# Conference Proceedings

## Volume II

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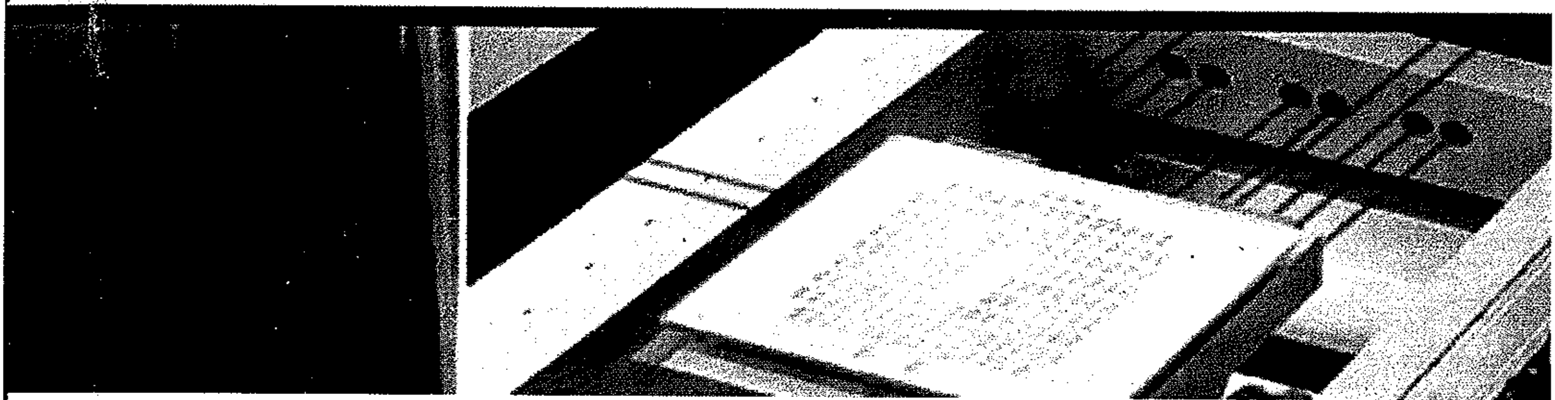

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# Analysis of Unbalances of Crank Shafts using Geometric Data

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**Abstract**

This paper focuses on the analysis of unbalances of crank shafts using geometric data. The necessary setup of a multisensor measurement system is presented, which is utilised for data acquisition. The calculated unbalances, based on the measuring data of two different sensors, are compared with each other.

## 1 Introduction

A crank shaft is one of the most important components of a motor. Because of this, the Collaborative Research Centre 489 (CRC 489), funded by the German Research Foundation (DFG), investigates the process chain for the precision forging of high performance components like crank shafts [1]. To improve the manufacture of crank shafts novel and innovative process steps must be developed. One approach of a new process step is the combination of the balancing of the crank shafts with the grinding of the bearing seats [2]. For this purpose the mass distribution and the centre of mass of the produced component must be determined. In contrast to the conventional balancing process, the unbalance of the component will be acquired solely on the basis of geometrical data.

## 2 The multisensor measurement system

To acquire the geometry of the crank shafts a measurement system is assembled, which uses three different optical sensors [3]. On basis of a shaft measurement system, which uses shadow projection technology, a conoscopic laser sensor and a fringe projection system are integrated to form an optical multisensor system, which is shown in figure 1.

The new balancing approach requires the measurement of all elements of the crank shafts, which consist of the main bearings, the pin bearings and the crank webs. Two different methods for the data acquisition and analysis are researched. In the first method only distinct line shaped profiles of the three crank shaft elements are taken. The shadow projection system, consisting of light source and CCD-camera, and the conoscopic sensor are utilised for this purpose. With the resulting geometric data the mass distribution of the measured component can be estimated. The second method is based on much more information than the first. With the fringe projection system`s areal measurement, the geometry data of the main and pin bearings are acquired. They are combined with the measurement data supplied by the shadow projection system, which forms an envelope of the crank shaft. Based on the geometric data of both measurements, the centre of mass of the crank shaft can be calculated. Taking into account the distance between the centre of mass and the rotation axis the unbalance of the crank shaft can be estimated.

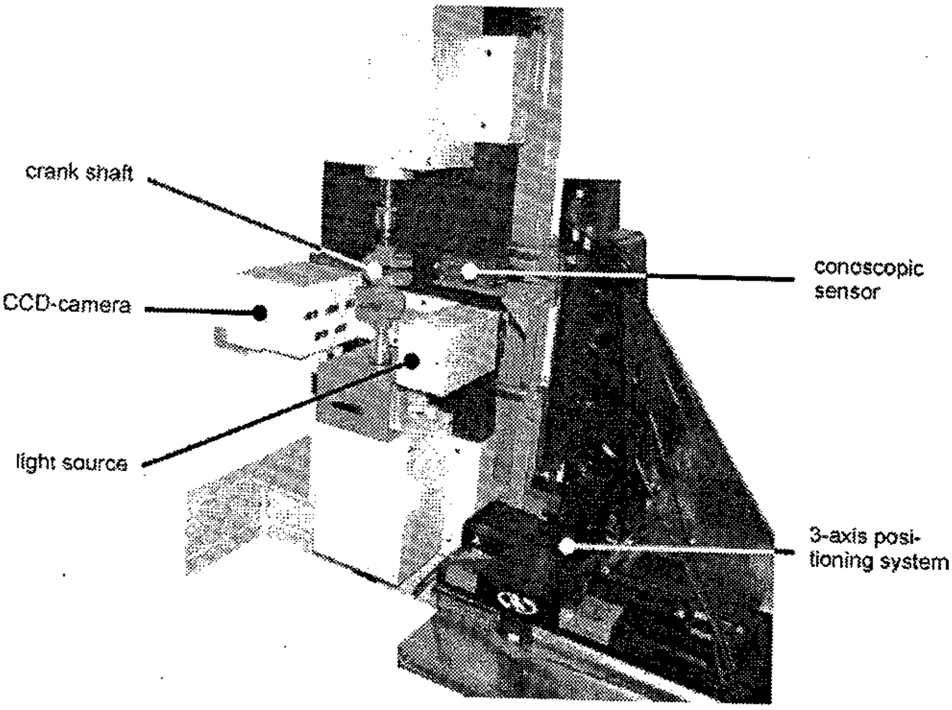


Figure 1: Multisensor measurement system (exemplarily shown with conoscopic sensor)

## 3 Results

With the methods described above, the geometric data of two one-cylinder crankshafts are captured (see figure 2).

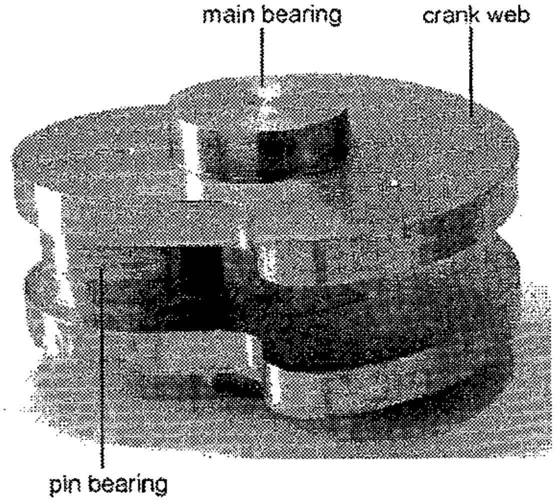


Figure 2: One-cylinder crank shaft and its elements

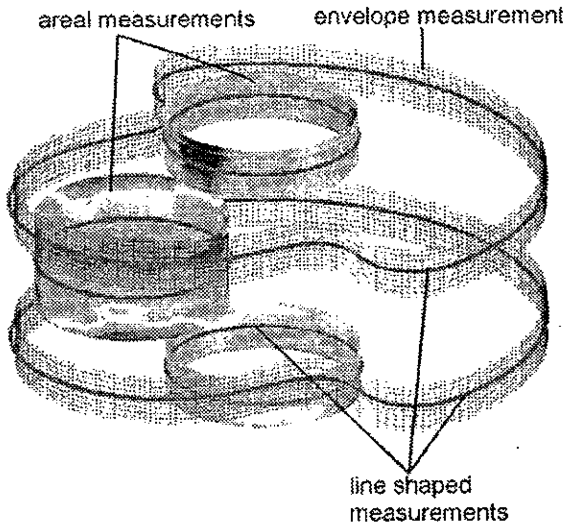


Figure 3: Measurement data of the three different measurement principles

In figure 3 the first measurement results are shown graphically. While the "line shaped method" uses only the line shaped measurements of all functional elements (for the width of all elements the nominal values are taken), the "areal method" uses the envelope measurements of the crank webs (the undercuts are here also nominal values) and the areal measurements of the bearings. For the comparison between the first results of the two different methods a few characteristics are shown in table 1.

Table 1: First results of the measurements

| | Crank shaft 1 | | Crank shaft 2 | |
|---|---|---|---|---|
| | line shaped | areal | line shaped | areal |
| radius main bearing | 22.4026 mm | 22.4026 mm | 22.4399 mm | 22.4526 mm |
| radius pin bearing | 22.4499 mm | 22.4844 mm | 22.4564 mm | 22.4880 mm |
| eccentricity pin bearing | 33.6887 mm | 33.6334 mm | 33.1094 mm | 33.1125 mm |
| mass | 2495.7 g | 2494.9 g | 2489.0 g | 2490.7 g |
| eccentricity: centre of mass ↔ rotation axis | 2.2080 mm | 2.2670 mm | 2.2325 mm | 2.1202 mm |

The deviations among the different methods by the calculation of the radii and the eccentricity of the pin bearing of the crank shaft are between 0 and 55 µm. The estimated masses can be additionally compared with the conventional weighting results. With 2494.420 g (crank shaft 1) and 2491.216 g (crank shaft 2) the maximum deviation to one of the calculated results using geometric data is 2.216 g for the line shaped measurements and 0.516 g for the areal measurement.

Based on the computation of the eccentricity between the centre of mass and the rotation axis of the crank shaft, which is needed for the identification of unbalances, deviations from about 100 µm appear. This difference, partly based on the a-priori geometry data, has, according to DIN ISO 1940, significant impact on the rest unbalance and can be decreased with additional measurements.

## 4 Conclusion and outlook

This paper shows a new approach for the analysis of unbalances of crank shafts. For this purpose a multisensor measurement system is developed, in order to accomplish measurements with two different measurement methods. Geometric data of the crank shaft is captured with different optical sensors and the mass and the eccentricity between the centre of mass and the rotation axis can be calculated. The estimation of the measurement uncertainties of both measurement methods is the current object of research.

## 5 Acknowledgements

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