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Device for the Determination of Impact Velocities in Shot Peening

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1 Abstract

A device was developed for the determination of impact velocities of shot-peened grains impinging workpiece surfaces. The impact velocity of shot-peened grains can be used as explanation of the characteristics of the workpiece changes, like roughness, tension or surface coverage. Also, modifications of these changes due to variation of shot peening parameters (shot peening media, jet parameter, jet direction) can be detected and evaluated.

2 Introduction

In the department "Cutting Technology" of the Technical University of Hamburg-Harburg research was performed in the field of the shot peening, concentrating on Peen Forming and the roughness of the shot-peened surface. In this context, the velocity of shot-peened grains at the impact on the workpiece surface had to be measured. A simple measurement device was designed and will be introduced in the following:

The impact velocity of the shot-peensd grains can not be determined by measuring parameters like the jet pressure, the shot-peened grain mass flow, the nozzle geometry or the jet intensity. However, the grain's impact velocity and the grain's mass determine the kinetic energy of a shot-peened grain. With that, the deformation of the surface (e.g. roughness) and the change of the peripheral area of the workpiece (e.g. compression stress) as well as the coverage of the surface can be identified. The knowledge of the impact velocity can contribute to the explanation of the type and the characteristics of the measured changes.

The attempt to measure the velocities of shot-peened media is not new and is documented in different papers [1, 2, 3, 4]. Partially with elaborative efforts [3].

3 Description of the Measurement Principle

The principle of the measurement device designed in the department of Cutting Technology of the Technical University of Hamburg-Harburg (TUHH) is based on a so-called " two-disk method " and is shown in *Figure 1*.

On a common shaft two disks are fastened, which turn with a constant rate. The first disk, the so-called hole disk, has a hole at a certain distance (r) of the disk's center. The second disc is the so-called registration disk. The jet nozzle is located with the distance (a) from the hole disk at the height of its hole. Whenever the through hole of the hole disk and the nozzle exit aligned, some of the shot-peened grains pass through the hole and mark the registration disk. Depending

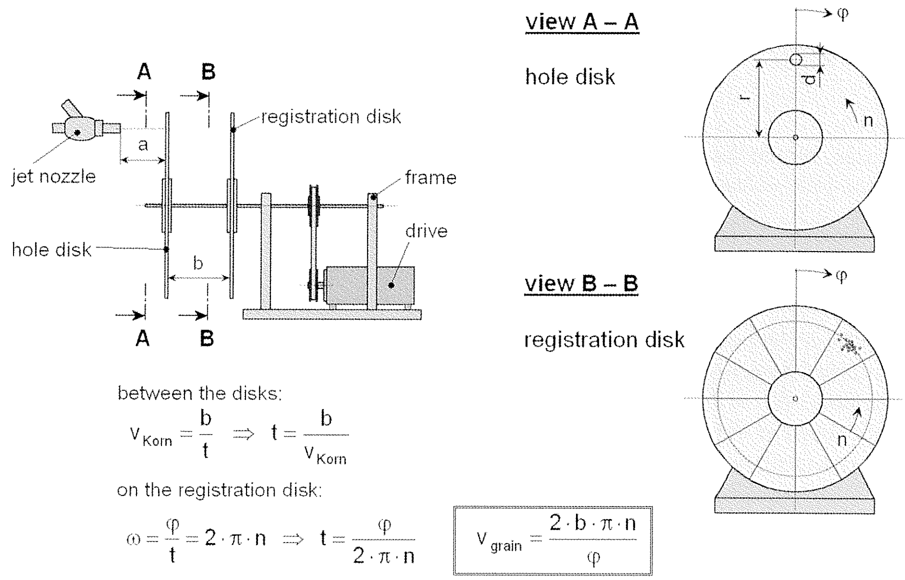

Figure 1: Measurement principle according to the "two-disk method"

on the grain velocities it takes a certain time (t) for the grains from passing through the hole disk and impinge on the registration disk. During the time span (t) the disks keep on turning about a angle (φ), so that the impact on the registration disk does not align with the hole in the hole disk and the nozzle exit. The grain impact velocity can be calculated with the parameters b (distance of disks), n (RPM of disks) and φ (turn angle of disks during t).

4 Description of the Measurement Device

In *Figure 2* the built measurement device is shown, including necessary power supply for the drive. In the following some boundary conditions for the measurement device are listed:

- Dimensions < 600x400x400 mm (workspace of the shot peening cabin),
- facility for converting the input parameters (a, b, r, d, n) for optimal adjustments of the device,
- low weight for transportation purposes,
- easy handling (registration disk, modifications of input parameters),
- low cost.

The device frame consists of aluminium profiles, which allow easy adjustments. The two disks, the bearing blocks and engine mounting plate are also made out of aluminium, the shaft consists of steel. The drive, an DC motor and a drive belt, allows an easy variation of the disk revolutions. The two disks are wedged on the shaft and are also easy to adjust. Likewise the mounting plate of the jet nozzle can be adjusted to the height and distance necessary according

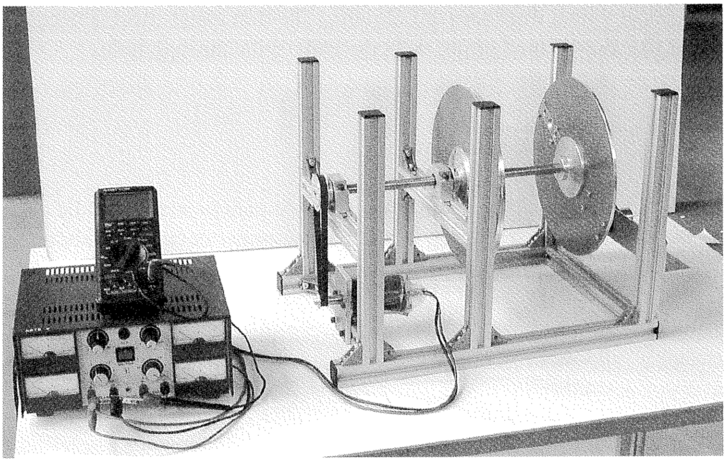

Figure 2: Measurement device with power supply

to the hole disk. The attachment of the graph paper on the registration disk is performed with the aid of a second recessed disk, with wedges the paper onto the base of the registration disk.

Figure 3 shows the hole disk and the registration disk from an other view for better understanding. The distance (*r*) from the rotation axis to the disk hole can be changed by the exchange of an insert. This insert is available twice, in order to keep the spinning disks in balance.

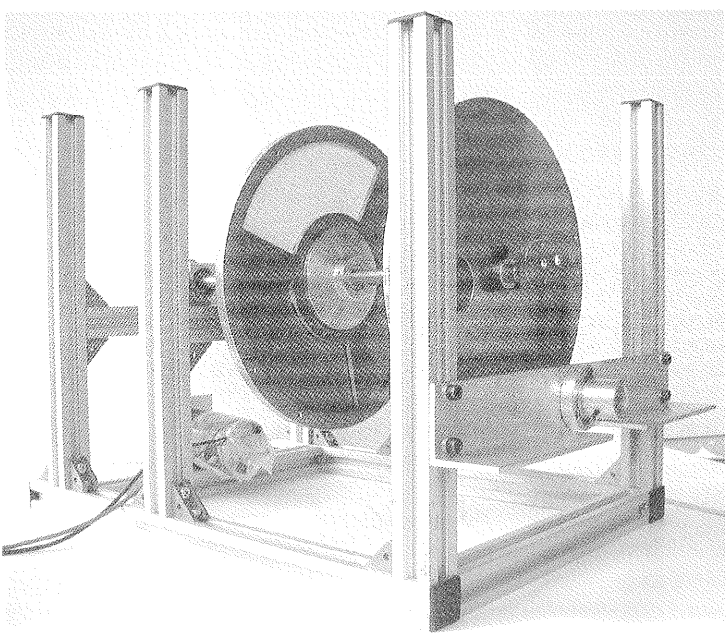

Figure 3: Measurement device with the hole disk and registration disk

The actual hole is in a metal sheet with a thickness of 0.25 mm. The thin metal sheet is necessary to prevent the collusion of the shot-peened grains with the wall of the through hole.

5 Test Run

For optimal test results the different, in chapter 3 described variable parameters had to be investigated and adjusted. *Figure 4* shows the setting up of the measurement device in a shot peening cabin. Following dimensions and/or settings turned out as favorable for the test run:

- hole diameter in the hole disk: $d = 5$ mm
- distance r (scribed circle): $r = 95$ mm
- distance between the disks: $b = 110$ mm
- distance nozzle exit to hole disk: $a = 135$ mm
- RPM of the disks: $n > 1200$ min^{-1} (2400 min^{-1})
- graph paper: Copy paper with 80 g/mm²
- necessary jet duration: 30 to 120 s

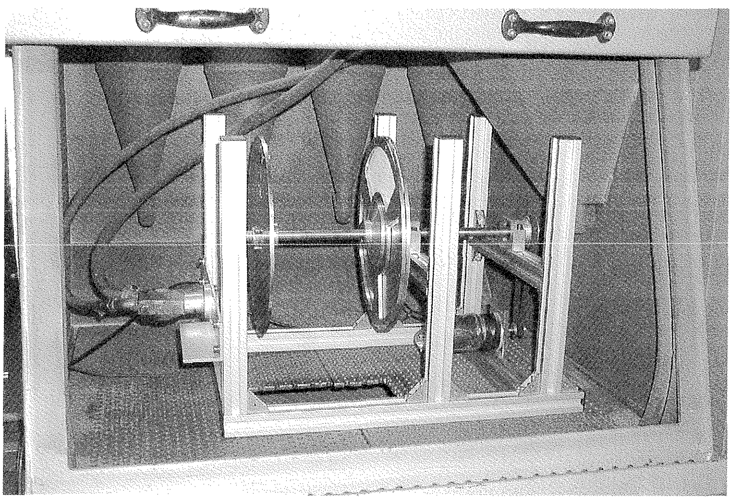

Figure 4: Measurement device set up in a shot peening cabin

Figure 5 shows the registration disk schematically. With selected settings ($b = 110$ mm, $n = 2400$ min^{-1}) the grain impact velocities show up according to the angle φ. The range of 10° to 70° equals grain velocity range of 158.8 m/s to 22.6 m/s.

Shooting grains on the standing disk through the hole onto the registration disk result in a scattering range diameter of 8 mm. This range does not change significantly using different shot peening media with different jet pressures. The effect shown in *Figure 6* results from a jet pressure of p = 4 bar using round cast steel shot peening media with the size of 0.2 to 0.4 mm (GS-R 0.2-0.4).

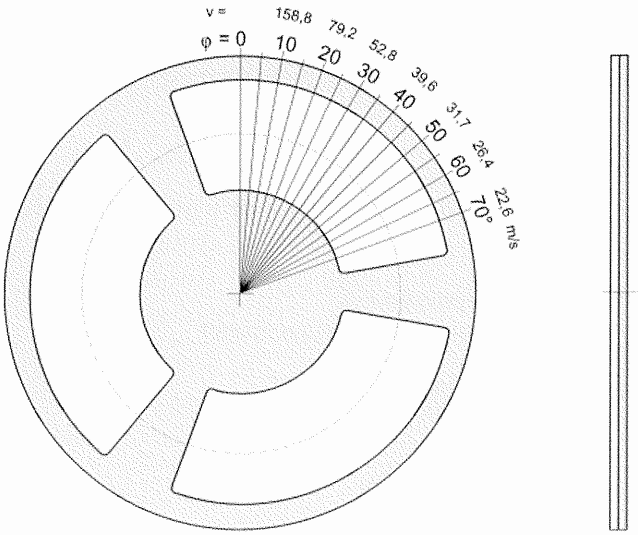

Figure 5: Registration disk with indication of the impact velocity according to the angle φ

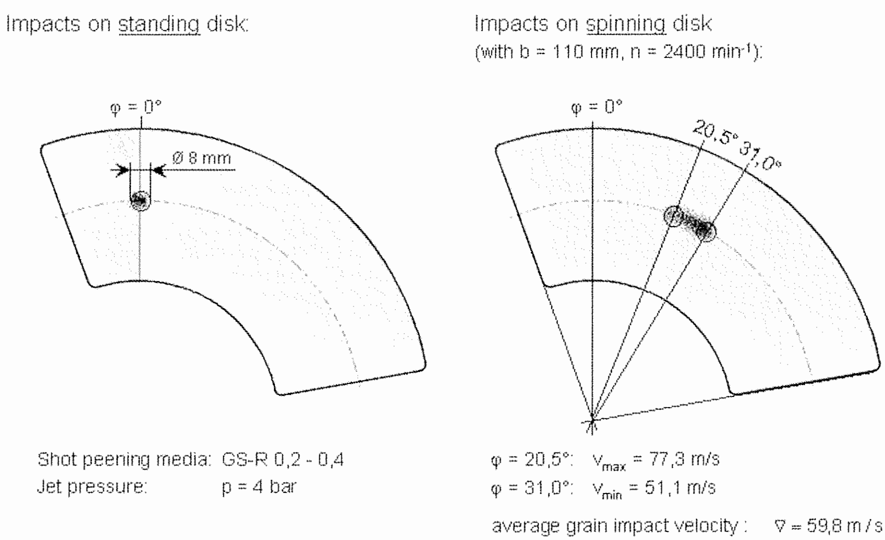

Figure 6: Graph paper, shot-peened grain impacts on standing and spinning disk

Shooting grains on the spinning disks (n = 2400 min^{-1}) the grain imprints on the graph paper appear in form of a tail, whereby an accumulation can be detected at larger angles. A test run with the parameters mentioned above indicated a grain velocity rate of v = 51.1 to 77.3 m/s. The scattering range diameter is again about 8 mm.

For the calculation of an average grain impact velocity the weighting for the lower speeds was taken double due to the accumulation of imprints at lower grain velocities:

$$\overline{v} = \left(2 \cdot v_{\min} + v_{\max}\right)/3 \tag{1}$$

To prove the functionality of the designed measurement device the following four types of shot peening media were used:

- MGL 0.250-0.420 and MGL 0.420-0.590 (glass beads),
- GS-R 0.2-0.4 and GS-R 0.4-0.8 (cast steel shot peening grain, round)

The jet pressure was within the range of 3 to 7 bar.

6 Interpretation of Experimental Results

In *Figure 7* the average grain impact velocity is shown depending on the jet pressure. The curves rise approximately linear within the examined jet pressure range. The glass beads achieves higher rates than the steel grains, as well as for smaller grains a higher velocity can be detected than for larger grains.

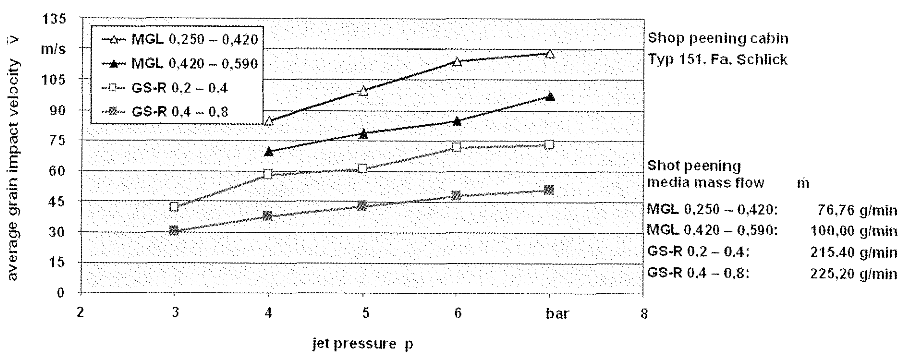

Figure 7: Average grain impact velocity depending on the jet pressure

For the upper and lower curve in Figure 7 the determined scattering range is show in *Figure 8*. The curves represent the weighted average grain impact velocity. It can be seen that the scattering range is relatively large, for the glass beads even more than for the steel grains.

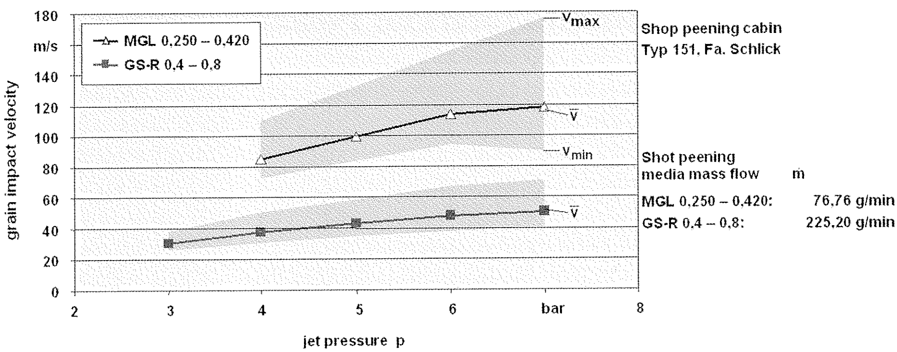

Figure 8. Scattering range of grain impact velocities

7 Summary

In summary the following conclusions can be drawn. The presented two-disk measuring method is basically suitable for determination of shot-peened grain impact velocities on workpiece surfaces. The shot-peened grain impact velocity rises almost linear with the jet pressure within the examined pressure range from 3 to 7 bar. However, further investigations are necessary for determination the possibilities of utilization of the presented measurement device.

8 Literature

[1] Martin, P.: Einzelkornversuche, Bestimmung der Kugelgeschwindigkeit nach dem Laufzeitverfahren mit Hilfe von 2 Impulsgebern (in: Beitrag zur Ermittlung der Einflußgrößen beim Kugelstrahlen durch Einzelkornversuche. Dr.-Ing. Diss. Uni. Hamburg 1980).

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[4] Andziak, J.: A new method of measurement of the velocity of solid particles and their mass for air blasting (ICSP7, 1999).