MEASURING SYSTEM WITH INTEGRATED CORRECTION FOR THE DIAMETER OF HUGE BALL BEARING IN WIND ENERGY PLANTS

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Abstract: The paper explains the necessity of geometrical measuring problems at production wind energy plants. The paper contains the concept and theoretical solutions of a measuring system for diameter of ball bearings. A measuring principle, measuring problems with solution are described. At the end the concept is compared with the high end and the low budget solution.
Key words: diameter measurement, length measurement, wind energy plant, ball bearing

1. BASIC INFORMATION AND STATE OF THE ART

In field of production and final inspection of ball bearings the measuring of geometrical quantities of every single component is very important. These large ball bearings are used in different technical applications from bottle filling plants to wind energy plants. The basic conditions of such a ball bearing are diameter (1m to 6m) and weight (up to 25 tons). The measuring of the diameter is needed because of the assembling of the inner and outer ring. Here the best matching from inner and outer has to be found, so that the optimal conditions for long life time and efficiency are given in this tolerance chain.

There are a few solutions to measure the large diameter of ball bearings. The high end solution is to use a double sided coordinate measuring machine. An example is shown in figure 1. This solution needs special ambient conditions and long measuring time at high costs. However the measuring results are very good. As example the accuracy of measurement is specified at ±10µm at a diameter of 3m.

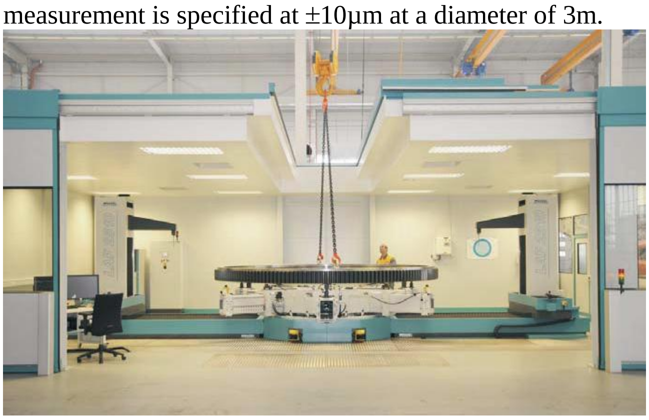

fig.1: double-sided coordinate measuring machine LAFD from Wenzel Präzision GmbH [1]

Other solutions are sliding calipers and scales of length. Here influences of the factory workshop, the operator or even the applied material, like CFK or aluminum are given. There are several kinds of external interference are temperature, temperature difference and also every kind of pollution. Biggest problem is the measuring of the diameter. The diameter only is appointed by two points. In the end the measurement accuracy is much lower, but also measuring time and costs.

The new concept has to realize the following specifications:

- portable fast and repeatable measuring of the inner and outer ring of great ball bearings
- measurement range of 1 m to 8 m
- absolute accuracy of measurement of the diameter by ±50µm
- possibility to measure under conditions of a factory workshop (dust, oil)
- calculating the diameter with more than three measuring points
- correction of the results related to the influence of temperature to measuring object and system
- measuring time lower than 20 minutes within buildup and configuration
- maximum price for sale lower than 30000 Euros

2. EXPLANATION OF THE CONCEPT AND MEASURING PRICIPLE

At the beginning several measuring principles were reviewed. Especially optical methods like interferometry, triangulation or laser-run-time were reviewed. Every method has pros and cons to the requirements. Main problem was the low price ant high accuracy for a large measuring range [2].

For more Information see full paper.

At the end measuring component from MTS-Sensors GmbH with a magnetostriction principle was found. This measuring system has a measuring range up to 7600mm and a solution of 1 µm [3]. These are good preconditions, but there are problems like a hysteresis and linearity, too. Also there are constructive problems, because the measuring range is not high enough and the temperature influences.

Anyway a measuring system was created. To reach the measuring range and the requirement of at least three measuring points a combination of two sensors was found.

The solution can be seen in figure 2. The background of this composition is founded in the definition of triangles.

To compensate temperature and absolute accuracy several other sensor were integrated. As example there are temperature sensors at the lay-on point on the ball bearing. Here the temperature of the measuring object will be detected. At the measuring system there are temperature sensors and resistance strain gauges to detect deflections.

For more information see full paper.

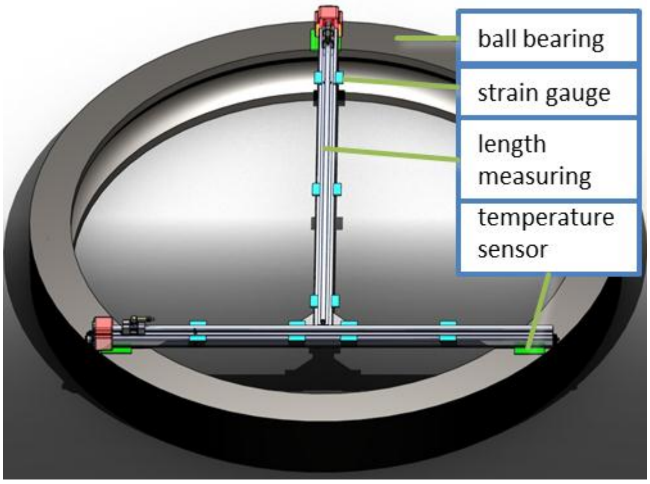

fig.2: constructive concept of the measuring system with planed sensors

3. MATHEMATICAL CORRECTION OF THE MEASURING SETUP

There are several corrections that have to be done. At first the change of length of the ball bearing has to be calculated.

$$\Delta l = \alpha * \Delta T * l_0 \qquad (1)\ [4]$$

At a length of 8000mm, a ΔT of 5 K and a α of $1{,}61E^{-5}$ K^{-1} equals Δl 0,644 mm. The same calculation has to be done for the measuring system.

Next is to calculate the deflection of the measuring system. For the measuring system the exact profile, stiffness and material has to be known. As example the deflection f can be for steel and a geometrical moment of inertia:

$$f = \frac{5*m*g*l^4}{38*E*I*10^7} = \frac{5*6*9{,}81*6000^4}{384*2{,}1*80{,}1*10^{12}} = 5{,}9mm \qquad (2)$$

These calculations for every part of the system and the analysis of the sensors have to be done and will be described in full paper.

4. CONCLUSION

In conclusion the concept of the measuring system is an improvement to the existing solutions. The created measuring system is usable in at conditions of laboratory and fabrication workshop. The whole system contains the possibility to measure the characteristics of the measuring object. To correct the measured values several appendages were chosen. In first practical tests only with one length measuring sensor the accuracy was shown. It was compared to a laser interferometer and an autocollimator. On the basic of this analysis the whole system has to be compared.

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