A NEW TYPE OF NOZZLE DEVELOPED FOR THE STUDY OF THE EFFECT OF SHOT-SIZE ON INTENSITY OF PEENING UNDER SPECIFIED PEENING PARAMETERS

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ABSTRACT

A new type of nozzle was developed for a shot peening equipment designed and fabricated for laboratory use. Discharge characteristics of the nozzle of different throat diameters were experimentally found out. For given peening parameters the overpeening (saturation) effect using nozzles of different diameters with steel shots of different sizes on medium carbon steel strips of different thickness were experimentally found out. The equipment could also be successfully used for shot peening the condenser tubes with the intention of enhancing their heat transfer coefficient under nucleate pool boiling.

Nozzle with 7.0 mm throat dia. under similar peening conditions gave overpeening effect after 15, 60 and 90 seconds for medium carbon steel strips of thickness 1.0 mm, 1.5 mm and 2.0 mm respectively. It was also observed that more the thickness of the strip the lesser was the arc height under similar peening conditions. Amongst S-170, S-280, S-330 and S-390 under similar conditions of peening the shots S-390 were more effective. The nozzle with 5.0 mm throat dia.could give overpeening for 1.5 mm thick strips with only one type of shots i.e. S-330 and it occured after 90 seconds.

KEYWORDS

Shot peening nozzles, overpeening effects.

INTRODUCTION

Shot peening is a process of continuously striking a surface of metal by streams of high velocity particles under controlled conditions. The various parameters controlling the shot peening effects are :

1. Material, size, shape and breakdown of shots (Hardness): The material may be steel shots, glass beads, nylon pearls, chilled iron shots, silicon carbide etc. again depending upon the peening

requirements. Shot size is related to the required arc height (1)

2. Shot velocity : In air blast type of equipment shot velocity depends upon nozzle bore, air pressure, and distance of the nozzle from the work piece.

3. Time of peening : It is a function depending upon shot size, arc height and coverage.

4. Coverage : It depends upon number of indentations per unit area and is a factor of time, with a maximum of 98% coverage.

5. Nozzle to work piece distance and angle by which shot strikes the surface.

6. Quantity of shot striking a unit area per unit time.

Combined effect of above factors is known as peening intensity and is expressed as Almen arc height.

The shot peened surface is residually compressed ; and its material shows increased fatigue strength (2). The process has other useful applications such as relieving tensile stresses that contribute to stress corrosion cracking, forming and straightening of metal parts and testing of adhesion of silver plate on steel. Apart from these well known applications shot peening process was tried in the present investigation on condenser tube materials with the intention of finding out its effect on heat transfer rate under nucleate pool boiling conditions. For this a shot peening equipment was designed and fabricated for laboratory use. An equipment designed for peening eight cylindrical specimens was earlier reported (3). The nozzle used for this equipment was a conventional type which could not peen effectively with heavier shot material. It was intended to improve upon the nozzles used earlier, and a shot peening equipment was designed and fabricated for peening round jobs like condenser tube, coil spring and other round jobs.

It was also intended to find out experimentally the overpeening time for medium carbon steel strips with various sizes of steel shots using nozzles of different sizes. Effect of thickness of the test piece on overpeening time for nozzles of various sizes could also be found out.

NOZZLE DESIGN

On analysing the conventional convergent-divergent nozzle used by Sharma and Mubeen (3), in their earlier shot peening equipment it was found that it did not suck 1.0 mm dia. steel shots uniformly and did not impart proper kinetic energy to the shots. Due to which there was not appreciable improvement in fatigue strength of shot peened specimen. The probable reason could be insufficient vacuum at the throat and improper crossections of the nozzle. Taking these factors into consideration a new design for a shot peening nozzle is suggested and important steps are given to decide the dimensions at various portions of the nozzle.

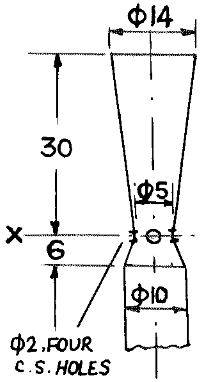

Fig. 1(a) Conventional nozzle.

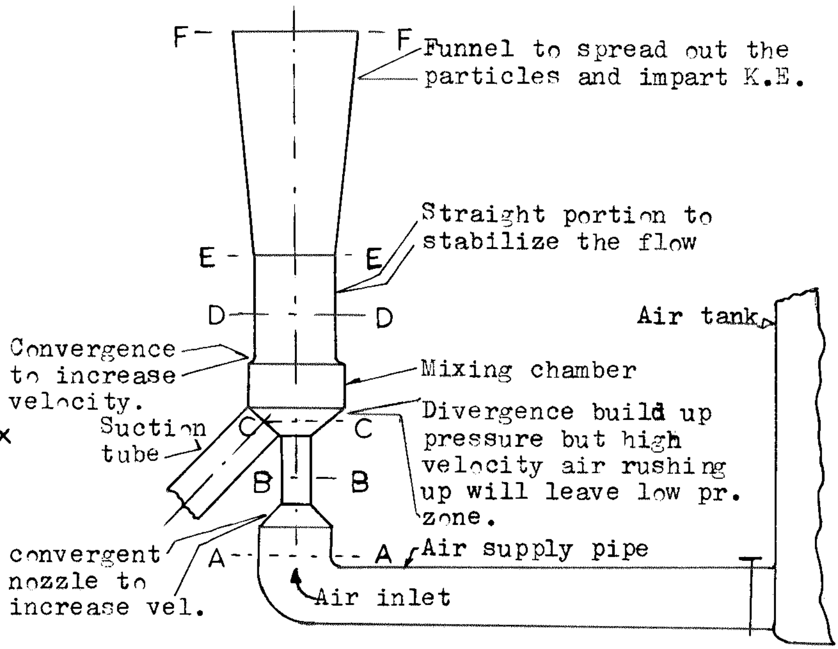

Fig. 1(b) Improved design of the nozzle (Schematic view)

Refer Fig.1(a), at Sec. XX, Due to decrease in crossection air pressure will fall, but at the same time air being compressible pressure will increase. The combined effect of these pressure changes did not provide sufficient vacuum to suck heavier shot materials. The four holes provided around the throat were in horizontal position. The suction of shots through horizontal holes was not beneficial. In improved nozzle the suction holes for the shots were less in number and inclined at 45° or 30° with the nozzle axis. The 30° inclination was found to be more effective when used with 7.0 mm nozzle.

Various steps involved in finding out the dimensions at various sections of the improved nozzle are as follows :

1. Refer Fig. 1(b). The air pressure and temperature of the supply tank were measured. Taking suitable losses at the outlet valve and pipe, the pressure at the section AA could be known. Temperature of the air at this Section AA can be assumed to be approximately the same as tank temperature. Density of air at this section was calculated by the relation $P/\rho = RT$ where $R = 29.3$ constant, P = Pressure of the air at the section in Kg/cm^2 , ρ = density in Kg/m^3 , T = Temperature of the air in °K .

2. Mass flow of the air at Sec.AA could be found out knowing the diameter of the section and velocity of the air flowing through inlet to AA. Air velocity was measured using pitot tube and mercury manometer.

3. Sample calculations : Refer Fig. 1(b) i.e. Schematic view and the figure 2(a) the dimensioned drawing of 5.0 mm nozzle.

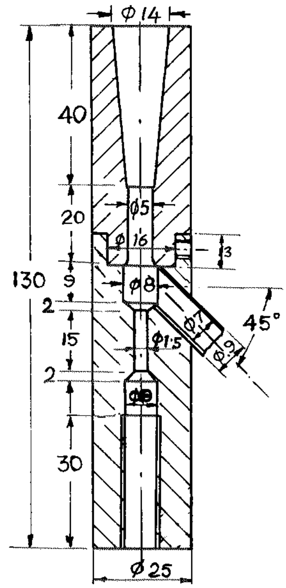

Fig.2(a)

Details of
Ø 5.0 nozzle

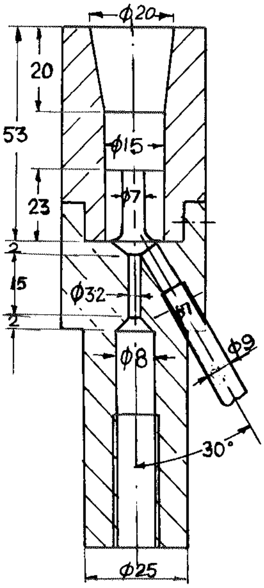

Fig.2(b)

Details of
Ø 7.0 nozzle

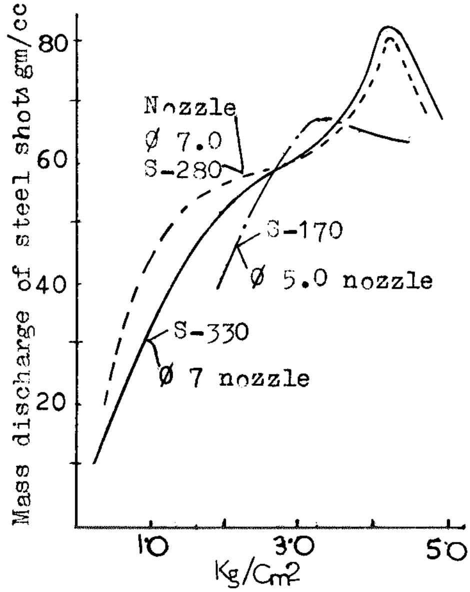

Fig.2(c) Discharge characteristics of different nozzles.

The maximum discharge for Ø 5.0 nozzle was found to be at 3.5 Kg/cm^2 gauge refer Fig.2(c). Assuming 20% lossess at the valve and supply pipe the actual pressure at section AA will be 3.62 Kg/cm^2 absolute.

Velocity at Sec. AA by pitot tube measurement = $454\sqrt{H}$ where H is the difference of Hg. column in metre will be $454\sqrt{.08}$ = 128.4 m/sec.

Assuming density of air approximately constant i.e. 1.293 kg/sec. Mass of air discharged at AA. (Fig. 1.b)

$$= \frac{\pi}{4}(.008)^2 \times 128.4 \times 1.293 = 8.345 \times 10^{-3} \text{Kg/sec.}$$

The mass discharge will remain constant through any section of the nozzle. Therefore velocity of air at Sec. BB i.e. 1.5 mm dia.

$$= \frac{8.345 \times 10^{-3}}{\pi/4(.0015)^2} = 4722.3 \text{ m/sec.}$$

This high velocity air rushing up towards Sec. CC will leave low pressure zone. Velocity of air at Sec. CC i.e. 4.03 mm dia.

$$= \frac{8.345 \times 10^{-3}}{\pi/4\ (0.00403)^2} = 654.22 \text{ m/sec.}$$

Using steady state energy flow equation for Sec. AA and Sec. CC .

$$Z_A + \frac{V_A^2}{2g} + \frac{P_A}{w_A} = Z_c + \frac{V_c^2}{2g} + \frac{P_c}{w_c}$$

where Z = Detum in metres
V = velocity at the section under consideration in m/sec
g = acc. due to gravity = 9.8 m/sec^2
p = absolute pressure at the section under consideration in Kg/m2

Taking Z_A as the detum

$$0 + \frac{(128.4)^2}{2 \times 9.8} + \frac{3.62 \times 10^4}{1.293} = .05 + \frac{(654.22)^2}{2 \times 9.8} + P_{c}/\omega_c$$

$$\therefore \quad P_{c}/\omega_c = 7000.8 \text{ Kg/m}^2 \therefore P_c = 0.9052 \text{ Kg/cm}^2 = 66.597 \text{ cm of Hg.}$$

As this pressure is lower than atmospheric pressure. Hence creates vacuum of amount 76-66.6 = 9.5 cm of Hg. at the section CC. Thus the shots would be sucked into the mixing chamber of the nozzle. Then the shots with air will flow through the adjacent convergent nozzle with increased velocity into the divergent funnel, where the shots are spread out and K.E. is imparted to them.

The dimensioned drawing of 7.0 mm throat dia. nozzle is given in Fig 2(b) and its discharge characteristics in Fig. 2(c). The pressure corresponding to maximum discharge was observed to be 4.8 Kg/cm^2 for both S-280 and S-330 shots. In 7.0 mm dia nozzle a mixing chamber was not provided but the inclination of the suction tube for the shots was only 30° with the nozzle axis. Performance of this nozzle was found to be better than 5.0 mm dia nozzle having mixing chamber,and 45° of inclination of suction tube of same dia.

SHOT PEENING EQUIPMENT

The details of the equipment are shown in the Fig.3(a) & 3(b)(photographs) . The shot peening equipment designed and fabricated could provide arrangements for controlling various shot peening parameters. The work piece can be rotated at various speeds of 60, 120, 180 and 240 rpm. Its specimen holder can accommodate the round jobs of size ranging from 50 mm dia. and length ranging from 50 mm to 250 mm. The shot peening nozzles could be fixed at any convenient angle ranging from its vertical position to any inclination upto 45°. Distance of the nozzle from the work piece can be varied. With the same nozzle holder nozzles of various diameters could be replaced. For uniform peening over the entire length of the work piece there is a provision by which nozzle can travel too and fro along the longitudinal axis of the job. The equipment is continuous type and doesnot require frequent refilling of shots. The shots after striking the workpiece and other exposed areas will fall down into the conical hopper where they surround the nozzle and its suction tube. From here the shots are resucked and brought to the passage of high velocity air. The kinetic energy of the air is imparted to the shots which will strike the work piece.

EXPERIMENTAL WORK

Experiments were designed to study the effect of peening time on arc height. The test stripe of medium carbon steels were fixed on a

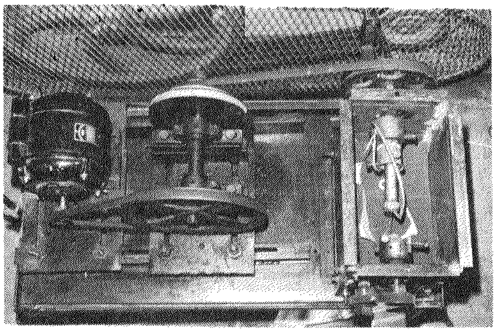

Fig.3(a) Shot peening equipment showing driving unit, condenser tube & holders.

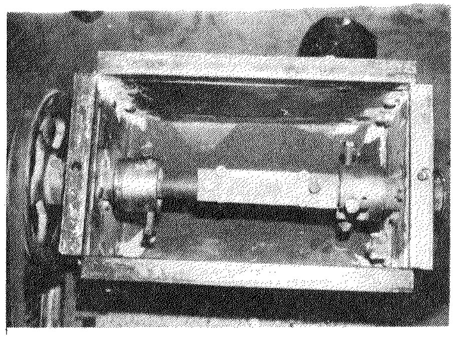

Fig.3(b) Shot peening equipment without cover, showing the fixture & strip.

fixture as shown in Fig.3(b). The fixture was kept infront of the nozzle in the shot peening equipment and different strips were peened for suitable time intervals. While peening the specimen holders were not revolved. After peening the arc height was measured by a dial gauge as shown in Fig.4(a).

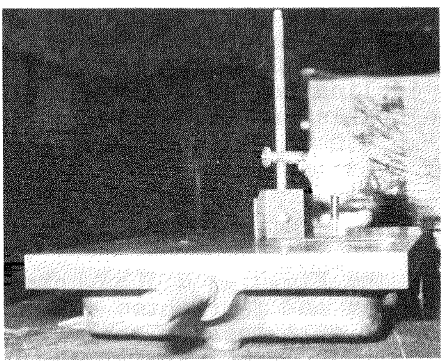

Fig.4(a) Measurement of arc height

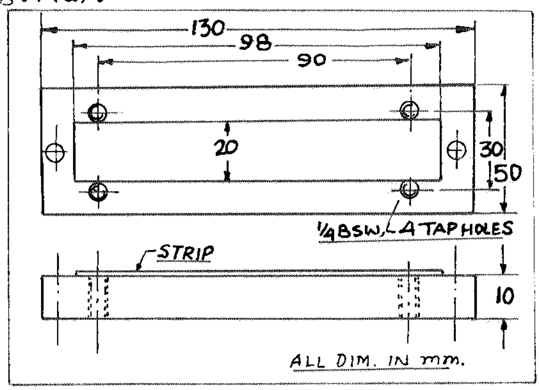

Fig.4(b) Fixture details for mounting strips.

The hardness of cold rolled medium carbon steel strips was 123 BHN for all the thickness 1 mm, 1.5 mm and 2 mm. Thus the effect of thickness on overpeening time for various nozzles could be experimentally studied with these strips.

RESULTS AND CONCLUSION

Under given peening conditions 7 mm dia nozzle with S-280 shots gave overpeening effect after 15, 60 & 150 seconds on medium carbon steel strips of thickness 1.0 mm, 1.5 mm & 2.0 mm respectively. Thus higher the thickness of strip the higher is the time required for overpeening. It was also observed that the higher the thickness the lesser will be the arc height. Similarly with S-330 shots the overpeening occurred after 10, 60 & 90 seconds on medium carbon steel strips of thickness 1.0 mm, 1.5 mm, and 2.0 mm respectively. As regards the effect of thickness

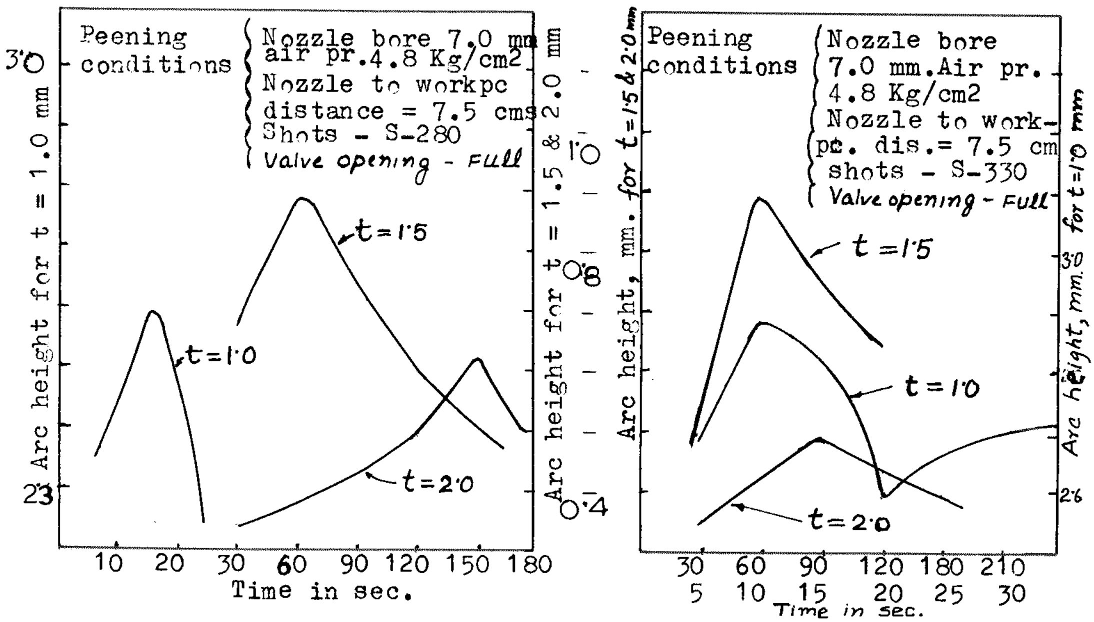

Fig.5 Graphs showing effect of peening time on arc height
Where t = thickness of the strip peened.

The same result was observed with S-330 shots also. It was observed that with two different size shots S-280 and S-330 the maximum arc height in two cases was approximately the same, but the only important difference observed was that with thicker strips, S-330 shots were more effective as compared to S-280. The shot size S-390 has given maximum arc height as compared to shots S-330, S-280 and S-170. The over peening occured only after 90 seconds of the peening time with a maximum of arc height. Smaller shots S-230 and S-170 were less effective and could give deflection to thin strips of 1 mm thickness only. Refer above results as shown in Fig.5 & 6.

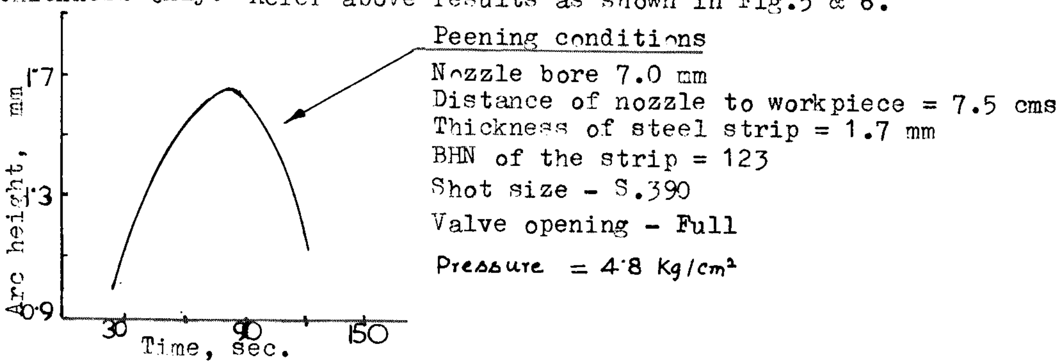

Fig.6 Effect of peening time on arc height.

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