1996157

Some Aspects of Mass Flow Control of Shots in Pneumatic Systems

Written by V.S. Nadkarni and M.C. Sharma. Reprinted with permission from the Proceedings of ICSP5.

Abstract

Mass Flow control of shots is an important factor to attain required and consistent peening intensity. Irregular mass flow of shots in pneumatic systems may give rise to different residual stress pattern in the work pieces of same material and shape, though peened to the same Almen intensity. Experimental investigations were carried out to correlate shot size, nozzle bore and shot feed opening to mixing chamber (orifice diameter), which could provide uniform shot flow at different pressure and air inlet valve opening in manual operated pressure systems. Different designs of mixing chambers were compared. In tubular mixing chambers, concentric tube type mixing chamber gave better performance. Similarly individual orifice plate system was found more convenient than adjustable opening type feed valve. Results showed that in pressure peening system for uniform flow of shots, orifice diameter must be about 0.7 times the nozzle throat diameter. While in syphonic and gravity feed systems this proportion can be still larger. Syphonic systems worked well with orifice diameter 1.25 times the nozzle diameter.

Keywords

Pressure peening nozzle, mixing chamber, syphonic nozzle, mass flow, shot feed valve.

Introduction

In pneumatic pressure peening for attaining a required and consistent peening intensity one has to select a proper throat diameter nozzle and orifice size or shot feed opening to mixing chamber for a given shot size. Again to ensure uniform shot flow at an air supply pressure there must be correct ratio of compressed air volume and shot mass falling through orifice into mixing chamber. In manual control peening, operator is first setting air volume such that a uniform flow of shot stream is attained and then peening is carried out.

As regards peening operations with low tolerance in intensity for instance like in aircraft and space industry, requires expensive metering units for mass flow control [1,2]. However, there are either machine parts where 125 to 300% coverage (peening for 1.25 to 3 times the saturation time) or even higher coverage is recommended with higher tolerance in intensity. Present investigation refers to manual operated pressure peening plants used for such applications only where uncontrolled method of feeding the shots via the orifice is used.

Experimental Work

Syphonic nozzles for shot and ball peening were developed as shown in Fig. 1 (page 31). In the present investigation an attempt was made to correlate orifice diameter, nozzle bore and shot size for uniform flow of shots. As regards pressure peening orifice diameter an important role while in syphonic system its size did not have any effect on mass flow. Since here shot suction into mixing chamber is proportional to the magnitude of vacuum created by sudden expansion of high pressure air into it. Thus required quantity of shots could only be aspired into mixing chamber through orifice. The number of orifices could be placed around the mixing chamber depending upon the space available or even one orifice could be accommodated of which diameter equal to 1.25 times nozzle bore was found satisfactory. As reported elsewhere [3] the mixing chamber length, diameter of nozzle and orifice diameter all of equal size (5 mm) also gave satisfactory results in case of syphonic system. Fig. 1 shows a detailed views of syphonic nozzles developed for the present investigation and performance of these nozzles were found satisfactory.

Different Models of Mixing Chambers

Fig. 2 (page 32) shows different models of mixing chamber/shot feed valve for pressure peening system. For comparative evaluation of these models mass flow and arc height/kinetic energy of shots were measured at different compressed air pressure. Observations for mass flow of successful mixing chamber are tabulated on page 33.

Observation for Single Tube Type Shot Feed Valve (Mixing Chamber)

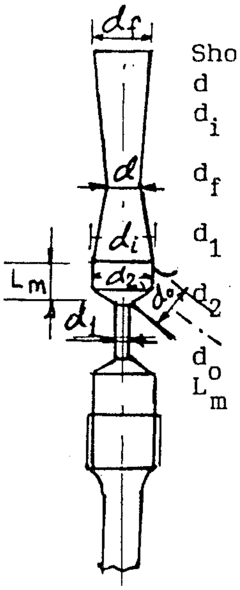
Schematic view of this design is as shown in Fig. 2(a). Three models of this design were made where orifice diameter was varied as follows:

i. Orifice diameter do = nozzle bore d = 6mm
ii. Orifice diameter do = 0.75 d = 4 mm
iii. Orifice diameter do = 0.5 d = 3 mm

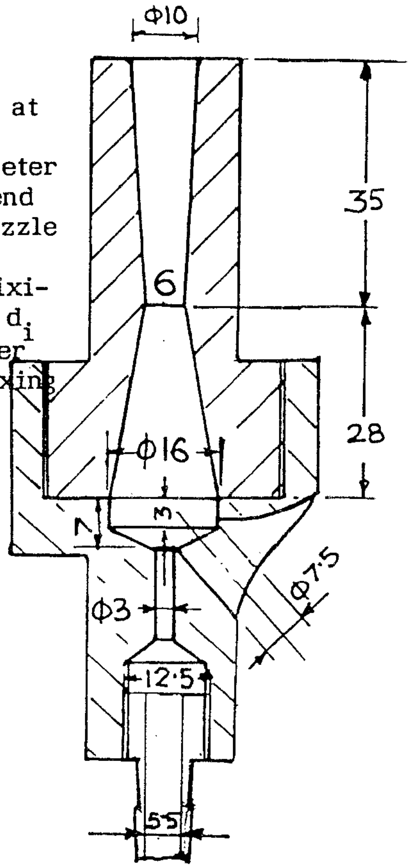
Nozzle size used form mass flow study was about 6 times the shot size.

First model gave clogging of shots at all air pressures. Second model gave non-uniform flow of shots but better flow than first. Third model with d_0 = .5d gave still better mixing of compressed air and shots, however, flow of shots through nozzle was still non-uniform. Therefore single tube type design was discarded and in order to stabilize the flow concentric tube shot feed valve was proposed as shown in Fig. 2(b) and detailed drawing at Fig. 2 (f). This design do not allow direct entry of shots into mixing chamber. The pressure peening set up developed was reported elsewhere.

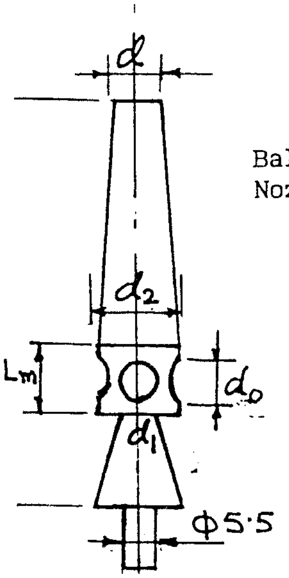
Article continued on page 34



Shot Peening Nozzle
d = Nozzle bore
d_i = Inlet diameter at convergence
d_f = Outlet diameter at divergent end
d_1 = Primary nozzle bore
d_2 = Diameter of mixing chamber = d_i
d_o = Orifice diameter
L_m = Length of mixing chamber



Schematic view and nomenclature of important diameters of syphonic nozzles.



Ball Peening Nozzle

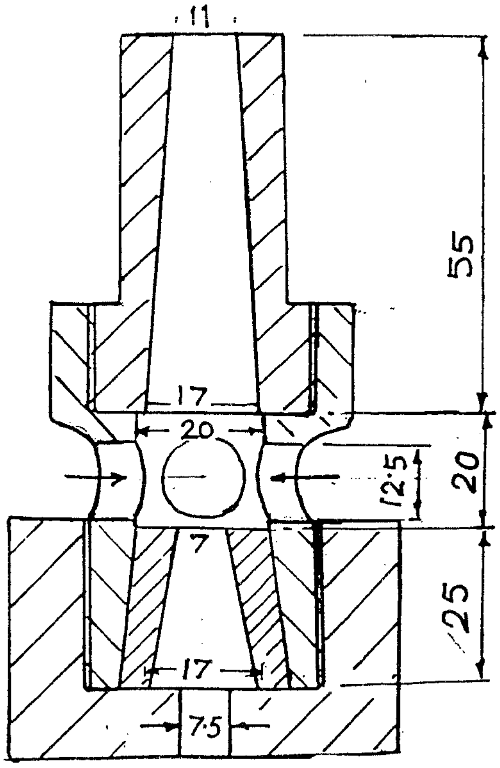
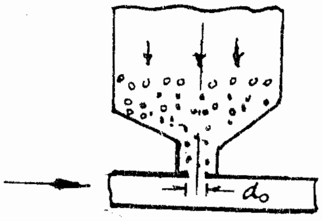
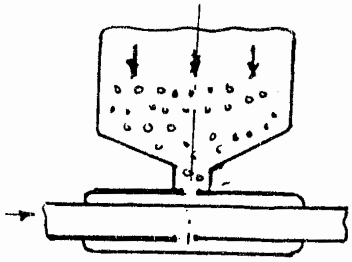


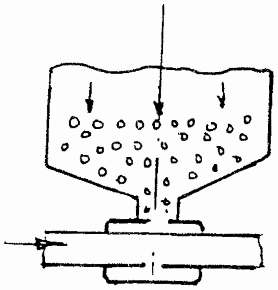
Fig. 1 : Schematic and Detailed views of Syphonic Nozzles.



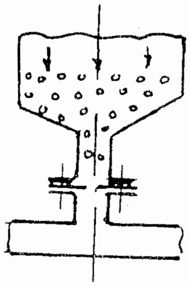
Single tube type
Fig. 2(a)



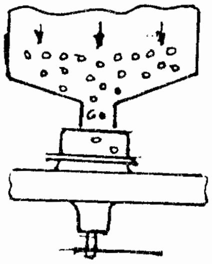
Concentric tube type
with longer outer tube
Fig. 2(b)



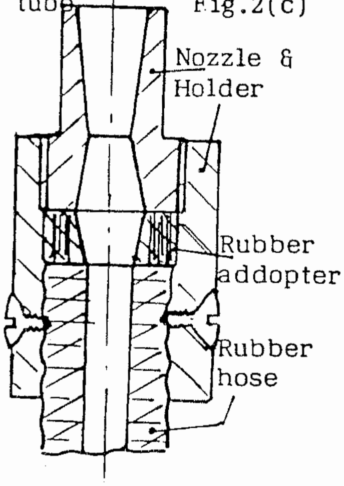
Concentric tube type
with smaller outer
tube Fig.2(c)



Individual Orifice
plate type
Fig.2(d)



Adjustable orifice opening
type
Fig. 2(e)



Pressure peening nozzle
profile

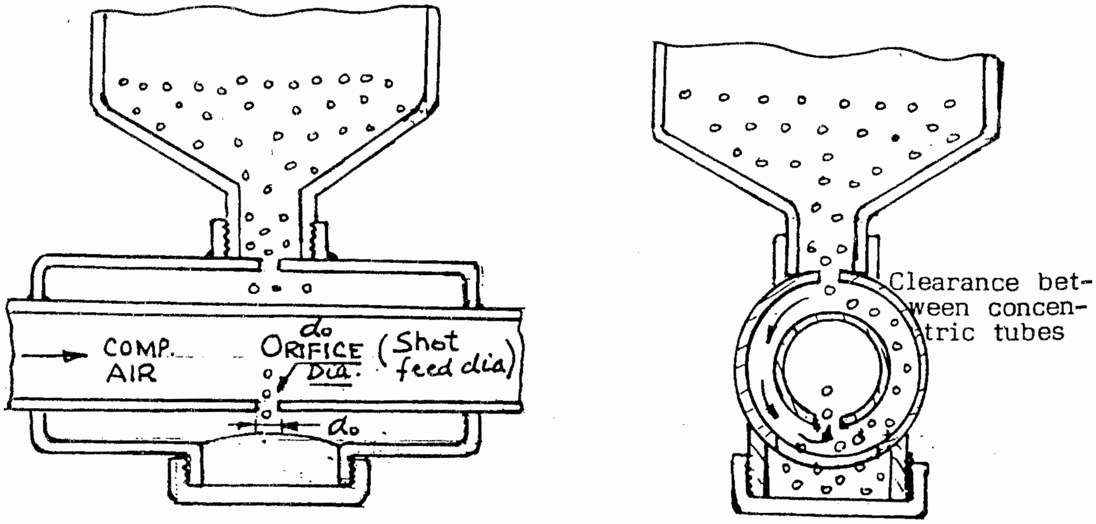


Fig. 2(f): Two views of concentric tube type mixing chamber

Fig. 2: Different models of mixing chamber (shot feed valve)

Table - 1

Pressure Kg/cm^2	Losses in Pipe line gm/sec		Losses due to nozzle	
	S-230 shots,	Glass bead 0.25mm	S-230 shots	Glass bead 0.25mm
6	5	1.6	60	70.0
5	5	1.8	42.5	62.0
4	5	1.8	30.0	58.17
3	5	2.33	27.0	37.67
2	5	2.00	17.0	23.0
1	4	2.00	6.0	11.33

Observations for Mass Flow

For 6 mm nozzle, air inlet valve opening - half, shots S-230.

Table-2 : Mass flow of shots with the nozzle at working height in gms/sec

Pressure Kg/cm^2	Orifice dia 4 mm outer tube length 100 mm	Orifice dia 4 mm outer tube length 30 mm
6	90.0	89.0
5	77.5	77.0
4	65.0	65.0
3	46.0	47.0
2	30.0	31.5
1	15.0	16.0

Thus practically there was no effect of outer tube length which could be kept of suitable size so as to accomodate blow off cock. The saturation curves for full and half open air inlet valve with 6 mm nozzle, 4 mm orifice diameter, 8 cm stand off and S-230 shots was plotted as shown in Fig. 3.

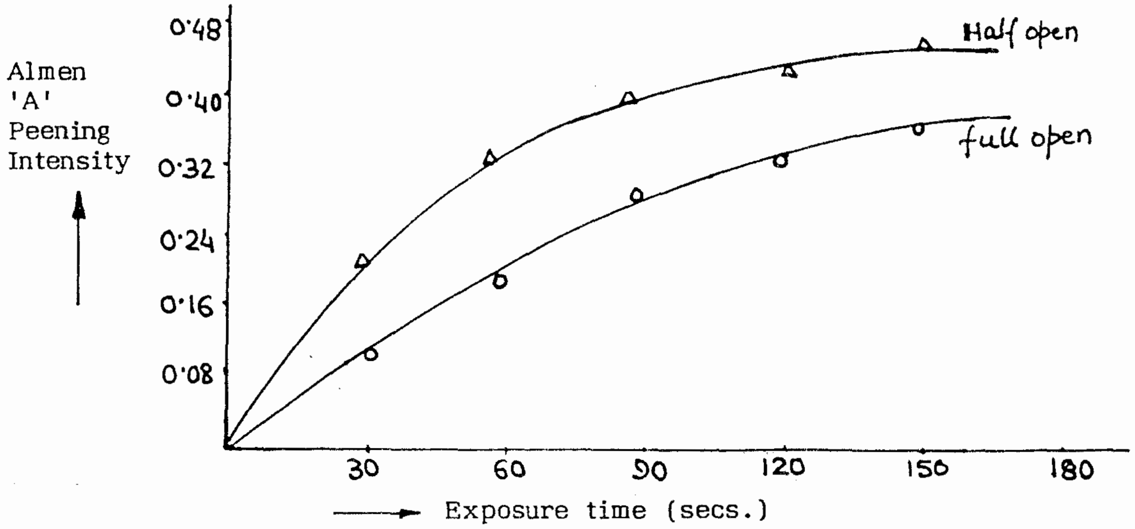


Fig.3 : Saturation curve with 4 mm orifice for full and half open air inlet valves.

Continued from page 30

Effect of Clearance Between Two Concentric Tubes

In order to account for resistance to flow of shots between two concentric tubes, first the clearance between two concentric tubes was kept lesser than orifice diameter. For 0.6 mm shots and 4 mm orifice diameter, the clearance was kept 3 mm, i.e. 0.75 items orifice diameter of shots. However, the clearance up to 3 mm did not allow proper flow of shots. Then clearance was made more than orifice diameter say 1.5 times the orifice diameter, then shot flow was found to be uniform. Thus it was concluded that clearance must be higher than orifice diameter to overcome the tube curvature resistance. Losses in mass flow due to rubber hose pipe length and nozzle was also noted at Table 1 (page 33). Using nozzle bore 6.0 mm shots S-230, orifice dia 4 mm, air valve opening half.

Results and Conclusions

In pressure peening system with manual control, the concentric tube type shot feed valve (mixing chamber) with orifice diameter 0.667 item nozzle bore gave uniform flow of shots. It gave higher arc height with lesser saturation time as compared to orifice diameter of 0.5 times the nozzle bore.

The clearance between the two concentric tubes should be equal to 1.5 times the orifice diameter and always more than 3 mm to provide uniform flow of shots.

Half opening of inlet air valve gave higher arc height and velocity of shots compared to full opening of air inlet valve. Saturation time for half opening of air inlet valve was lesser compared to full opening for same work piece material.

Thus mass flow control in a important aspect and manual control is difficult. Therefore automation in this regard can provide better controlled peening.

Acknowledgement

Authors are thankful to M.P. Council of Science and Technology, Bhopal, India, for providing research grants for the project "Impact Treatments and Newer Areas of Applications". This peening system was developed out of this grant.

Reference

1. Bosshard R.G., Baiker A.G., "Controlled Shot Peening, Complete Plants and Examples of Applications", Proc. ICSP3, p. 63.
2. Champaigne, Jack, "Measurement and Control of Shot Peening and Blast Cleaning Process".
3. Nadkarni, V.S., Sharma, M.C., and Sharma, S.G., "Syphonic Nozzle System for Glass Bead Peening of Aluminum Parts" Proc. Int. Conf. IITT on Titanium and Aluminum, Paris 27-28 Feb. 1990.

Free newsletter from Metal Improvement Company, Inc.

If you would like to receive *Impact*, a free newsletter from Metal Improvement Company, write or call:
10 Forest Avenue, Paramus, NJ 07652, (201) 843-7800.

Our apologies to the Metal Improvement Company, Inc. and our readers. In the last issue of The Shot Peener, the area code in the phone number for Metal Improvement Company was incorrect. We are sorry for any inconvience this might have caused.