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MODELING OF WORK OF SHOCK DAMPER WITH MAGNETORHEOLOGICAL FLUID

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Active and semi-active suspensions used in the construction of vibration isolators have particular advantages, especially in the case of shocks. This kind of dampers, usually applied to vehicles for the reduction of shock effects, is important because they can improve the quality of comfort and ability of manipulation.

The adjusting of damping coefficients is realized by activating the magnetic field, included in the magneto-rheologic fluid damper, in order that it rapidly changes the stress and viscosity.

1. INTRODUCTION

The increasing of comfort in vehicles is the result of using efficient suspensions, built on principles of optimization of work. A big importance has the vibration isolators whose development consist a special target for the researchers and constructors [1].

Important developments can be obtained by replacing passive isolators by semiactive or even active isolators, whose efficiency is superior. This kind of isolators especially uses magnetorheological suspensions, which, by command, can be adapted to any demand of damping. This is the reason for which in the paper it was approached the study of behavior of a complex magnetorheological media also in relation to the possible applications from the point of view of vibrations.

2. VISCOUS-PLASTIC BODIES.

The plasticity is the way of manifestation of matter under the action of solicitations. The viscous-plastic bodies are these one, mainly liquid, which present a flow limit, before that they comport as a rigid body and in the case of solicitation bigger than the flow limit they present the phenomenon of flowing. At small solicitation, the main behavior is of rigid body and at bigger solicitations the behavior becomes the liquid-viscous one [2].

The viscous-plastic behavior is characteristic especially for materials under the form of suspensions like fero-fluids, all with flow limit. This materials flow only after the shearing stress becomes equal or bigger than the flow limit. The behavior can be explained true the existence of one structure capable to interrupt the flow for smaller tangential stress. The structure instantaneously recuperates her self after the loading removal.

The body with preponderant solid or liquid behavior between the limits of solicitation and the presence of critical flow limit between the two situations leaded to the formulation of some specific rheological models.

The viscous-plastic bodies are formed by elements of Newtonian viscous fluid (N) and a skate Saint Venant (SV).

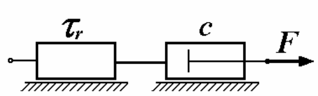

Fig. 1.

$$t = h_0 \dot{g} \qquad (1)$$

The simplest rheological model results by serial binding of the two elements, the Newtonian (N) and the Saint Venant (SV) one, shown in the figure 1. The Newtonian fluid behavior takes place until the flow limit t_c according to the low (1). In the proximal moment after the stress becomes equal to the flow limit ($t = t_c$), the velocity of slipping variation increases and the skate SV is designated as solicitation limiter, but the body can not sustain a stress bigger than t. The stress variation as a function of shearing velocity until the flow limit t_0 is shown in figure 2.

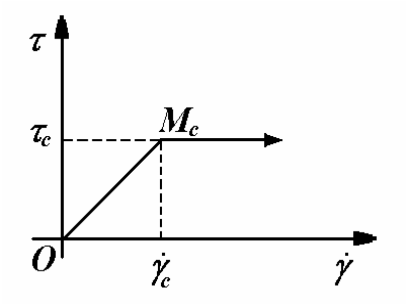

Fig. 2.

The stress variation has place on the segment OM_c, after that it follows a parallel to $O\dot{g}$ axis.

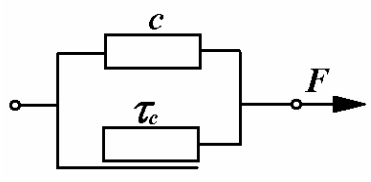

Fig. 3.

Another model includes a parallel damping element (figure 3). This one, under the action of one variable increasing force is comporting like a rigid body and after the flow limit it has a Newtonian fluid behavior. The corresponding diagram is shown in fig. 4, where the representation is a straight line that starts from the M_c point, situated on the ordinate line, at $OM_c = t_c$ distance.

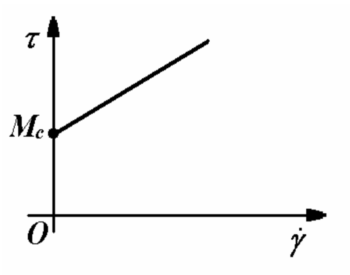

Fig. 4.

The rheological model of such a body is named Bingham plastic and it has the characteristic equation

$$t = \begin{cases} t_c, & \text{for } t \le t_c \\ t_c + h_p \dot{g}, & \text{for } t > t_c \end{cases}$$

where h_p is the plastic viscosity.

Generally, the behavior corresponding to the Bingham plastic is specific to suspensions.

3. MAGNETORHEOLOGICAL SUSPENSIONS.

It has been previously pointed out that, the magnetic properties such as saturation magnetization, permeability, susceptibility of the dispersed phase, as well as the applied magnetic field are important parameters in obtaining high magnetorheological (MR) effect.

Rheology of magnetic particle dispersions are generally analyzed in 2 steps which are known as pre-yield and post-yield conditions, respectively.

$$s = G'g, \dot{g} = 0,\ s < s_y,\ \text{pre-yield} \qquad (2)$$

and

$$s = n\dot{g} + s_y,\ s \geq s_y,\ \text{post-yield} \qquad (3)$$

where ? is the plastic viscosity and ?' is the shear rate and t_y is the dynamic yield stress. The MR fluids within the pre-yield region exhibit viscoelastic properties and these are important in understanding MR suspensions, especially for vibration damping applications. For applied stresses $t>t_y$, the material is able to flow.

The Bingham Plastic model is only valid at high shear rates and given the right measuring techniques (i.e. stress controlled and very low shear rates), the yield stress doesn't exist.

The post-yield behavior, also known as Bingham Plastic model is used to model the flow properties of MR fluids for practical and industrial purposes. The dynamic yield stress can be obtained according to (3) by extrapolating the shear stress vs. strain rate curve to zero shear rate. This model recognizes that the property of an MR fluid that changes upon application of the magnetic field is the yield stress defining the breaking of the chains of magnetic particles formed by dipolar interactions and thus the fluid starts to flow.

The importance of the "off-state" viscosity of MR fluids comes from the figure of merit for MR fluids which is given by the turn up ratio defined as the ratio of on-state yield stress to the "off-state" viscosity. On-state refers to the state of the MR fluid under an applied magnetic field and the on-state yield stress behavior depends on the magnetic properties and the volume fraction of the magnetic phase. The off-state viscosity, which is a function of carrier liquid, additives, surfactants, particle loading and particle size distribution (PSD), is the value when no magnetic field is applied. Due to the addition of additives and surfactants and changes in magnetic particle microstructure during shear, most MR fluids exhibit thixotropic behavior and shear thinning. The break up of weak agglomerates or bonds in the shear field is a major cause of a shear thinning behavior of MR fluids.

For MR fluids, the plastic viscosity which provides a more useful measurement for design purposes is typically in the range of 0.1 to 0.7 Pa-s. The plastic viscosity is determined with the Bingham Plastic Model (3) where it is defined as the slope of the linear curve fit to the measured shear stress vs. strain rate data. In literature, there aren't many reports on the "off state" viscosity of the MR fluids, especially at higher volume fractions ($f > 0.3$).

In MR fluid applications, most devices operate using pressure driven flow mode, direct shear mode or squeeze mode. Examples of pressure drive flow mode devices include servo-valves, dampers and shock absorbers.

4. SEMIACTIVE ISOLATORS FOR SHOCKS

Generally, the shock isolator is easily obtained by placing in the piston a small solenoid valve and different damping states are realized by modifying the aperture. The difference between the adjustable shock isolators in regard to the ordinary ones, passives, is that it exists furthermore additional circuits that activate the solenoid intern valve.

Practically, the systems with consecrated semiactive suspensions as adjustable isolators are designated to produce different levels of damping. There are constructions that can realized any damping coefficients in a certain domain, but they are very complex and of low reliableness. The constructions with one or even three damping states are more simple and reliable and also more efficient.

The way in which the adjustment of damping coefficients is realized is the activating of solenoid, included in the isolator with magnetorheological medium, so that to obtain continuous variable damping.

It also exist the possibility to use a step by step motor or a solenoid valve for modifying of the area orifice in the piston or in the piston bar.

The introduction of suck a semiactive isolator in the vehicle suspension leaded to the increasing of comfort by the important reduction of vibration and noises. The way of situation of isolator in vehicle suspension is shown in figure 5.