

PREDICTING THE MOVEMENT OF AN ENGINE SUPPORTED BY AN ELASTIC SUSPENSION DURING A TRANSIENT PHENOMENON

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1.0 INTRODUCTION

In the quest for noise reduction, the purpose of the engine's suspension is the minimisation of vibration transmission between the motor and the structure. On the other hand, the engine's movement must be minimised to prevent failure in the propulsion system. At the conceptual stage of development, one must evaluate the dynamic behaviour of the suspension since it dictates the motor's movement. Suspension design is a delicate balance between adequate engine support and low vibration transmission to its structure.

This paper presents an experimental approach in determining engine behaviour when submitted to transient phenomenon. First, an experimental approach to determine the non-linear dynamic properties of a suspension is developed. Then, an equation of motion is elaborated, using the experimental properties of the suspension. This equation gives the maximal movement of the motor in regards to the transient phenomena measured on the vehicle.

2. SUSPENSION

The studied suspension has viscoelastic properties. This kind of material is associated with viscous damping. Based on a Voigt model [1], which consists of a dashpot in parallel with a spring, a non-linear equation of the force transmitted by the suspension is established:

$$F = K(x)x + C(\dot{x})\dot{x} \quad (1)$$

Where $K(x)$ is the spring function, which depends on the amplitude of the deformation, and $C(\dot{x})$ is the damper function, which depends on the velocity of the deformation.

The damper causes the energy dissipated by a mass-spring-damper system, since the spring

doesn't produce any net work over a complete cycle or any integral number of cycles [3]. This energy is related to the area enclosed by the hysteresis loop [2], which is the transmitted force versus displacement (figure 1).

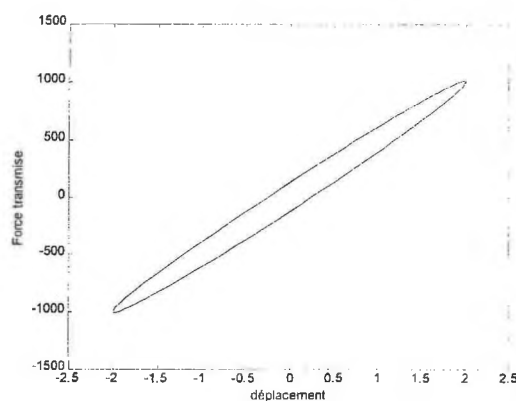


Figure 1: Hysteresis loop.

An experimental set-up produces a harmonic movement at one end of the suspension while the other extremity is fixed. Sensors read simultaneously the displacement, the velocity and the force transmitted by the suspension.

The area enclosed by the hysteresis loop leads to the damper force. The spring force is then the difference between the transmitted force and the damper force.

To approximate the spring function, a curve fitting on the spring force versus displacement is made (figure 2).

A similar process is followed for the damper function (figure 3).

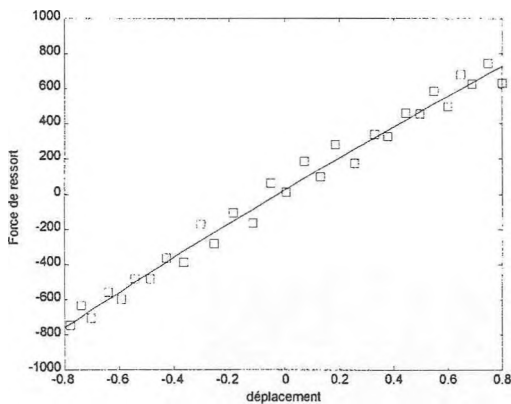


Figure 2: Curve fitting on the spring force versus displacement curve.

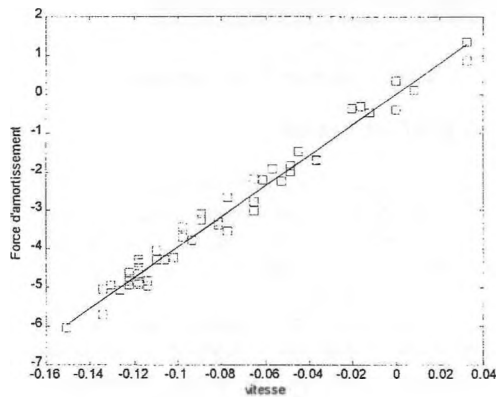


Figure 3: Curve fitting on the damper force versus velocity curve.

3. EQUATION OF MOTION

The goal is to determine the behaviour of the motor when submitted to transient phenomena. Since it is only affected by the suspension, its equation of motion is:

$$M\ddot{x} = F \quad (2)$$

Where M is the motor mass, \ddot{x} is the motor absolute acceleration and F is the force transmitted by the suspension, found with equation 1. Otherwise, the motor's behaviour is associated with the relative movement between the motor and its structure.

If we assume the relative movement between the motor and its support to be:

$$z = x - y \quad (3)$$

The equation of motion of the motor-suspension system becomes:

$$M\ddot{z} - C(\dot{z})\dot{z} - K(z)z = -M\ddot{y} \quad (4)$$

Where \ddot{y} is the absolute acceleration of the frame. This acceleration is measured experimentally.

Knowing the initial conditions of the motor-suspension system and an approximation of the rigidity and damper functions, a numerical method is used to determine the state of the system at each time interval. The computation is done in the time domain to find the behaviour of the motor.

4. CONCLUSION

The use of a Voigt model gives theoretical results that fit well with reality. The resolution of second order differential equations in the time domain is an easy way to include the non-linearity behaviour of the viscoelastic suspension.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

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