Concept of a torque calibration unit for low ranges based on air bearing combination

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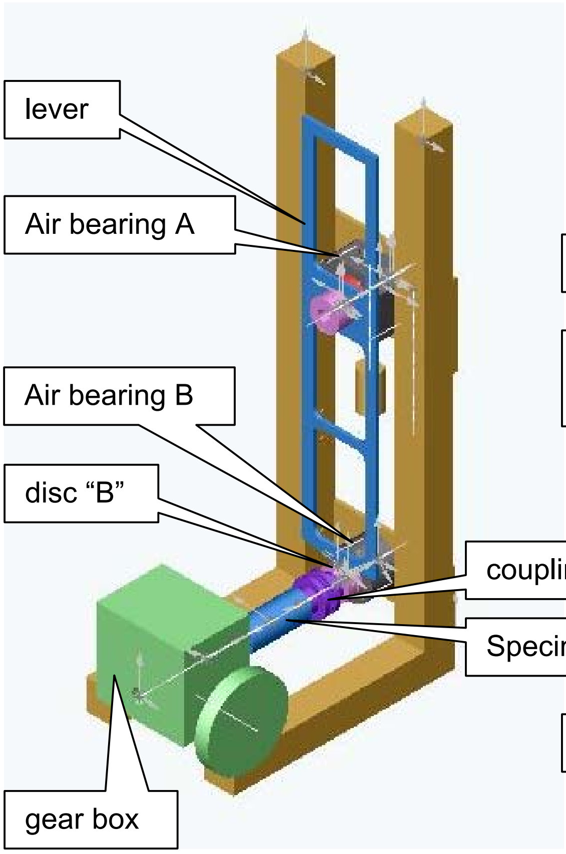
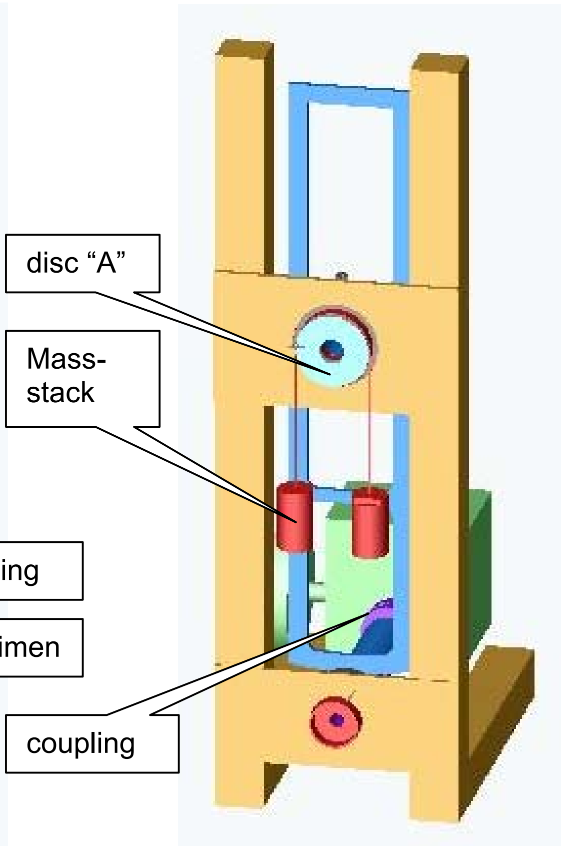
Abstract:

The need to calibrate torque in low ranges is given in case of dentist tools, viscometry or friction measurement in ball bearings. Ranges starting about 0,005Nm as an example, is the target of the following description. A theoretic possibility is shown how to handle all disturbing influences in using mass beam systems as a basic quantity.

1. **General description**:
Usually beam mass systems are limited in low ranges because the necessary very small masses getting unhandy. Their sensitivity to environmental influences like air blowing as an example is very high. Positioning is worst in reproducibility. By using a mass stack designed like a pendulum the swinging influence get worst. While using short levers to get bigger masses the relatively tolerances in production of lever length are getting higher. The question was, how to get low torque by using basic quantities in high precision. Figure 1 view of front and rear of a general principle. The





following idea based on using bigger mass stones. The size of smallest mass by 0,5 N for driving the system is calculated. A kind of gear is given by driving a disc”A” in diameter 59.8mm which is fixed in the centre axis of a lever . The force of masses are coupled tangential to the disc by using a thin steel string which is in high precision by diameter 0.2mm. The lever ends in a radius, is 10 times higher than disc ”A” radius. The end of beam is formed as a circle segment by clear radius of 299.9mm by using a steel string by thickness 0,22mm. This combined “lever – disc” design is supported on an air bearing ”A”. The driving torque from the disc produced a peripheral force on the 10 times higher radius on lever end. A second air bearing ”B” with a small disc “B” in diameter 39,89 is driven by a 0,1mm thin kevlar string, also high in precision which is winded around this disc “B” several times. The friction between wire and disc is responsible for the force translation. The both ends of the wire are fixed and stretched in proper contact to the surface of the beams radius. Figure 1 shows a general 3D illustration.

2. Disturbing influences and their countermeasures

The inertia of mechanics in main the lever and the air bearings. To minimised inertia air bearings are produced in aluminium. To get a stable torque the driving disc “A” is done in invar steel. The temperature differences to both gear partners lever and disc ”B” has no influence to the ratio.The bending moments of both strings. and the impact in case of mass coupling are the effects which disturbs the sensitivity of the system. To get a stable radius both string ends are tensioned by heavy preloaded plates for coupling additional mass parts. The high in weight is responsible to get a minimised difference of working radius. The symmetric design minimised the influence to the torque measures. The runout of beams balance point is responsible for differences in clock wise and counter clockwise signal. Therefore an adjustment by moveable tare masses in vertical and horizontal direction is given. Also radius difference or runout of disc “A” lever end and disc “B” are produced in high precision by tolerances span 0.5 μm.

3. Air bearings in detail

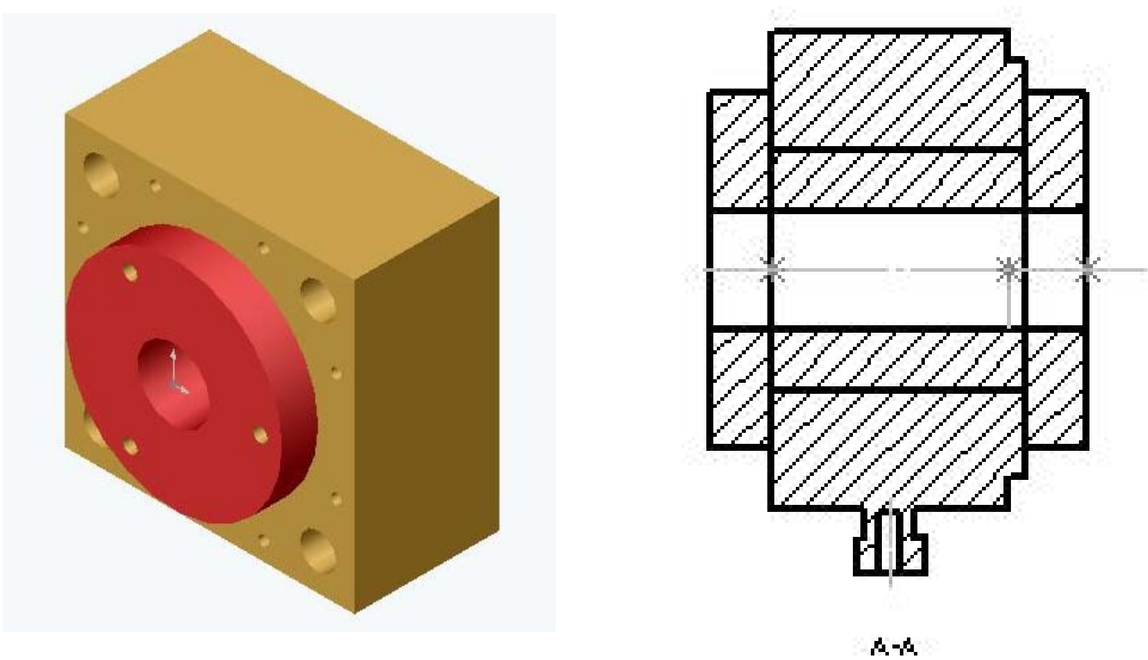


Figure 2 Air bearing version A used to support the lever, 3D and sectioning shows version A / “H” type . LLH4040

Figure 2 shows the “H” type of the air bearing which supports the lever. It could be loaded radial by a max. of 200N, axial by a max of 100 N. All parts produced in aluminium surfaces are hard coated. The air gap between rotation parts and the stator is about 10 μm. Stiffness in case of max. load is about 2 μm.

Version B figure 3 shows the “H” type of the air bearing”B” which drives the specimen an d is driven by kevlar string. It could be loaded radial by a max. of 80N, axial by a max of 50 N. All parts produced in aluminium surfaces are hard coated. The air gap between rotationed parts and the stator is about 7 μm. Stiffness in case of max. load is about 1.5 μm. The input air pressure is 4.5 up to 8 bar.
To reduce the weight a boring is through the centre and plan discs are in thin wall shape.

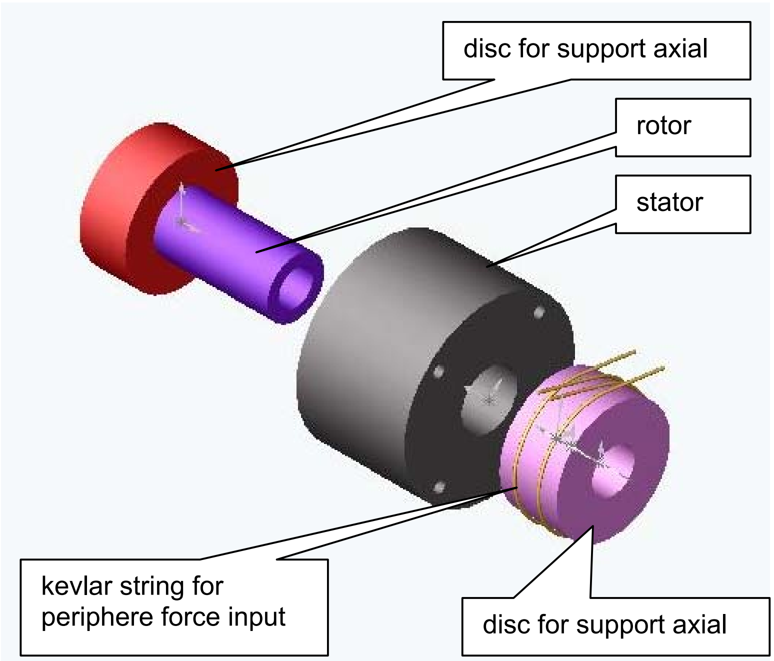


Figure 3. The air bearing “B” in light weight version shown in exploded view

4. Estimated friction of a non rotating air bearing

both air bearing are non rotating. To measure their friction is usually done by oscillate the rotors by fix a small mass out of centre and watch to the decrease of amplitude. In the period of design we had no clear results of the designed bearings. The estimated influence of friction is less 0,5% of torque step ±0,001Nm. The sensitivity of the complete torque machine should be proofed by using masses about 0,05 N as an add on to the working mass stack.The described torque machine is in production. It should be finished at the end of august 2002.

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