Gas bearings are popular for their high speed capabilities, low friction and clean operation, but require low clearances and suffer from poor damping properties. The poor damping properties cause high disturbance amplification near the natural frequencies. These become critical when the rotation speed coincides with a natural frequency. In these regions, even low mass unbalances can cause rub and damage the machine. To prevent rubbing, the variation of the rotation speed of machines supported by gas bearings has to be carefully conducted during run-ups and run-downs, by acceleration and deceleration patterns and avoidance of operation near the critical speeds, which is a limiting factor during operation, specially during run-downs. An approach for reducing the vibrations is by feedback controlled lubrication. This paper addresses the challenge of reducing vibrations in rotating machines supported by gas bearings to extend their operating range. Using $\mathcal{H}\infty$-design methods, active lubrication techniques are proposed to enhance the damping, which in turn reduces the vibrations to a desired safe level. The control design is validated experimentally on a laboratory test rig, and shown to allow safe shaft rotation speeds up to, in and above the two first critical speeds, which significantly extends the operating range.