ABSTRACT

Pneumatic mountings are generally used to achieve very low natural frequencies and as active vibration isolators. For low natural frequencies the air spring is connected to a tank through a capillary tube. Passage of air through capillary tube introduces damping which may be desirable or otherwise. When used on vehicles connecting front suspension with the rear may have significant effect on pitching motion.

A survey of literature on airsprings has been carried out in detail. It is seen that damping in capillary depends on various parameters but papers have presented this only qualitatively in graphical forms. Similarly effect on pitching motion of vehicle has not been considered. Nonlinear solutions (numerical) for capillary connection is not yet presented

In this thesis the equation of motion and fluid flow are solved in their nonlinear form numerically. Response of the system in free vibration has been worked out. All the parameter-s affecting capillary flow and hence the damping are varied and their effects are studied.

It is shown that damping due to capillary flow varies with different parameters in opposit trends in two regions viz. regions of higher values and lower values of capillary coefficient. In the region of higher value of capillary coefficient we get a relation,

$$2\pi\delta = \frac{0.75\, A^{3/2}\sqrt{\vartheta_c(V_t-1)}}{m C_r}$$

Where δ is the damping factor (pl see the notation).
In the region of lower values of capillary coefficient

$$2\pi\delta = \frac{11.8\, m C_r}{\sqrt{\vartheta_c}\, A^{3/2}}$$

Thus it can be seen that tank volume has no effect in this region. Value of capillary coefficient which marks the boundary of these two regions is given by

$$C_r^2 = \frac{0.0636\, A^3 \vartheta_c \sqrt{V_t-1}}{m^2}$$

Maximum value of damping occures at this value of capillary coefficient and is given by

$$2\pi\delta = 2.97\,(V_t-1)^{1/4}$$

Thus it is shown that maximum possible damping is entirely governed by the tank volume. Also value of capillary coefficient for this maximum damping depends on other parameters. No such relation relating all parameters in one expression has been available in literature.

Effect of stiffness of auxiliary spring in parallel to air spring is also studied. It is shown that in case of values of capillary coefficients higher than critical damping ratio is proportional to period of free vibrations (as in any other case). However it is found that when capillary coefficient is much smaller than critical damping ratio is proportional to the cube of period. In the neighbourhood of critical capillary coefficient no such relation could be established.

Above theoretical results were confirmed by solving equations for steady response and finding damping from the reasonance transmissibility values.

A similar study is carried out for pitching motion of a system on two airsprings connected by a capillary. Obviously for free vibrations pitching does not exist if capillary passage is large. Thus pitching motion damping exists only when capillary coefficient is very samll. This damping is found to obey the law.

$$2\pi\delta = \frac{17.5\, m C_r}{\sqrt{v_0}\; A^{3/2}}$$

Use of airsprings on vehicle is on increase. (However no studies have been found in the literature for vehicle systems.) Equations for a vehicle model have been developed for a two degrees of freedon system in bounce and pitch motion. A linearised system of equations of motion is also presented. Effect of phase angle between the excitation under two wheels has been studied by means of these linearised equations and have been presented graphically.

Extensive experimental work was carried out to establish the above mentioned theoretical results. A good agreement between the theoretical and experimental results was observed Limitation on experimentation and reasons for the differences in the results have been brought out.

Finally scope for future work is indicated and listing of computer programs is given.