PROPOSAL FOR ECONOMIC DESIGN OF SAND BLASTING EQUIPMENT FOR BLAST CLEANING

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ABSTRACT

The cleaning of the in process products is very significant & precious phenomenon, which requires special attention and care to get accurate dimensional, ethical and physical finish. One of these cleaning processes is the" Blast cleaning".

The process entail forceful direction of abrasive particles suspended in a fluid media against the surface of the product to be cleaned or to remove contaminants or to impart the desired finish. This process is known as “Sand Blasting” /“Grit Blasting” / “Shot Blasting” depending upon the type of abrasive used.

The proposed machine has been designed with a view to help the students to understand the concept of “Blast Cleaning and Shot Peening the Proposed machine is much more economic and easy to handle with less maintenance. The machine presently available in the market is costly economic only for large and continous use. It does not justify the sole purpose of demonstration on economic grounds. Therefore the proposed machine is very much suitable for the purpose of demonstration and light uses.

In the proposed type of equipment the sand used as the abrasive with the fluid media, so it is termed as sand “Blasting Machine”. This equipment finds utility in almost every sphere of manufacturing. The proposed design incorporates and utilizes both gravity and suction principle for feeding the sand, hence it has made the design and the fabrication of the equipment less compli-
cated and less expensive, with a longer life of nozzle of the blasting gun.

INTRODUCTION OF THE ABRASIVE BLASTING PROCESS

The Process entails forceful direction of abrasive particles dry suspended in a fluid media against the surface of metal part or product to remove contaminants or to import desired finished. The process is also called Sand Blasting, Grit Blasting, Shot Blasting depending upon the type of abrasive used. In our type of machine, we are using sand as the abrasive, and so it is termed as Sand Blasting Machine.

The various abrasives that can be used for blasting purpose are Steel shot, aluminium oxide, Silicon carbide, Glass beads, Walnut shell, Plastic Grit, Saw dust are used as blasting media. Selection depends upon type of surface, contamination to be removed, type of finish needed & required Production.

It is most important to recognize that blasting always produces a "Non-Directional" (isotropic) mate surface as opposed to a directional surface imparted by conventional polishing methods utilizing wheels or belts. Blasted surfaces are never highly reflective, but are of satin, matte and nonglaring type. Still there is no relationship between reflectivity and smoothness. A dull appearing blasted finish can be smoother than a bright or polished finish.

METHODS OF ABRASIVE BLASTING

There are basically three established ways of abrasive blasting. Induction-Suction, Direct Pressure and Wet blasting. These are briefly described below:

DIRECT PRESSURE

In this method abrasive is permitted in a pressure vessel by com-
pressed air forced to the nozzle. It imparts high abrasive velocity and blasting is faster. The direct pressure based machines operate with the help of compressed air. Air entering the system is first cleared into moisture separators. The clean compressed air is divided into two main parts. One part enters in pressure vessel or blast generator, seals it against any leadage by lifting and pressing a mushroom valve against an “O” ring. The second part of air is brought to a mixing tube where abrasive falling from the blast generator, gets mixed with its nozzle. Abrasive particle issues out of blast nozzle with great velocity and strike a solid surface removes from it any coating, corrosion product or a larger of work material itself. Used abrasives are cleaned up sieved and transferred to the ballast generator for a few seconds. Dust generated in the ballast cabinet as a result of blasting operation is collected in a dust operator

**INDUCTION-SUCTION**

In this method abrasive is drawn from hopper into the gun blast by a partial vacuum created by high velocity air flow. This is useful for light weight abrasive and cleaning of light corrosion. The induction suction type of blasting machine operates with suction principle of abrasive blasting. Compressed air is made to issue through an injector and render a nozzle. A vacuum is created through a hose to an abrasive storage. The suction effect due to the vacuum lifts the abrasive from its storage tank to the air re-entry point at the nozzle in the blasting gun to strike the surface to be blasted. Used abrasive and air is sucked in a reclaim, where the reusable abrasive is separated and re-circulated. Air dust mixture further passes in to a filter bag where the dust particles are trapped and air escapes to the atmosphere. A moisture separator provided in the machine cleans the air of any moisture or oil and thus protects the surface from any contamination. The induction-suction type machine works on induction-suction principle of abrasive delivery. This system ensures continuous working and no interruption in Blasting cycle, it is used
for light and medium size components where surfaces to be cleaned or debarred or to impart fine, matte finish. It is widely used for heat treatment shops, tools die, and mould makers and shot peening of light components etc.

**VARIOUS ABRASIVES USED IN BLASTING**

In blasting operation, the abrasive used will be substantially effect the result and cost of the operation. All these abrasives are available in coarse, medium and fine grades to suit the particular application.

<table>
<thead>
<tr>
<th>Abrasive Name</th>
<th>Type</th>
<th>Mesh</th>
<th>mm size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Chilled iron grit</td>
<td>Coarse</td>
<td>12-18</td>
<td>1.40-0.85</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>18-52</td>
<td>0.5-0.30</td>
</tr>
<tr>
<td></td>
<td>Fine</td>
<td>52-85</td>
<td>0.30-0.18</td>
</tr>
<tr>
<td>2. Chilled iron shot</td>
<td>Coarse</td>
<td>12-18</td>
<td>1.40-0.85</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>18-15</td>
<td>0.85-0.30</td>
</tr>
<tr>
<td></td>
<td>Fine</td>
<td>52-85</td>
<td>0.30-0.18</td>
</tr>
<tr>
<td>3. Glass beads</td>
<td>Coarse</td>
<td>12-36</td>
<td>0.85-0.42</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>36-60</td>
<td>0.42-0.25</td>
</tr>
<tr>
<td></td>
<td>Fine</td>
<td>72-150</td>
<td>0.21-0.10</td>
</tr>
<tr>
<td></td>
<td>Very fine</td>
<td>100-350</td>
<td>0.15-0.04</td>
</tr>
<tr>
<td>4. Aluminium oxide</td>
<td>Coarse</td>
<td>12-18</td>
<td>1.40-0.85</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>18-25</td>
<td>0.85-0.18</td>
</tr>
<tr>
<td></td>
<td>Fine</td>
<td>85-115</td>
<td>0.18-0.07</td>
</tr>
<tr>
<td>5. Silicon carbide</td>
<td>Coarse</td>
<td>12-18</td>
<td>1.40-0.85</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>18-25</td>
<td>0.85-0.18</td>
</tr>
<tr>
<td></td>
<td>Fine</td>
<td>85-220</td>
<td>0.18-0.07</td>
</tr>
<tr>
<td>6. Walnut shell</td>
<td>Medium</td>
<td>18-30</td>
<td>0.85-0.50</td>
</tr>
<tr>
<td>7. Plastic grit</td>
<td>Acrylic</td>
<td>18-30</td>
<td>0.85-0.50</td>
</tr>
<tr>
<td></td>
<td>Urea</td>
<td>18-30</td>
<td>0.85-0.50</td>
</tr>
<tr>
<td>8. Sand (Silica)</td>
<td>Etc.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
WORKING PRINCIPLE

Air is forced through a cross-section area, which creates a low pressure (partial vacuum). Now according to Bernoulli's principle whenever there is a difference in pressure head, the tendency of matter is to low from high pressure to low pressure to maintain static equilibrium.

Another method for feeding which can be used is by using the force of gravity. Gravity feed ensures free flow of abrasive to the blasting process.

In a simple gravity mode, the air fails to carry the abrasive particles with it and there is a non-uniform flow of abrasives which makes the blasting process unsuitable.

As already discussed, in a suction mode, minor variations (errors) in the design may render the entire process ineffective due to its inability to create vacuum.

Therefore, we have devised our machine to be a combination of both gravity feeds as well as suction principle. This has made the process more effective and hassle free eliminating most of the design complications. In our system of blasting, we ensure a gravity flow by keeping the gun in an inclined position. The sand falls automatically to the chamber and a partial vacuum is created by the suction principle. This imparts a swirling motion to the air-sand mixture in the chamber which helps in formation uniform mixture. This enrich mixture of air and sand is then forced through a nozzle. This augments the velocity of air sand mixture at the desired level of output and is then impinged on the workpiece.

COMPONENTS OF SAND BLASTING MACHINE

The sand blasting machine consists of following parts:

1. Blasting gun
2. Blast area or enclosure
3. Abrasive and air feeding system
4. Air compressor
BLASTING GUN

The blasting gun consists of the following three parts;

* Gun body
* Back cover plate
* Nozzle

**Gun Body**

This has been designed for streamline flow. The gun body could have been made of rectangular cross section. But due to inherent drawback associated with design, we modified the inner contour. The sharp corners in a rectangular cross section prevents the swirling of mixture and turbulence will be created at the corners which would hamper streamline flow. So, we opt for reshaping the corners and rounded the sharp corners. The problem still existing with the present design is that sand would get accumulated around the nozzle periphery which would again prevent the free flow. The design was further improved so that the contour fits the contour of outlet nozzle exactly. The dimension of the gun body were approximated according to the dimensions of the nozzle.

**BACK COVER PLATE**

The back cover plate has two functions, firstly it helps in sealing of hole chamber, secondly it acts as coupling of the feeding systems. Two holes are provided on the back plate, which have extensions at the read side for fastening of the pipes. Larger pipe has an internal diameter of 3/4 inch. Which is used for feeding the sand to the gun chamber. The other pipe of internal diameter 1/2 inch carries the compressed air to the gun chamber. On the other side of the back plate, an injector (protruding pipe) of length 20mm and internal diameter 8mm is casted. This helps in directing the compressed air to the nozzle, thereby providing ann area for suction also.

**NOZZLE**

It is used to increase the velocity of air-sand mixture. The nozzle is designed according to velocity required at the outlet and the air velocity available at the inlet.
BLAST AREA OR ENCLOSURE

It is a cuboidal box. It consists of a door for placing the work piece on the mesh. This has been provided for retrieval of the abrasive. On the front side, a square glass hole is provided for proper viewing of the blast process and the job. The gun is held in the left hand and the job can be manipulated by right hand if required.

At the top of the box, a hopper is provided which is used to store the abrasive particles. A control valve is provided on the hopper to regulate the flow of the sand (abrasive). The mesh has been incorporated as an alternative to a perforated sheet, which is expensive to fabricate.

ABRASIVE AND FEEDING SYSTEM

The sand feeding is done by a hopper attached with the blast enclosure, pipe of diameter 3/4 inch has been provided to convey the abrasive (Sand) from the hopper to the gun chamber. Clips have been provided to make the connections leak proof. The air feeding system has pipes, which carry pressurized air from the compressor to the gun body. Clips have been provided to maintain air tightness.

AIR COMPRESSOR

The blasting machine requires dry, moisture free and oil free compressed air. The air compressor to suitable capacity is needed for the proper functioning of the entire blasting system. The air pressure required from the compressor is around 4 to 7 Kgf/Cm*. The compressor required for our blasting purpose is provided by the collage. The compressor can provide that much and hence suitable for our blast cleaning.

PRELIMINARY DESIGN AND LAYOUT OF MACHINE AND BLASTING GUN

The type of machine that we have designed is a suction-cum-gravity feed kind of sand Blasting machine. The foundation for
our design that we have made use of is the morphological process of design. The steps involved in morphological design consists of in the first place need identification and concept generation. It was found that the design features and the mechanism used in the present machine are costly. This was the genesis of our design. Then a feasibility study was done and it was found that the scope of a cheaper Blasting machine is far than the present machines. Then in the stage of preliminary design we thought of various mechanisms and design features which would remove the complicacies. Finally detailed design was carried out, which is explained in the following pages.

During the entire process of preliminary design preparation, we studied the various processes that can possibly be incorporated during the Blasting of a product. After having analyzed all the processes (suction, direct pressure, gravity) with their pros and cons, we have finally made use of suction cum gravity feed system.

**CALCULATIONS FOR THE NOZZLE**

We know that for air

- Specific heat or constant pressure \((C_p)\) = 1.005 KJ/Kg.K
- Gas constant \((R)\) = 0.287 KJ/Kg.K
- Adiabatic constant \((Y)\) = 1.4
- Pressure available from the compressor \((P_o)\) = 6 bar
- Temperature \((T_o)\) = 300 K

For duct,

- Velocity \(C_1\) = \((YRT)^{1/2}\)
- Pressure at outlet \(P_1\)
- Temperature \(T_1\)
- Temperature \(T_{o_1}\)

Calculating \(C_1\), \(P_1\), \(T_1\):

Therefore after putting values

- \(T_1 = 250K\)
- \(C_1 = 316m/s\)
- \(P_1 = 3.168\) Bar
This is the input to the nozzle. The same formulae for the duct are applicable for calculating the throat parameters of the nozzle.

Mass flow rate (m) = 0.06 Kg/s
Pressure at throat (P₁) = P₁(0.528) = 1.673 Bar
Temperature at the throat (T₁) = T₁(2/2.24) = 208.3 K
Velocity at the throat (C₁) = \[C₁^{2} + 2000\]
\[Cₚ(T₁ - Tₖ)\] = 429 m/s

Specific volume (V₁) = \(\frac{RT₁}{P₁} = 0.357 \text{M}^3/\text{Kg}\).
Area at throat (A) = \(mV₁ / C₁ = 50.34 \text{mm}^2\)
Area = \(3.140 \text{R (PIE)} / 4D₁^2\)
Diameter of throat = 8mm
Temperature at outlet (T₂) = 125K
Velocity at outlet (C₂) = 44.72 \(\text{Cₚ(T₁ - T₂)}\) = 500 m/s

We know that \(T₁ / T₂ = (P₁ / P₂)^{(y-1)/y}\)
Therefore, \(P₂ = 0.28 \text{ bar}\)
\(V₂ = \frac{R T₂ / P₂ = 1.28 \text{m}^3/\text{Kg}}{2}\)
Area at outlet \((A₂) = mV₂ / C₂\)
\(A₂ = 151 \text{mm}^2\)
Hence \(D₂ = 13.08 \text{mm}\)

**FABRICATION OF THE MACHINE**

**MANUFACTURING OF THE BLASTING GUN BODY**

The process selected for manufacturing the gun body is fabrication and the material for gun body is selected to be mild steel. First a hollow cylindrical piece of outer diameter of 10cm and internal diameter of 2cm and a height of 10cm is taken and faced both sides of the cylinders so that length of the cylinder is 7.2cm.

Then the outer surface is turned to a diameter of 9.4 cm. A length of 2cm is turned to a outer diameter of 6.1 in order to specify the cap end of the gun body. The material between the cap end and the back plate is then taper turned. The cap end to the gun body is threaded to accommodate a mating cap used to hold the nozzle firmly. The next process is to internally taper
turn the cylinder so that the diameter at the cap end is 6.1 cm and internal diameter at the back plate end is 6.4 cm. Four threaded holes on the back cover side of the gun body are drilled in order to tightly screw the back cover plate to the gun body. The diameter of the holes is 0.7 cm. A small threaded blind hole is made on the outer tapered surface of the body to screw the mild steel handle to the body.

**MANUFACTURING OF BACK COVER PLATE**

The method selected here is fabrication. A disc 1 cm thick and a diameter of 9.5 cm is taken and faced on both sides of the disc so that its thickness is reduced to 0.85 cm. The disc is turned to a diameter of 9.4 cm. Four holes are drilled by appropriate marking so that these holes come concentric with the threaded holes in the gun body. Two holes are then drilled in the disc of diameter 1.2 cm. Then tapped these holes to fasten the extension of which the hoses will be fitted.

**MANUFACTURING OF THE NOZZLE**

Process involved here too is fabrication. For the nozzle the material taken is mild steel. A hollow cylinder to internal diameter of 1.2 cm and external diameter of 3 cm and length of 5.8 cm is taken and faced on both sides of this large collar of thickness 0.6 cm both smaller collars are tapered to make the assembling easy.

The convergent side of the nozzle is taper turned on the internal side from which the distance of the collar was fixed. The throat of the nozzle is just at the base of the collar. The job is then reversed on lathe and taper turning of the divergent side of the nozzle on the remaining length of the nozzle is done.

**MANUFACTURING OF THE NOZZLE CAP**

Nozzle cap again is manufactured with the help of fabrication. The starting of the process was made with a hollow piece of internal diameter 3.4 cm and external diameter of 5.7 cm. Which
is then faced off on both the ends to limit the length of the cap to 2cm. The cap is then turned to an external diameter of 5.6cm. The job is bored to a length of 1.6cm so that the thickness of the cap at this end is 0.35cm. This length is then threaded to match the threads on the cap end of the gun body. Finally the outer surface is diamond curled to facilitate the screwing and unscrewing of the nozzle cap on the gun body.

**APPLICATIONS OF ABRASIVE BLASTING MACHINE**

The various applications of abrasive blasting process are:

* To remove heat treat scale, rust, corrosion and paint
* To remove residual film from moulds and dies.
* To remove slag, oxides and discoloration from weld joints
* For cleaning and deburring of ferrous and non ferrous castings
* To produce decorative matte or satin finish.
* To produce surface ideal for lubrication retention.
* To improve metal wear, finish and appearance
* To prepare surface for pre-plate and pre-anodize.
* Shot peening for producing residual compressive stresses.
* To improve strength, fatigue life and reduce corrosion.
* Shot peening blades, gears, springs and transmission components.

**ECONOMIC JUSTIFICATION**

The equipment finds utility in almost every sphere of manufacturing. The high cost associated with the machine available in the market makes it economically infeasible for a small scale industry to use it. A less competitive market exists in this field and this is the major cause of the high cost of the machine. The major cost contributor in manufacturing of the machine are the cost of the nozzle, which is so designed so as to have high resistance to corrosion and wear, cost of enclosure and cost of
gun. The machine available in the market is solely based on induction-suction principle. Hence, the gun chamber needs to be designed with very accurate and specific contours, making the gun very expensive. The manufacturer also charges for its technical know-how of the machine. The design incorporated by use utilizes both gravity and suction principle for feeding the sand. Hence it has made the designing and the fabrication of the gun chamber less complicated and cheap.

**COST COMPARISON**

The machine using tungsten carbide nozzle has an approximate life of 100 hrs. On the other hand, the machine using mild steel nozzle has an approximate life of 4hrs. The rough estimate of cost of the machine available in the market with the reclamation unit and the blast enclosure is approximately around 70,000 to 100,000. The machine designed by us consists of simple design aspects of the gun chamber. This leads to simple fabrication and thereby low cost of machine. The cost incurred in our project are follows:

a. Fabrication Rs. 2,500  
   b. Mild steel nozzle Rs. 300  
   c. Blast enclosure Rs. 200 

This was a demonstrative model and does not incorporate all aspects of practical design. If we use Tungsten carbide lining in the gun chamber, the cost of our machine will roughly amount to Rs.25,000 to Rs.30,000.

**CONCLUSION**

After the entire design and manufacturing of the machine, we have finally come up to with the design which add to the present machining and cleaning operations. The machine we have prepared is a demonstrative model which when produced commercially can yield good results. Ours is an attempt to add value to the machine used presently for sand blasting. Our design in comparison with the machines available in the market is simpler and
less problematic functionally. In small-scale industries, even the mild steel nozzle may be used and it would be more feasible than the Tungsten carbide nozzle. We feel that there is immense scope for sandblasting machines. The model made by use can be used for study purposes by students to get an overview of entire blast cleaning procedure.

REFERENCES
5. Pandey A. K., Jain P.Soni and Singh H. “Project report on sand blasting machines”