Gas journal bearings have been increasingly adopted in modern turbo-machinery due to their numerous indisputable advantages. They can operate at higher speed than most bearing designs, almost without noise or heat generation and in most cases, as in this work, the gas used is air which is cheap, abundant and clean. Nevertheless, this technology has important drawbacks: the low viscosity of the lubricant results in a low load carrying capacity and gas bearings also presents low damping properties, which often lead to a reduced stability range and make dangerous running close to, or across the critical speeds. In order to overcome such limitations, a mechatronic device has been proposed as a possible solution. This device named “hybrid active radial gas bearing” or simply “active gas bearing”, combines an aerodynamic gas journal bearing with piezoelectrically controlled injectors. In the present work, the control signal design is based on a theoretical model. This approach enables easy modifications of any of the numerous physical parameters in the system if needed. The theoretical model used is based on a modified version of Reynolds equation where an extra term is added in order to include the effect of external pressurization. In order to validate the theoretical model, a test rig is used, which consists of a flexible rotor supported by a ball bearing and the active gas bearing.

This thesis has three main focuses and original contributions: Firstly, contribute to improving a existing theoretical model for active gas bearings, with special attention to the modelling of the injection system. Secondly, experimentally validate the improved mathematical model in terms of static properties (journal equilibrium position and resulting aerodynamic forces) and dynamic properties (natural frequencies and damping ratios of the rotor-bearing system) is performed and finally to design controllers that allows improvement of the dynamic properties of the rotor-active gas bearings system and lets the system to safely cross the critical speeds, using the theoretical model as a design tool. The results show a significant increase in the damping ratios of the system (10 times), which enables the flexible rotor to run safely across the critical speeds and up to 50 % over the second critical speed, without any instability problems. The theoretical and experimental results in the active cases clearly show the efficiency of having a theoretical model as a design tool for testing different controllers and also show the advantage of applying active lubrication techniques to gas lubricated bearings.