PROGRAMMABLE RING GAGE

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1. Introduction

Ring gages are widely used in industries and metrology labs as masters for setting bore gages. They come in different sizes and for every different size of bore to be measured a ring gage of that particular size has to be available. These ring gages need to be maintained in a temperature controlled environment and should be used at 20° Celsius in order to maintain accuracy. The need of temperature-controlled environment to store these masters comes at a cost. Also periodic recertification (i.e. calibration) and replacement of worn out ring gages contributes to the maintenance cost. The current process of measuring is tedious and inconvenient to personnel involved in the process. Our goal is to design, build and validate an electromechanical computer operated device for use as a sizing master to set bore gages. The aim of our research is to replace the concept of master rings (or ring gage) used currently in industry with a robust easy to use device.

2. Design Aspects

The design of this programmable ring gage was based on the following customer supplied specifications:

1. Two point measuring system.
2. Range of 1" – 3".
4. Operating temperature range of 15 – 55° C

Figure 1 shows the schematic of our design. The main components of the programmable ring gage are:

a. Base
b. Ram
c. Flexure
d. Drive Mechanism
e. Anvils
f. Air Bearings

The material used for the programmable ring gage is Aluminum 6061- T6. All parts are machined out of the same material in order to minimize the effects of differential expansion and temperature gradients on the measuring accuracy of the system.
A frameless, brushless DC motor provides motion to a non-influencing drive mechanism that connects to the ram. The ram slides over the base on air bearings, the surface of which is diamond turned. The ram is constrained from all the four sides by air bearings, two on either side and four each on the top and bottom of ram. A 5nm resolution glass scale tracks the movement of the ram. Refer to figure 2 and figure 3 which show the assembled and exploded views of the gage.

The anvils are made out of Aluminum oxide with the radius of the largest circular diameter to be measured (i.e. 3\(\text{\textquotedbl}}\)). Aluminum oxide is a very hard (3000 HK) and wear resistant material form a better material than Aluminum for measurement purposes. The anvils are so designed so that they can be replaced with new ones in case they show signs of wear.

We know that when a force is applied to an object it deforms, similarly when the distance between the anvils is set to the required dimension and a bore gage is inserted between these anvils the ends of the bore gage in contact with the anvils will deform. This deformation is well represented by the Hertzian model. In order to provide force measurement to allow compensation for the deformation due to contact forces, a flexure is provided which is designed for the maximum travel of 200 microns at 5N load. A capacitor at the back of the flexure tracks the distance moved depending on the amount of force applied. A computer program will calculate the deformation based on displacement that then moves the ram accordingly to compensate for the deformation.

Temperature sensors are provided, one at the scale and other to measure the room temperature; this is done so we can compensate for the part dimensional changes due to temperature. This is done in such a way that the part when measured using this ring gage measures as it would when measured at 20\(^{\circ}\text{C}\). The system will be calibrated with zerodur masters so that the actual spacing between it anvils is know throughout the operating temperature range. When in use, the anvil spacing will be corrected for the nominal expansion of the part to be measured so as to provide temperature compensation. The uncertainty in this computation due to the uncertainty in the nominal coefficient of expansion and the uncertainty in the temperature measurement will be computed and reported to the user.
Mechanical limit switches are provided one on either end of the ram to prevent damage from over-travel. Other accessories provided are a pressure switch to prevent damage to air bearings in case of non-operating air pressure through the channels. A fault detector is provided in order to indicate the location of a problem in case of some failure in the system.

Air provided to the system is filtered through a coalescing filter and a desiccant drier before being fed into the channels. A flow meter and a regulator keep track of the air flowing through the system to maintain the proper flow for the required air gap (2 microns in our case).
3. Conclusions and Future Work

Currently, there is no flexible instrument to set bore gages that performs temperature and force deformation compensation. The programmable ring gage will be computer-operated and will use lab-view to compute corrections for temperature difference and force behavior of different bore gages. The device will also be equipped with temperature sensors that will monitor the temperature for software correction, thus reducing the requirements for a temperature controlled environment. Contact forces will be measured by measuring the displacement of a calibrated flexure that is part of the device. This paper describes a concept, design of the instrument, and the operation. The overall goal of this project is to provide a robust easy to use measuring device, which can improve the accuracy as far as is practically possible in a workshop environment.

References

