Static and Dynamic Performance of an Air Pad Controlled by a Diaphragm Valve

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This paper presents the analysis of the static and dynamic performance of a passively compensated air pad. The proposed method consists in the integration of a custom-built pneumatic diaphragm valve and an aerostatic pad. A design procedure of the diaphragm valve is proposed in order to optimize the stiffness of the air pad. Static and dynamic performance of the controlled pad is analysed by a mathematical lumped model.

Keywords: Aerostatic pads, tribology, numerical model, dynamic performance

1. Introduction

Aerostatic bearings are used in applications where very high precision of positioning is required. However, air bearings suffer from low relative stiffness and poor damping. To compensate for these limitations, many active and passive compensation methods have been proposed [1]. Despite their limited performance, the lower costs of passive compensation solutions may render them more attractive to be employed in industrial applications. This paper presents the performance of a passive compensation method consisting in the integration of a custom-built diaphragm valve and a commercial pad. Moreover, this work describes a straightforward design procedure of the diaphragm valve depending on the geometry and features of the controlled air pad.

2. Compensation method

A circular air pad with a single central feeding hole has been intentionally chosen as the simplest geometry to exploit the analytical solution. The diameter of the air pad is equal to 40 mm, the diameter of the air pad supply hole is 0.5 mm. Figures 1 shows a scheme of the diaphragm valve, where: R_v=0.125 mm is the radius of valve nozzle, p_v=0.7 MPa is the supply pressure of the valve, R_m=3 mm is the radius of the diaphragm, X_0 is the initial distance between the nozzle and the diaphragm and p_s is the pressure supplied the air pad. The diaphragm deflects under the pressure p_s acting in the valve chamber. The air supplied to the pad is suitably regulated depending on the distance between the nozzle and the diaphragm (X_v). A numerical lumped model was used to investigate the static and the dynamic performance of the compensated pad.

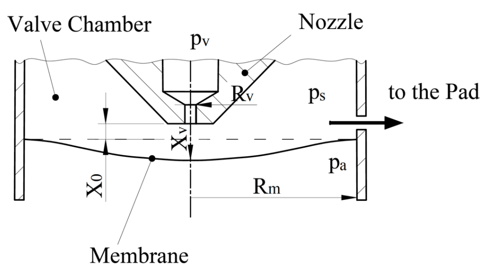

Fig. 1 Scheme of the diaphragm valve.

3. Results and discussions

Figure 2 shows the static load capacity of the compensated air pad considering three different values of the desired air gap height h_{des}. Each characteristic curve exhibits a by-pass zone (A-B), a compensation zone (B-C) and a saturation zone (B-D) [2]. The design procedure allows to determine the diaphragm stiffness that optimizes the stiffness of the compensated pad depending on h_{des} and the supply pressures of the pad (P_{s1} and P_{s2}). The dynamic stiffness and damping of the controlled pad were numerically evaluated in a frequency range from 1 to 100 Hz.

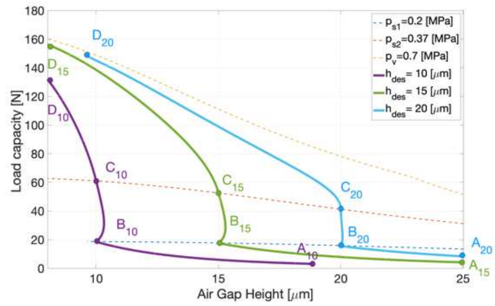

Fig. 2 The static load capacity of the compensated pad.

Static and dynamic results show that the proposed compensation method makes it possible to increase significantly the performance of the pad in a quasi-static frequency range [1].

4. Conclusions

Results demonstrate that the proposed passive compensation method makes it possible to significantly increase the stiffness and damping of the air pad in a low frequency range. The proposed compensation can be used as a cost-effective solution in many industrial applications.

5. References

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