 INTRODUCTION

VARIOUS TYPES of vibration can occur in an automobile transmission system. A conventional driveline—comprising engine-gearbox assembly, propeller shaft and back axle—has been an outstanding source of vibration problems for many years. Flexural modes have been analysed using receptance curves (1)(2), and this assists in solving problems such as whirling. Some types of torsional vibration can occur during clutch engagement, whilst others can be present when the clutch is fully engaged. In the latter category is 'driveline rattle', which is a noise rather like a rotating cement mixer full of nails. 'Engine fight' can occur after a rather fierce clutch engagement, in which the torque reaction on the engine causes it to rotate on its mountings; the subsequent oscillatory motion of the engine can then be associated with the 'kangaroo hops' which the vehicle performs. In the former category is 'clutch shriek', which might bear some similarity to 'brake squeal'.

At around 10–13 Hz, 'judder' can occur during the engagement of the clutch; this can also be associated with the movements of the engine on its mountings (3). Judder is sensed partly by its noise and partly by feel. It can occur when an automatic transmission is fitted, although this paper is only concerned with manual shift configurations. Furthermore, clutch judder can occur irrespective of driveline layout, e.g. whether a front- or rear-wheel drive vehicle; although vehicles with independent suspension systems for the driving wheels have seemed more susceptible to the problem than those with rigid axles.

The severity of clutch judder is largely influenced by the manner in which the vehicle is driven. If judder is easily produced, it is usually considered unacceptable, and steps are then taken to reduce its presence. Torque fluctuations may be introduced into the transmission by the normal clutch during the conditions of slip. The danger of these forces is that they may be present and sufficiently consistent to form the exciting forces for various spring mass systems in the transmission. The result of this may be exhibited by one or more of these auxiliary systems being brought to a state of resonance or judder.

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* Automotive Products Company Limited, Tachbrook Road, Leamington Spa, Warwickshire.

† References are given in Appendix 2.

Two text-book methods of preventing such a condition from developing may appear obvious; one is to eliminate the exciting force, and the other is to avoid resonance by designing the various elements in the system such that the natural frequency of the offending system is outside the normal range of frequency of the exciting force. The former method may appear to offer a more direct solution, and whilst this may be true it may not necessarily be the easier nor the least costly. On the other hand, practical limitations may prevent a complete cure being effected by modifying the offending natural frequency. The purpose of this paper is to examine transmission oscillations and the factors which influence clutch judder and then analyse the significance of these.

Engineers often name many factors said to influence judder such as:

- (1) Properties of the facing material, including degree of 'bedding', friction and the possible presence of oil,
- (2) properties of the clutch assembly, shown in Figs 1 and 2, including truth, flatness and sticking of the hub on the quill shaft spline, and
- (3) properties of the vehicle including driveline stiffness, engine mounting, axle mounting and interaction between engine movement and control pedals.

2 METHODS OF ANALYSIS

When judder problems have arisen in practice, *ad hoc* experiments have sometimes been carried out to obtain solutions, and by these means a useful catalogue of engineering experience has been obtained.

In recent times, attempts have been made to simplify the problem in such a way as to lend it to rational analysis by analogue computer simulation (3) (4). These studies were carried out mainly for interest, without bringing them to a point where correlation with a vehicle could be demonstrated. Nevertheless, these studies indicate how the nature of transmission vibrations makes an analogue computer simulation a ready means of analysis. The problem is whether sufficient aspects of the transmission system can be accommodated in the simulation in a sufficiently realistic manner to enable the results to be meaningful in practice. For this purpose, some practical records on a vehicle were obtained, so that judder could be identified in terms that can be measured, rather than as a subjective assessment.

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