# Evaluation of surface integrity after BTA deep-hole drilling of AISI 4140 by means of Barkhausen noise analysis

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There are various deep-hole drilling methods that can be used to machine holes with large length-to-diameter ratios. One of them is the Boring Trepanning Association (BTA) deep-hole drilling process, which is the predominantly employed technique for drilling bores with diameters in the range of D = 6 to 125 mm. The method is widely used in fields like petroleum exploration or the aerospace industry. Typical industrial applications of BTA deep-hole drilling include the fabrication of drill collars or hydraulic cylinders [1]. The manufacturing of these components tends to be costly and most times strict quality specifications need to be met. Thus ensuring process stability and workpiece quality is of major importance. An innovative approach in this respect might be found in the application of the magnetic Barkhausen noise (MBN) method for the characterisation of sub-surface conditions of deep-drilled specimens.

The MBN analysis can be used to non-destructively evaluate properties like hardness or residual stresses. The application of this technique in the field of grinding has been extensively studied in the past so that nowadays the MBN method is a well-established, non-destructive alternative for nital etching for the detection of grinding burn [2]. However, less attention has been paid to the application of the MBN method in other areas of machining. In the field of deep-hole drilling first attempts in using micromagnetic techniques for the characterisation of surface integrity of drilled specimens have been made by Baak et al., who used the MBN method to analyse sub-surface zones of specimens machined in a single-lip deep-hole drilling process [3].

In order to evaluate the applicability of MBN analysis for characterising specimens, machined in a BTA deep-hole drilling process, the boreholes of samples made of AISI 4140 with a length of l = 500 mm were analysed by means of the measurement device FracDim (Fraunhofer IKTS, Dresden). The maximum MBN amplitude $M_{max}$ was detected in the axial direction of the bores as well as in the radial direction. In addition to this, further investigations were performed to evaluate the impact of residual stresses, hardness, grain size, etc. on the detected $M_{max}$. X-ray diffraction measurements were carried out to examine residual stresses in the sub-surface zones of the bores. In addition to this, metallographic analyses, as well as hardness measurements, were done at different positions along the bore.

Figure 1 displays the detected $M_{max}$ at the beginning, the middle and the end of the bore in the radial direction, with measurements being performed every $\Delta\alpha = 4.5°$.

$M_{max}$ shows fundamentally different values as well as different radial developments for the analysed positions along the bore. The detected amplitudes are higher at the beginning and the end of the bore. The reason for this might be found in the inconsistent cutting situation at these stages of the drilling process.

Another effect that can be observed in the measurements is a periodicity of $M_{max}$ in the middle and at the end of the bore. The reason for this might be found in rising vibration with an increasing length of the bore. This dynamic and sequenced character is reported for the BTA deep-hole drilling process [1].

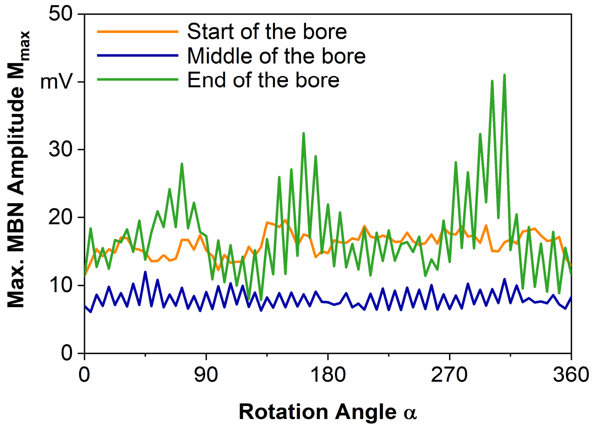


*Figure 1*. Max. magnetic Barkhausen noise (MBN) amplitude $M_{max}$ for different stages of the process in the radial direction

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