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ACTIVE SUSPENSION: AN INDUSTRIAL FACT

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ABSTRACT
To make a good active mount, we have to take into account the different functions of a suspension and the cost. A grouping of a hydraulic mount and of an electromagnetic actuator gives an answer to this industrial problem. This type of actuator can be added easily to an ordinary mount and, with a specific design it can work in three directions. The control can be global or individual. To day, we can consider that active suspensions can be used on the industrial field.

1 - INTRODUCTION

The aim of an active suspension is to minimize the transmitted vibration as much as possible through the mounts. To day; we can consider that active suspension can be used on the industrial field Fig. 1. We have to take into account the different functions of a suspension and the cost.

2 - THE KEY COMPONENTS OF AN ACTIVE MOUNT

The passive mount: Generally, passive mounts are used because they are a good solution to basic mechanical problems.
This mount has several functions.-The principal functions: One of them is to connect the suspended machine to a structure below; so it has to transmit heavy static loads. Another one is to attenuate the transmission of vibration as much as possible.
The secondary functions: Some are required such as a safe connection available under high level of excitation, a minimum performance when the active system is out of work.
The actuator: The actuator can be electrodynamic, piezo-electric, magnetostrictif or electromagnetic. If high forces are needed, hydraulic actuators can be used when there is no problem to provide oil at high pressure. Don't forget the amplifier used to command the actuators.
The controller: It is possible to find controllers on the market. For feed forward control, LMS or modified LMS or HHC algorithms are used according to the nature of the excitation The devices used to measure the controlled vibration: accelerometers, velocity transducers, load transducers used to have data about the input and the output vibration.
The excitation spectrum has several tones which level is too high and even after the passive attenuation.

3 - THE ACTIVE MOUNT DESIGN

The problem is to put all these key components in one mount with a low cost and a minimum volume.
The active hydro-elastic mount: Some time the requirement is to improve the passive suspension from low frequency to a medium range of frequencies and with an excitation with a lot of tones as we find with a diesel engine. More over the static load has not to weight heavily on the mount dynamic performance.
In order to solve this problem we have gathered an hydraulic mount and an inertial actuator. The hydraulic mount which principle is shown on the fig. 2 is made with rubber. It has two cavities. The lower one is connected to the upper one through a small pipe which natural frequency depends on its dimensions, on the density of the fluid that is in these cavities and on the stiffness of the cavities. Under

the tube natural frequency it is possible to transfer fluid between the two cavities, therefor a static load does not change the stiffness of the mount. Above this frequency, in the pipe, the fluid does not follow the vibration, therefore with a small piston we can pilot the pressure in the upper cavity. We do this with the inertial actuator which principle is shown on the fig. 3. This kind of actuator is useful because its performance increases quickly with its dimensions. Moreover, above its natural frequency we add this inertial effect on the hydraulic effect. On fig. 4 we see the performance with several tones from 30 hz to 300 hz and fig. 5 the dynamic load.

The active sole mount: above around 50 hz it is possible to use the inertial actuator only. The design is flat and the actuator works in three directions. On the photo 2 we can see an industrial mount for 800-kg static load.

The piezo active mount: When the amplitudes of displacement to be compensated are low, a piezo-electric actuator can be used. A mechanical device is protecting the piezo-ceramic against shearing forces. The photo 2 represents an industrial active mount and the fig. 6 shows the performance.

4 - CONCLUSION

Industrial active mounts and robust actuators are available. The tests have demonstrated that a system set on the structural vibration path can give an attenuation of the structural noise borne of 10 to 20 dB and moreover with a local control the attenuation is still good. On account of the robustness of the actuators and of the algorithms the MTBF bids fair high.

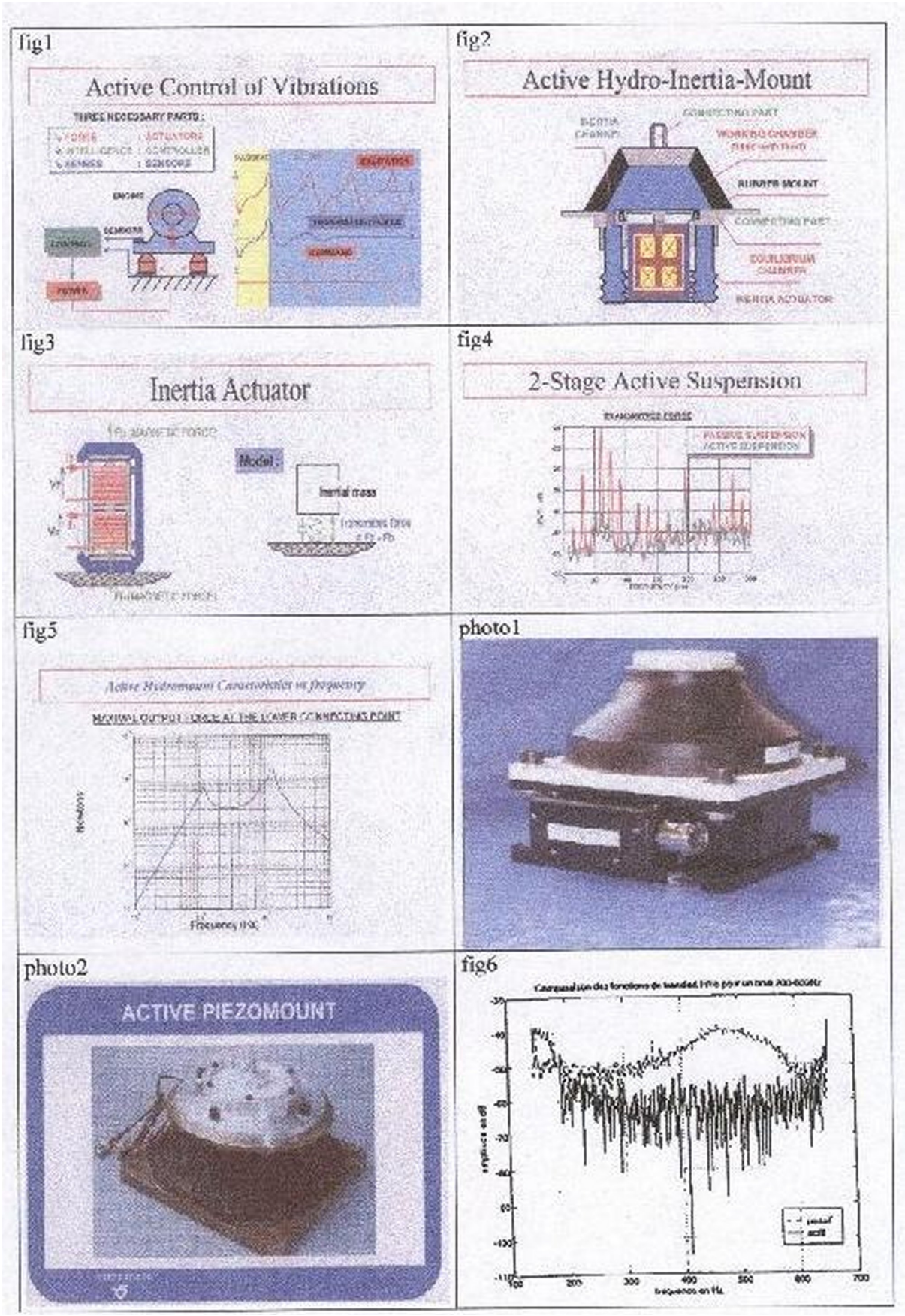
fig1
Active Control of Vibrations
fig2
Active Hydro-Inertia-Mount
fig3
Inertia Actuator
Model :
Inertial mass
fig4
2-Stage Active Suspension
fig5
photo1
photo2
ACTIVE PIEZOMOUNT
fig6

Figure 1.