Non-contact measuring method of geometric errors on grinding wheels

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Abstract

Highest machining qualities and accuracies during grinding operations can be obtained by fulfilling some basic requirements. One of these basic requirements is a high form and balance accuracy of the used grinding wheel. Geometric errors like roundness errors cause dynamic process instabilities and lead directly to a bad machining quality on the work piece. In order to reduce rejected parts and increase machining quality it would be advantageous to know the current roundness error and the causes of this error. The porose structure of a grinding wheel and the high rotation speed make it very difficult to measure any roundness error. Studies of chatter phenomens in grinding were looking usually on vibration measurements and analysis or chatter effects on the work piece roundness [1, 2]. The chatter origin could be detected by these studies but they were not able to deduce from their measurements to the real geoemtrical form of the grinding wheel. Consequently, there is no system available for this application.

In order to to analyze the different types of roundness errors on grinding wheels a special non-contact measuring method was developed. In a first step a simulation tool was realized to simulate the effects of single roundness errors and the superposition of different roundness errors on rotating grinding wheels. Following experimental test were carried out in order to prove the measuring method and identify the further development need of this system.

1 Method development

The geometrical roundness error of a grinding wheel is always a superposition of the geometrical form defect of the grinding wheel and the balance error respectively the mounting inaccuracy. In order to separate each kind of error a measurement concept with two laser triangle sensors (measurement frequency 10 kHz) were chosen which were displaced by 90° in order to measure the deviations of ΔX and ΔY on the grinding wheel geometry in X and Y direction during several rotations (figure 1). The following analysis were done by the developed MatLab tool (figure 2).

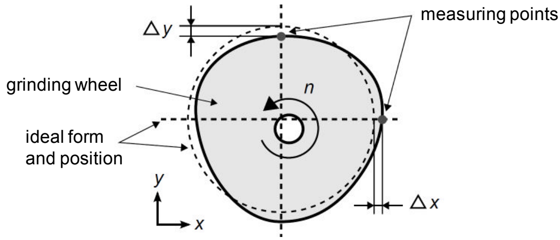

Figure 1: Measurement concept with two laser triangle sensors displaced by 90°

The obtained measurement signals ΔX and ΔY are showing the phase-delayed deviations of the grinding wheels geometry in X and Y direction. Both signals have some difference to each other because the measured rotating geometry deviations of the grinding wheel are a superposition of geometrical (roundness) errors and position (balance) errors. Especially the position errors and vibration effects from the rotating complete system (spindel, grinding machine, etc.) cause additional dynamic moves in X or in Y direction. These characterisitc system dynamics have to be identified and separated from the signals of the grinding wheel geometry. By using the developed MatLab tool both of signals ΔX(t) and ΔY(t) were tranformed by FFT into two frequency spectra. Now all of the detected characteristic frequencies in X and Y direction could be seen. Only frequencies which are harmonic frequencies of the rotating frequency are errors of the grinding wheel and the rotating system and have to be analysed more detailed. Following the comparision of both frequency spectras showed if there are some identical frequencies in X and Y direction. Frequencies which can be seen only in the spectra of X or Y direction are no geometry errors of the grinding wheel, they are dynamic effects from the system (balance error, runout error, etc.). Only the frequencies which can be seen in both spectras are caused by the waviness of the grinding wheel. This identified common frequency spectra of both directions (X, Y) was treated by an inverse FFT. The result of this inverse FFT analysis was the deviation line of the grinding wheel roundness and with this deviation line the real grinding wheel form could be reconstructed.

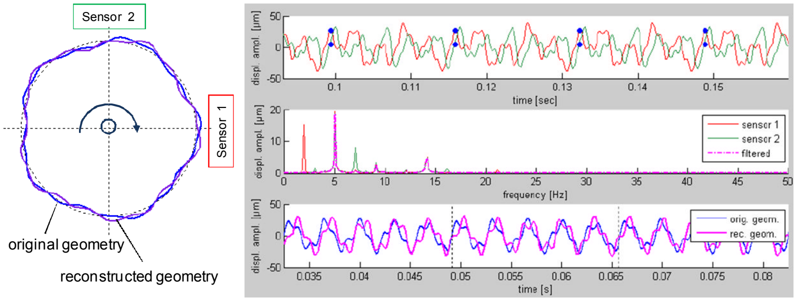

Figure 2: New simulation and analysis tool for seperating the measured signals of geometrical deviation and the other signal interferences and for reconstructing the real geometrical deviations of the grinding wheel

2 Experimental verification

One of the first results was that the laser sensors need quite clean conditions inside the grinding machine, that means the grinding wheel has to be free of coolant. If not coolant dust causes problems on optic during measuring. By avoiding of coolant dust the laser sensors were working very well. Three different grinding wheel specification were tested and some limitations of the new developed method were identified. There was no suitable laser signals for analysing if a coarse-grained and high porose corundum grinding wheel were measured. The random noise of the measuring data was to large for analyzing. In contrast to that a fine-grained and low porose corundum grinding wheel could be measured well. Balancing error as well as waviness of the grinding wheel could be detected. The last one tested, a ceramic bonded cBN grinding wheel showed a new measurement problem. This cBN grinding wheel was typical made of cBN grinding segments fixed on a metal core wheel. So the grinding wheel topographie was interupted by the fixing gaps between the cBN grinding segments. This fixing gaps caused a random noise signal during the measurement of the rotating grinding wheel. By using different standard filter algorithm this random noise signal could not be eliminated successfully because the lengths of each cBN segment was varying.

Most of the tests were done at a grinding wheel velocity of 10 m/s and geometrical deviations in a range of 1-2 micron could be detected on a grinding wheel. Higher velocities caused a strong increase of noise vibration because of dynamic behaviour of grinding wheel, spindle and grinding machine. These dynamic effects made a clear signal analysis quite difficult. Generally the obtained results showed that the superposition of dynamic effects and complex form errors of the grinding wheel are difficult to separat from each other. Consequently the parallel identification of charateristic vibrations of the spindle and grinding machine is neccessary.

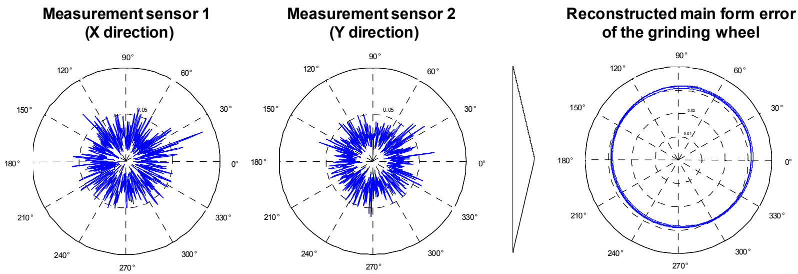

Figure 3: Example for original laser signals and reconstructed of wheel geometry (fine-grained corundum grinding wheel, velocity = 10 /m/s)

3 Outlook

The focus of the next improvement steps for this measurement and analysis method will be the development of a smart filter algorithm for eliminating the random noise signal during measuring segmented cBN grinding wheels and the test of other laser sensor specification in order to measure coarse-grained, porose grinding wheels, too. Also an approach has to be developed to measure and to filter out the noise vibration and dynamic effects caused by the spindle system in oder to identify the geometrical grinding wheel deviations at higher grinding wheel velocities as well as to identify reliable complex form errors of the grinding wheel (waviness of higher-order).

References:

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