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Virtues & Limitations of Almen Round

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1 Introduction

There are many parameters involved in shot peening. Among them are: The shot speed, the size, shape, nature and hardness of shot, projection angle and exposure time. This multiplicity of parameters makes the precise control and repeatability of a shot peening operation very problematical. For this purpose, research was carried out to develop a more comprehensive and easier method of controlling these parameters. Present investigation gives a detailed discussion of the development of various methods of controlling shot peening parameters and proposes also a promising method which is called "Interactive *Almen Round* Method".

2 Chronological Development in Shot Peening Process Control

Shot peening control aims to either reproduce a previously-established intensity of peening or to induce a specified level of peening intensity. Control of shot peening operations for strain hardening is currently achieved by means of Almen gauge system or "*Almen Strip*" system. The "Almen Gauge" introduced by J. O. Almen in 1943 has served the shot peening industry very well. Rectangular steel strips of controlled chemical composition and thermal history are shot peened whilst being held flat and deflection of the strip on release is measured .The deflection from flatness is Almen arc height H , being measured using an Almen gauge and is presented for strips with a choice of three different thickness. These three thickness accommodate the wide range of peening intensities that need to be used for different applications. No doubt, Almen strips have proved out to be the only means to set up the shot peening parameters for different materials and applications But apart from having such extensive usage, Almen strips do have some limitations. They are work intensive like clamping and unclamping (tightening/loosening). This is a time consuming procedure and regarding details there are very many tricky mechanical process effects in respect of accuracy and application. Apart from these limitations for taking one set of reading we need at least 4-5 strips to establish a saturation curve.

Until 1993 this method was the only method, but in 1993 the term "Interactive Shot Peening" (1) came into existence and at that time lot of work have been done on this particular field. An initial attempt to produce an interactive peening intensity measurement device (2) involved the use of standard Almen strips but without the standard four screwed securing procedure. This device incorporated LVDT (Linear variable displacement transducer) for sensing and measuring the deflection of strip continuously. This method was reliable and fast but the main problem with this method was that LVDT was very sensitive to long term damage.

Further development on LVDT based devices had given a device in which a screw down ring presses the circular test disc against a recess in the disc holder. An LVDT is secured in the disc holder by means of a grub screw and the output fed to a displacement recorder. The screw down ring and disc holder afford excellent protection for the LVDT. This device was more versatile and accommodating for wider range of peening intensities.

To further improve this device masking washers were used to expose different areas to the incoming shot stream. These fit on top of the disc. This technique is in regular use for research and development purposes, but the LVDT itself is relatively bulky and too delicate and has to be carefully protected from high-velocity shot.

After this LVDT method a new development in monitoring device (3) involves the use of elastically–strained arm carrying a strain gauge that is in contact with a disposable steel disc. As the disc deforms, due to peening, the arm relaxes with consequent strain gauge signal changes being continuously chart-recorded. The very high sensitivity of this strain gauge device allows very small changes in intensity to be detected. This method used test specimens which were made of simple mild steel rather than the very hard steel of original Almen Strips.

3 Alternative Method ("Almen Round" Technique)

Pertaining to above-mentioned limitations of the "*Almen Strip*" technique and other methods, the present presentation proposes the concept of having an alternative test piece, the "*Almen Round*" with an unique on-line monitoring of shot-peening process. This system (predecessor was the "Impact Sensor" (4), established in centrifugal peening / blasting applications) facilitates the use to mount Almen Rounds in a special fixture, having a sensor (for convexity measurement), which displays the values of convexity on a digital monitor. The most outstanding feature of this system (5) is that everything is online, i.e. we can see the increasing arc height, the saturation curve, on the monitor.

Procedure: This method involves two steps for any set of readings which are:

1) Setting the arrangement: In this step we have to make all arrangements which include tightening of an Almen Round with swivel nut using simple hand force, plugging in the monitor and linking monitor with the sensor head arrangement.
2) On-line reading: In this step we expose the sensor head with the fixed Almen Round to the shot process and read the increasing arc height with the help of the monitor simultaneously or have the event e.g. software processed.

4 Constructional Details

This arrangement has in minimum 4 elements: The test specimen, the sensor head, the monitor and calibration disks A, N and C.

4.1 The Test Specimen (Almen Round)

The test specimen or so called Almen Round (Fig.1) is a cut out from a standard Almen strip of either A, N or C–thickness and of original quality Premium. The precision Laser-cut operation followed by an extensive flatness examination guarantees a Almen strip equivalent round disk in every respect.

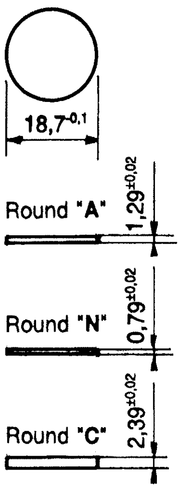


Figure 1: Almen rounds

4.2 The Sensor Head

A heavy, specially shaped steel bar, rectangular at one side , carries a finger like dome. On top of this dome the Almen Round specimen gets tightened with the swivel nut. The specimen is only fixed peripherally on both sides on a tiny rim. The dome bears inside a pin touching the specimen on the inner side, the other side of the pin works on a strain gauge, actually transmits the deflection of the specimen. This will induce a output signal exactly linear to the deflection.This unit (Fig. 2) is treated to highest hardness in order to withstand the hazardous conditions when exposed to shot stream. It is designed for simple installations supposed to be exposed

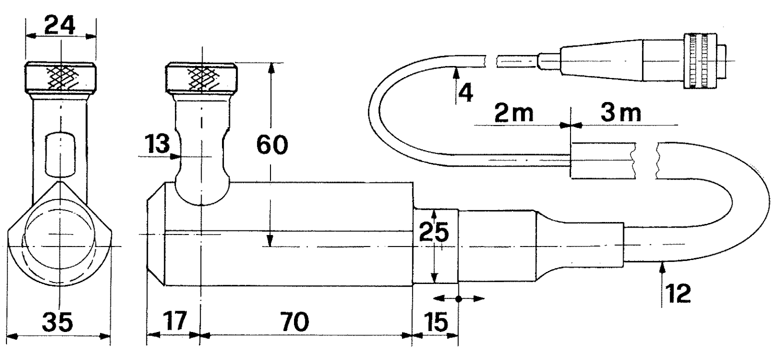


Figure 2: Sensor with cable

to the shot stream. The unit does not contain any other items then the strain gauge. A protected cable also connects to the monitor box or interface outside the peening area.

4.3 The Monitor

Common to this equipment is a hand hold battery operated monitor (Fig. 3) that allows a 3 digit reading of the Almen arc height in metric or inch system. Additionally an analog out signal 0-1 V is provided. One toggle switch ON/OFF one switch for DATA/HOLD and the ZERO setting knob allow the operation of the outfit. However the sensor out signal can be connected directly e.g to a chart recorder or to any suitable interface for further processing by an suitable software even combined with an automatic 2T calculation.

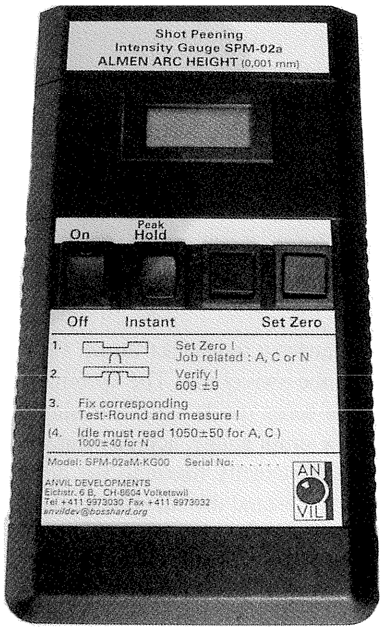
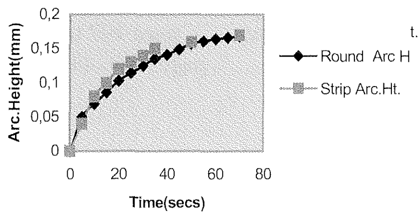


Figure 3: Hand held monitor

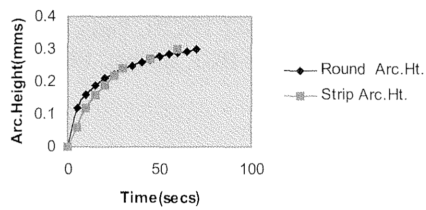
4.4 Saturation Curves

When a component is shot peened, it incurs a deflection, which is the result of residual stresses that have been induced by shot peening. For a given shot peening condition the variation in deflection with the shot peening duration may be plotted and these kind of curves are called saturation curves. These curves are very helpful in controlling the shot peening parameters and are used worldwide for this purpose.

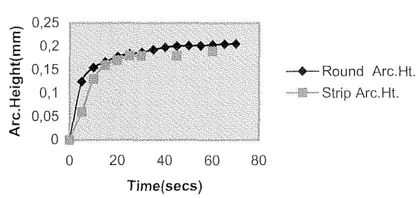
Some saturation curves are shown. The values of the deflections obtained after a saturation time are considered to be the characteristics of the intensity of the shot peening. Following figures show the saturation curves obtained from shot peening carried out using an air operated standard peening machine. For such preliminary studies injection type equipment has been used and parameters such as shot, flow, pressure etc. have been set to commonly used standards. Saturation curves have been plotted by using the conventional "Almen Strip" method and the alternative "Almen Round" technique. The results obtained from both of the methods are given and found as a result, they are almost identical. It could be discussed whether discrepancies are a matter of tolerances and errors or whether a real physical difference could be noted. At least it seems that for industrial use such differences could be disregarded.



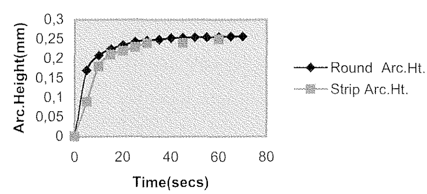
Curve 1 "N" specimen peening pressure **1.0** bar



Curve 2 "N" specimen peening pressure **2.0** bar



Curve 3 "A" specimen peening pressure 4.**0** bar



Curve 4 "A" specimen peening pressure **5.0** bar

5 Discussion

This interactive "**Almen Round**" method is very useful for determination of Almen values (intensity) at the time of setting of machines. This method is considerably faster than "**Almen Strip**" method as this method doesn't involve cumbersome process of clamping and un-clamping of strips which is replaced by a simple hand clamping of the swivel nut. This method uses the test specimen (Rounds) which are made of original Almen strips (thickness, hardness, material etc). In this method the clamping practically does not affect the buckling up of the disc and the setup is rigid, and all the components of forces are in defined position. The measuring gear is mechanically linked to the test specimen therefore reducing errors and increasing accuracy. In view of the calibration provided for digital gauge giving convexity (spherical shape) accurately at par with conventional Almen arc height (as it is evident from the herewith presented research work according above given results/graphs), this interactive peening control method can allow the control of shot peening parameters more accurately and conveniently. Also this device is claimed to be industrially approved.

If there is an interest from the shot peening industry or from research side, certainly the method can be trimmed to meet international approval standards.

6 References

[1] D. Kirk, ICSP5, Oxford, "Interactive Shot Peening Control" p.10 to 15 (pre-prints)
[2] see page 12, fig. of reference1)
[3] D. Kirk, ICSP6, San Francisco, "Developments in Interactive . .", page 95 to 106
[4] R. G. Bosshard, MAT-TEC91, Paris, "Shot Intensity Monitoring . . ", page 197 to 200
[5] R. G. Bosshard, SP-BC1, Bhopal, 1966, "On Line Monitoring . . ", page 37 to 44