

SOME ASPECTS OF MASS FLOW CONTROL OF SHOTS IN PNEUMATIC SYSTEMS

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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.

KEY WORDS

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

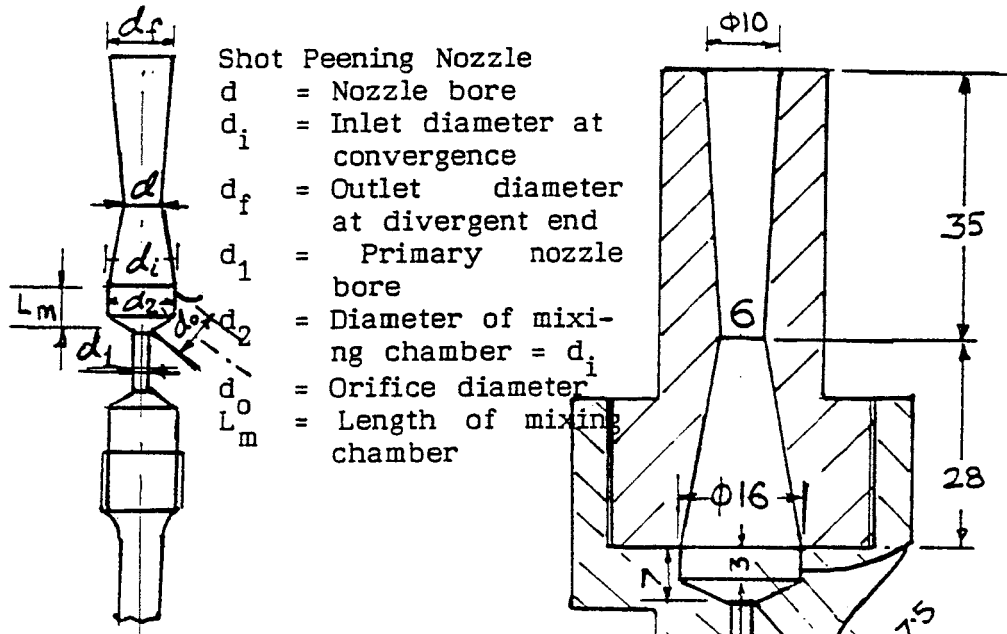
INTRODUCTION

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 other 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.

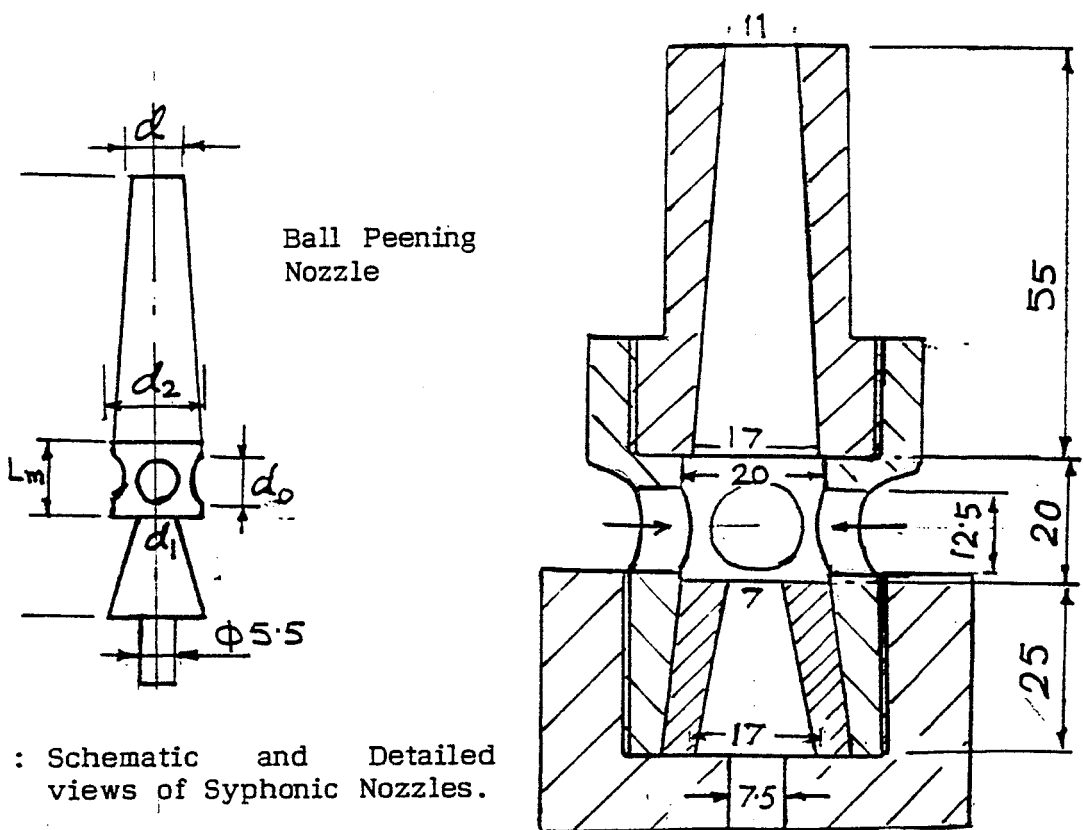
EXPERIMENTAL WORK

Syphonic nozzles for shot and ball peening were developed as shown in Fig.1. In the present investigation an attempt was made to correlate orifice diameter, nozzle bore and shot size for uniform flow of shots. As regards



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_0 = 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.

pressure peening orifice diameter plays 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 aspirated 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 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 the next page.

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 d_o = nozzle bore d = 6 mm
 - ii) Orifice diameter d_o = 0.75 d = 4 mm
 - iii) Orifice diameter d_o = 0.5 d = 3 mm
- Nozzle size used for mass flow study was about 6 times the shot size.

First model gave clogging of shots at all air pressures. Second model gave nonuniform flow of shots but better flow than first. Third model with $d_o = .5d$ gave still better mixing of compressed air and shots, however flow of shots through nozzle was still nonuniform. 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.

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 times orifice diameter of shots. However the clearance upto 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. Using nozzle bore 6.0 mm shots S-230, orifice dia 4 mm, air valve opening half:-

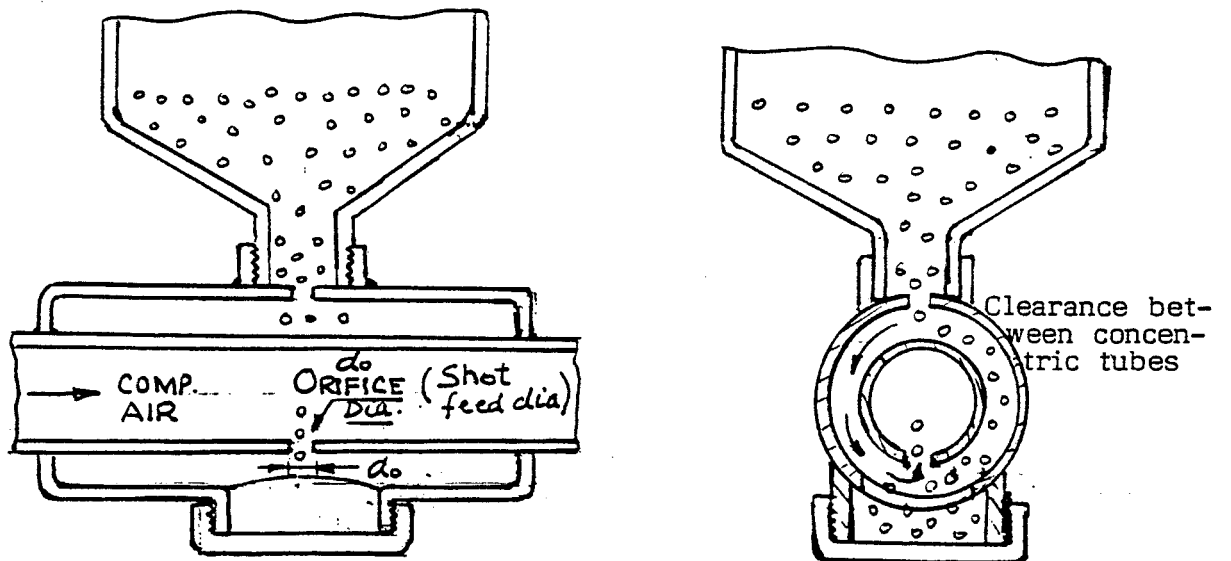
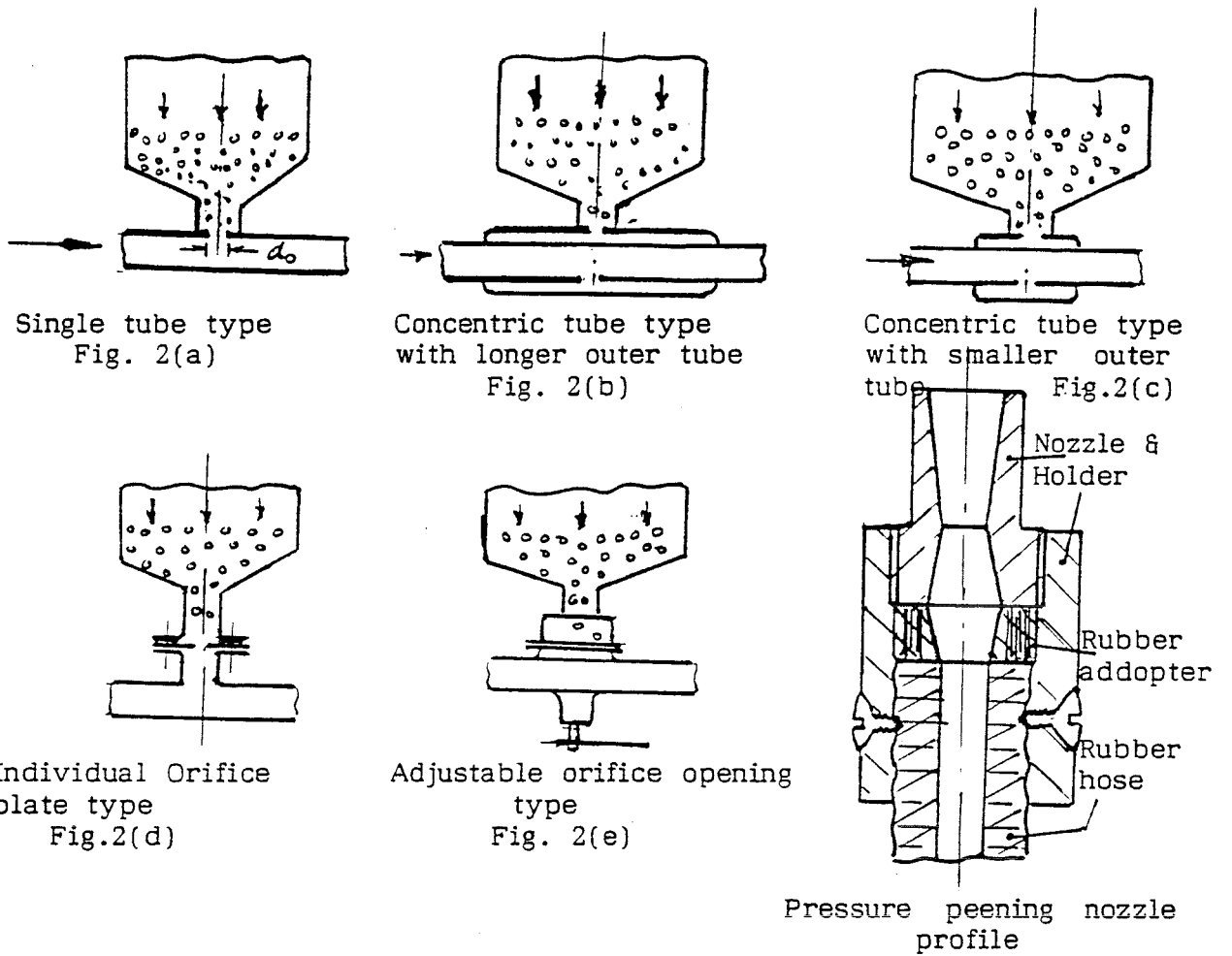


Fig. 2(f): Two views of concentric tube type mixing chamber

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	Orifice dia 4 mm outer tube
	tube length 100 mm	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.

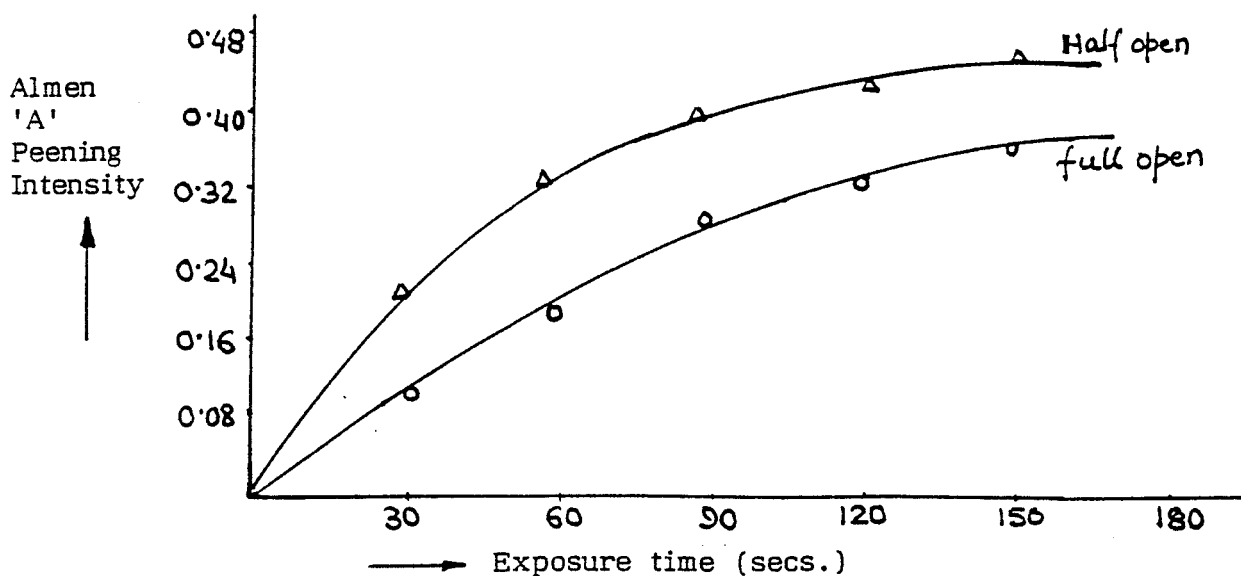


Fig.3 : Saturation curve with 4 mm orifice for full and half open air inlet valves.-

RESULTS AND CONCLUSIONS

In pressure peening system with manual control, the concentric tube type shot feed valve (mixing chamber) with orifice diameter 0.667 time 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 is an important aspect and manual control is difficult. Therefore automation in this regard can provide better controlled peening.

ACKNOWLEDGEMENT

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