Controlled shot peening, complete plants and examples of application

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Introduction

The conception of the peening equipment and the material and shape of the peening media depends on the workpiece to be peened. This will be determind by the following facts:

- Cleanness and structure of the surface
- improvement of the mechanical behavior
- changing of the geometrie.

These are the main facts to define which peening media shall be used. If an appropriate media has been selected, also a suitable peening equipment is necessary for the reason that different media requires specialised machinery in order to obtain high performance and quality. The linear and rotative moving for workpiece and nozzles are determined by the largeness and the geometrie of the workpiece. Peening operations with low tolerance in intensity, for instance like in the aircraft and space industry, and the asked reproducibility determines the expences of monitoring and control. Questions of economics stipulate the value and number of the aggregates. At last the requirements of the cleanness, dimension and shape of the peening media will fix the amount of the separation plant. The following pages will show some important views of modern peening machines and some examples of application.

Mass flow control of the peening media

Media quality and electronical means of moving the nozzles are not enough to reach wanted coverage and hence consistency of depth and magnitude of compression or the wanted geometrie. To reach a good reliability the wanted and

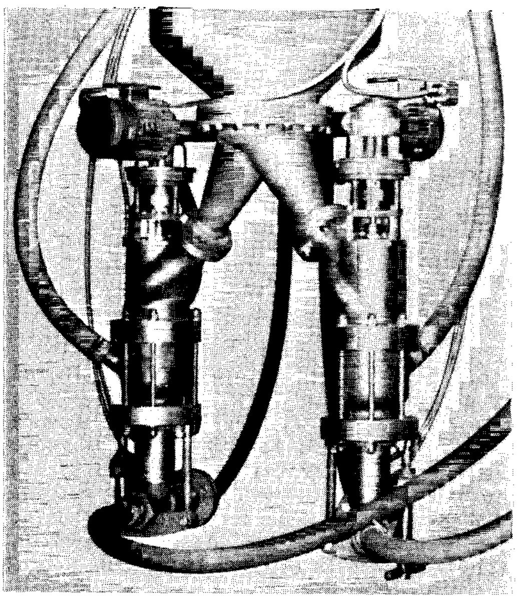


Fig. 1: Metering units for mass flow control of dry steel shot

Strahlmittel-Dosierköpfe (geregelt, trocken) constant mass flow of the peening media must be guaranteed. Fig. 1 shows the shot regulating heads with the electronical device to control the mass flow of the media. If the peening machines are working dry with steel shot, it is possible to measure the mass flow of the peening media with inductive methods (Fig. 2). By this online measurement of shot flow, the accuracy of media flow will be very high. The repeatability of the mass flow is high too. This is dependent on the size of the peening media and the mass flow (Fig. 2). For nonferrous shot, e.g. ceramics, similar a flow rate sensor has been developed covering the range form 1,1 - 22 lbs/min (0,5 - 10 kg/min).

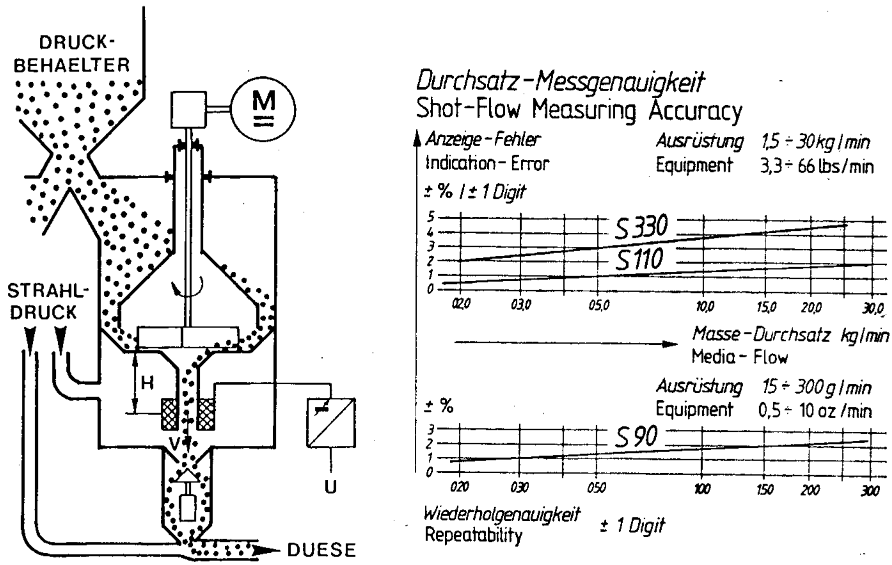
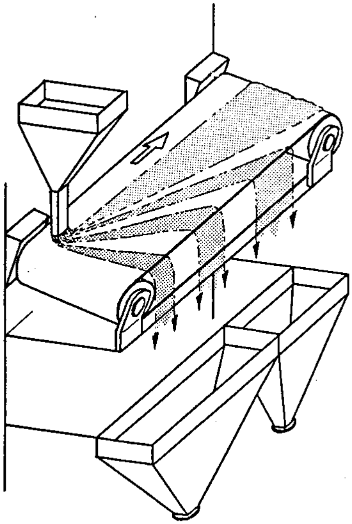


Fig. 2: Regulation principle and shot-flow measuring accuracy

Funktionsprinzip der geregelten Dosierung und Beispiele zur Messgenauigkeit

Quality of peening media

The shape and the size of the particle generates the shape and the size of the identation. Insufficient working of the surface with bad peening media like cutting or abrading considerably reduces the peening effect. Therefore it is necessary to have carefully classified media. Fig. 3 shows the media disposition unit to classify shape and size of dry steel shot. The sizing of the media is made by sieves, the separation of the media shape is done by an inclined conveyerbelt. The principle of the separation of the peening media is also shown in Fig.3. Cross to the moving direction the conveyer is at an angle. Balls with good shape will leave inspite of the gravitation down the



(principle of shape separation)
(Prinzipbild)

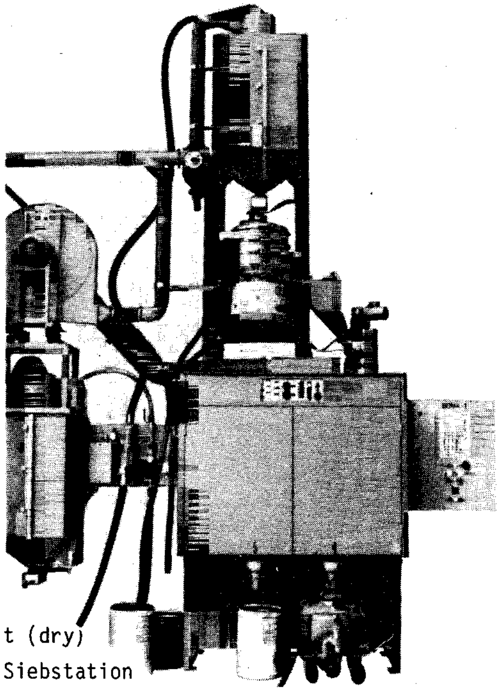


Fig. 3: Shape and size separation unit (dry)
Bandsortierung (trocken) mit Siebstation

conveyerbelt by the shortest way. Bad media follows more and more the moving direction of the conveyer, finally released as waste. This is a very good method to separate the peening media regarding shape and it is no problem to fullfill MIL-specification-requirements.

Shot peening of small holes

One of the small typ installations introcuced in industry shows Fig. 6.This arrangement is capable of peening oil supply holes in turbine shafts. The standard precision peening apparatus is made for precise control of peening media for one nozzle for different peening media up to S 330 (about 1 mm). Combined with a moving unit with one longitudinal axis and a rotating nozzle it is possible to shot-peen with this equipment holes of about 2,50 mm (0,1 inch) in diameter and in minimum ten times of the diameter deep with equal intensity over the entire hole. Such holes can be peened to required specifications in less than 3 minutes with little quantity of shot. Main facts of the peening operations are uniform solidification in the entire hole and a soft gradiant in solidification and residual stresses in the surface of the shaft. For this a special system of nozzle and target has been developed (Fig. 4 and 5). To prove the peening parameter, a dummy shaft-section with holes will be used (Fig. 6). To fix the Almentest-strip a special strip holder is used. After peening with this teststrip-holder, it is possible to get some practical information in comparison to the normal Almen intensity with the help of the conversion diagram shown in Fig. 5.

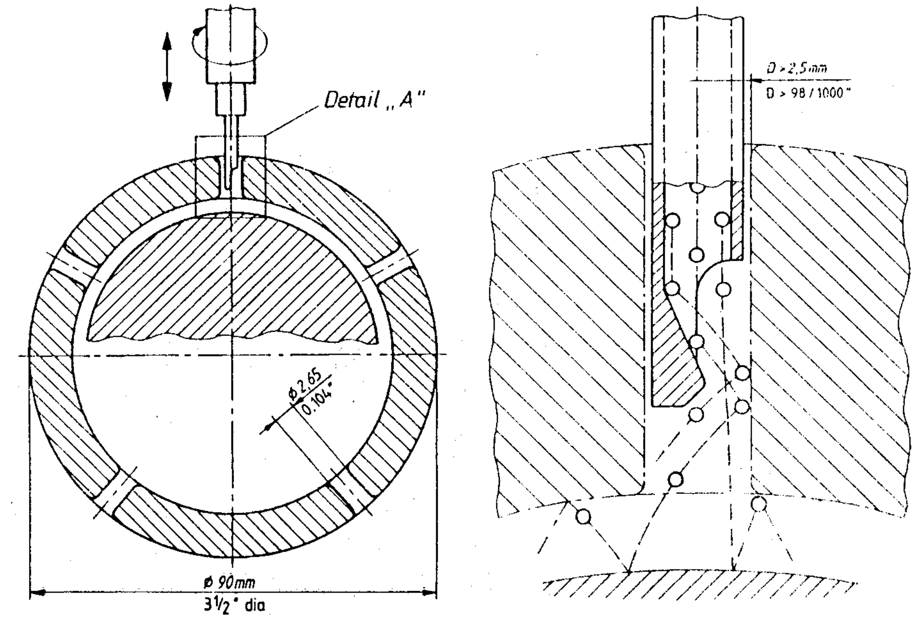
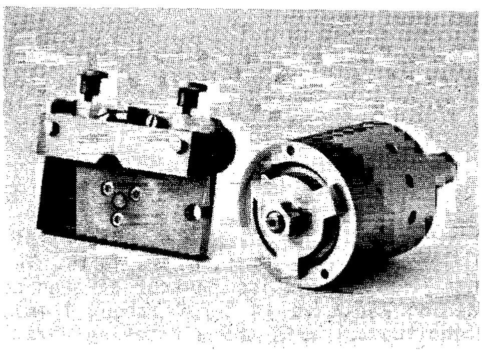


Fig. 4: Geometrical situation when peening small holes in turbine shafts
Darstellung von Verhältnissen, wie sie bei Kugelstrahlen von kleinen Bohrungen in Turbinenwellen vorliegen



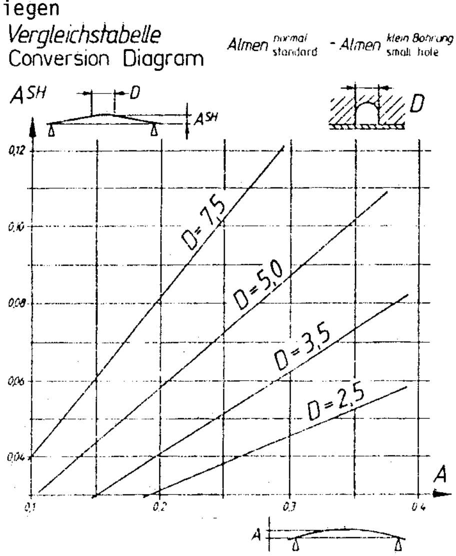


Fig. 5 : Test fixture for Almentest-strips, dummy to test peening operation. Conversion diagram: Almen small hole - Almen standard
Halter für Almenplättchen zur Ermittlung des Almen-Standard-Wertes mit Hilfe der Vergleichstabelle. Bohrungsgeteilte Einstell-und Prüfattrappe in genauer Werkstückgröße

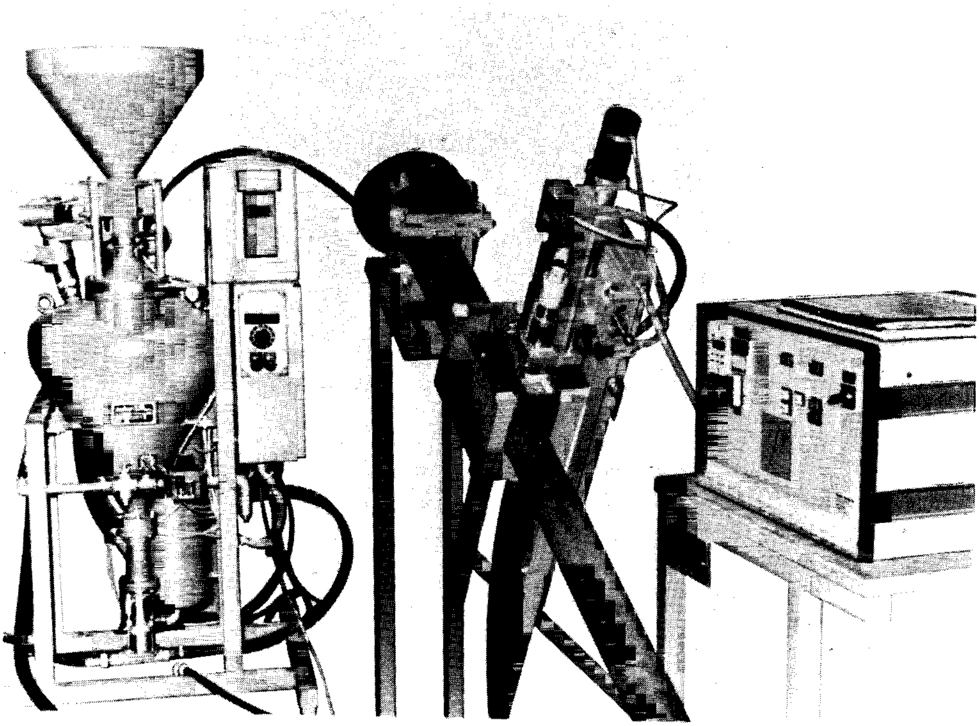


Fig. 6: Installation for the shot-peening of small holes
Strahleinrichtung für das Verfestigen kleiner Bohrungen

Shot peening of turbine blades

Generally turbine blades can be peened wet or dry with steel, glass or ceramics. The most important facts are the intensity of the Almentest-strip and the degree of coverage. To fullfill these requirements one linear motion and one rotation is necessary. Inspite of the reasons of economics several nozzles are needed. In Fig. 7 you will see an installation, with which some fan-blades will be peened without interruption of the peening process. In this case the method is wet peening. The wet peening operation has the benefit that there is no dust. Another benefit is the possibility to separate undersize shot very precise by a spezial separator. It is important too, that in wet peening it is possible to separate various impurties from the peening media by a filter.
The principle function of a wet peening installation is shown in Fig. 8. It shows, that metering and measuring is possible in wet peening too.

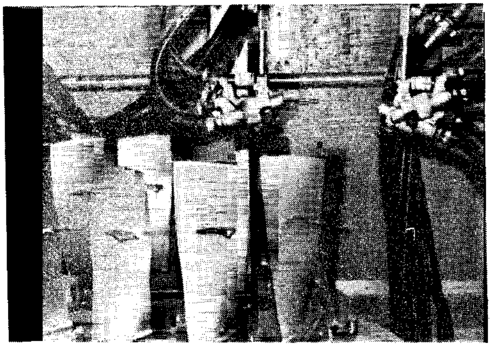


Fig. 7: Peening-installation for fan blades
Strahleinrichtung zur Behandlung von Turbinenschaufeln

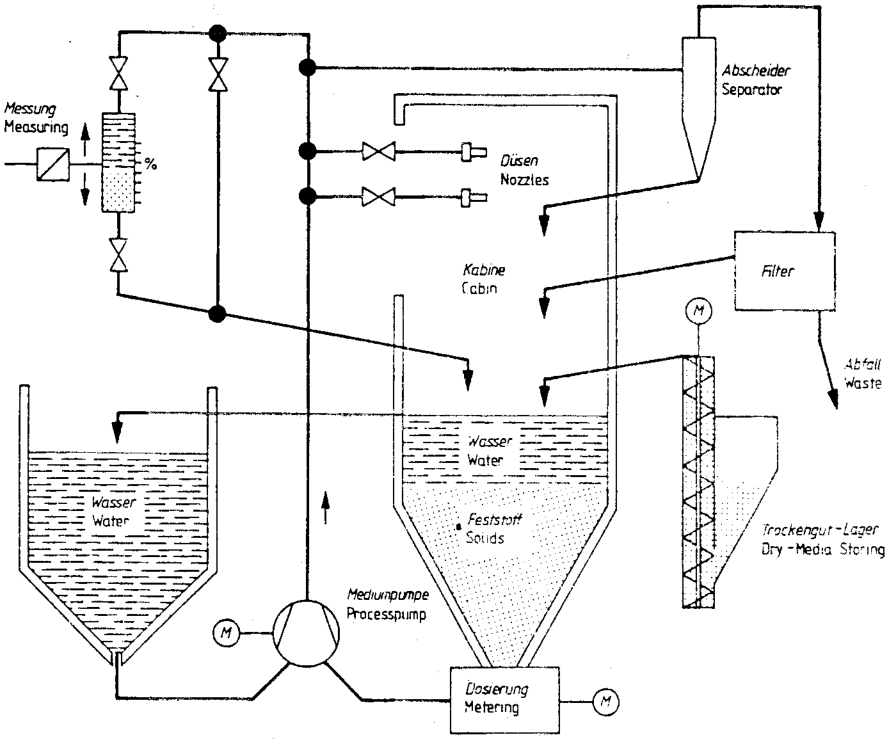


Fig. 8: Wet peening installation for glass and ceramics, metering and proportion control, separation of undersize particles and waste out of peening media
Prinzip der Zwangsdosierung und Strahlmittelaufbereitung für das Naßstrahlen mit Glas oder Keramik

Peening of slots in turbine disks

To peen the slots of turbine disks it is necessary to have moving units for one longitudinal movement, one rotation of the workpiece and one rotation of the nozzle. To work more economically it is possible to use several nozzles simultanously. Usually these movements of several axis are controlled by NC or CNC.

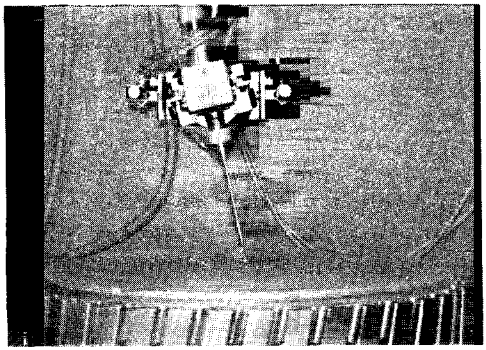


Fig. 9: Peening-installation to peen the slots of turbine disks

Beispiel für das Kugelstrahlen von schwer zugänglichen Geometrien (Turbinenscheibe)

Peening with industrial robot

For very complex shaped workpieces a robot may be a good solution. Usually such equipment carries two or four nozzles. Standard non-robot installations with movement arrangements in the configuration of e.g. x/y-combined linear axis, additional w-horizontal- z-vertical- axis and turntable-axis/rotation

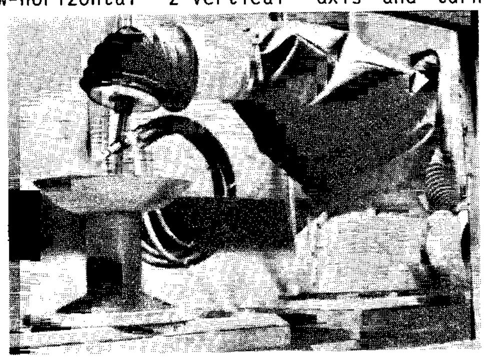


Fig. 10: Peening robot inside the peening chamber

Roboter innerhalb einer Strahlkabine

are equipped with at least 6 nozzles. In such a case, 3 sets of nozzles can work individually on one job at the same time. The robot itself obviously has to be installed within the cabin, so that the size of the cabin has to be considerably bigger. Also a reliable protection of the robot itself against hazardous influence by the peening media is necessary. In some cases a standard 6-axis robot should be assisted by an additional linear movement, preferably in an overhead arrangement in order to gain more flexibility. Regarding prime costs, robots produced in big lots are cheaper than a comparable CNC-equipment.
Under the present situation shop- and production requirements have to be studied individually for each application, to decide if a robot - or even a combined one, will be the best solution.