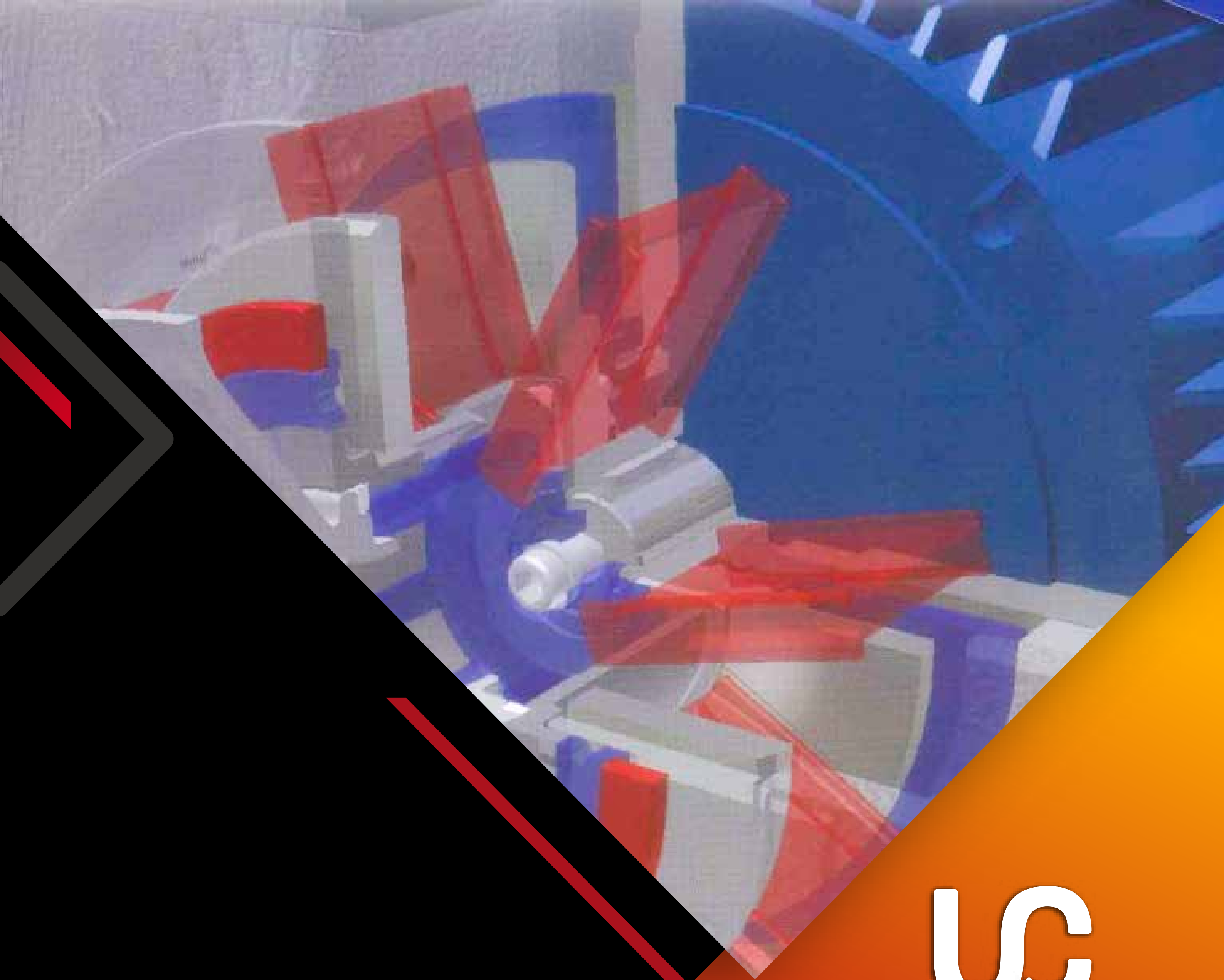

Ümit Döküm

Shot Blasting Machines Maintenance Manual

Ümit Döküm İthalat İhracat ve Ticaret Ltd. Şti.
www.umitcasting.com

Foreword

Our company is acting in foundry industry since 1992. By means of evaluations of the requests that are made to our company concerning the wheel spares that we are producing, we observe that problems arise from wrong utilization or improper maintenance in general. Just like symptoms observed on the surface of the skin which is caused however by an interior illness of human body, problems in blasting machines appear as fast wear or breakage of turbine spares.

This manual has been prepared on the basis of our experiences in shot blast industry and our technical expertise. Purpose of this manual is to supply information to management and technical personnel working in several industrial areas.

We wish this manual will be helpful for our valuable customers.

Ümit Döküm

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SECTION 1

UMIT CASTING FACILITY AND PRODUCTION TECHNOLOGY

CONTENT

This section consists of information about Umit Casting facility, production technology and product range.

1.1. GENERAL INFORMATION

1.1.1. MACHINERY, EQUIPMENT AND PRODUCTION KNOWLEDGE

All machinery, equipment and production knowledge is unique to our company. Production knowledge covers metallurgical knowledge, process and quality control application of all foundry production.

1.1.2 ORGANIZATION

A functional organization has been established together with emphasis on specialization and experienced personnel have been employed.

1.1.3 RAW MATERIALS

Raw materials are obtained in the frame of international quality standards from domestic and international markets and being subjected to a tight and sensitive quality control.

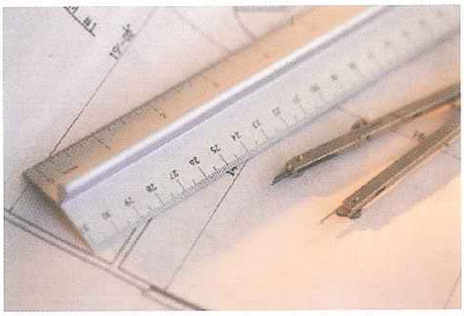
1.2 FOUNDRY PRODUCTION TECHNOLOGY

By means of two induction furnaces having capacity of 500 kg and 350 kg, stainless steel, medium carbon, high carbon and nodular iron casting productions are being carried out in our foundry. Depending on customer demand, we are also able to deliver machined cast parts. Our molding method is consisted of conventional molding, cold box, CO2 process and manual molding. After preparation of proper sand mixture and necessary cores, molds are prepared and sent to casting area. Heat samples, taken from induction furnaces, are analyzed by using optical spectrometer and casting is carried out if heat analyze is approved. Molds are opened after solidification and cast parts are transported to shot blasting machine. After shot blasting, cast parts are transported to fettling area to remove runners and feeders. Fettled parts are subjected to quality control. After dimensional controls and possible casting defect controls are carried out, heat treatment is applied to cast parts according to their chemical compositions. After heat treatment, final controls and compatibility control with other parts are done. The blades of shot blasting machines are weighed and balanced with 1 gram and packed in sets.

SECTION 1

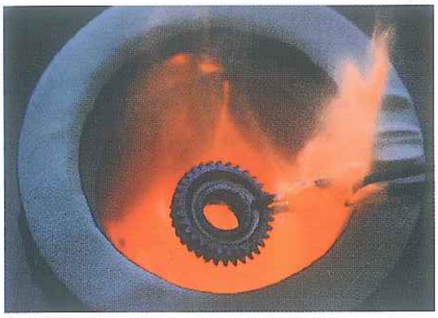
UMIT CASTING FACILITY AND PRODUCTION TECHNOLOGY

Technical drawings or samples supplied by our customers are evaluated by our technical team. Material type which fulfils requested technical specifications (such as strength, corrosion resistance, heat resistance, frictional resistance, etc.) is determined. Production process is determined by our engineers (casting, heat treatment, machining)



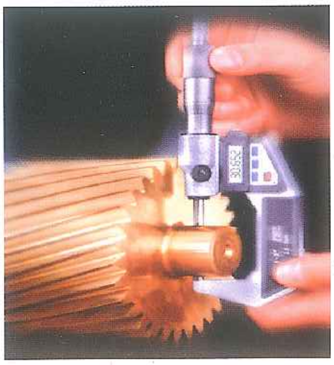
As a solution partner, first of all, we make a virtual molding design by using computer. After approval of design by our engineers, very highly sensitive machining is done by using a modern 5 axis CNC machine to produce molds.

Sand molding is done by using modern molding presses. Requested chemical specification is guaranteed by using spectral analysis machine.



Heat treatment is applied to remove residual stresses and to reach requested hardness and impact resistance.

After final quality control is finished, products are delivered together with quality control and technical reports.



1.3. QUALITY CONTROL IN UMIT CASTING

In Umit Casting, Quality Control Group Manager is responsible from quality control and laboratory activities. Production ability of requests from our customers is evaluated by Production Department. If production is approved and order is confirmed, depending on the application area of finish product, casting, machining and heat treatment instructions are prepared. During production, whole stages of production are controlled by quality control personnel and cast pre inspections, semi and finish product inspections are done to assure conformation of production instructions.

Samples, taken during several stages of production, are tested by laboratory in compliance with related standards and according to special customer requirements. Results are evaluated by Quality Assurance Manager and only those products which are approved in accordance with order and utilization purposes are dispatched.

In our laboratory, consisting of chemical analysis, mechanical testing, metallographic and heat treatment sections all metallurgical tests are carried out using modern equipments.

Quality Assurance Management also assists and coordinates with Technical Service Department to detect customer problems on site.

1.4. PRODUCTION PLANNING AND CONTROL

1.4.1. PRODUCTION PLANNING

Production is made on the basis of customer orders so that foundry, machining and heat treatment lines should be synchronized carefully. Main task of production planning and control system is to make sure that customer orders should be delivered on time.

1.4.2. PRODUCTION RECORDS

Records of every stage of production are kept on the basis of heat and orders. All production data are converted into reports so that in case of any request from customers, it is possible to reach every detail.

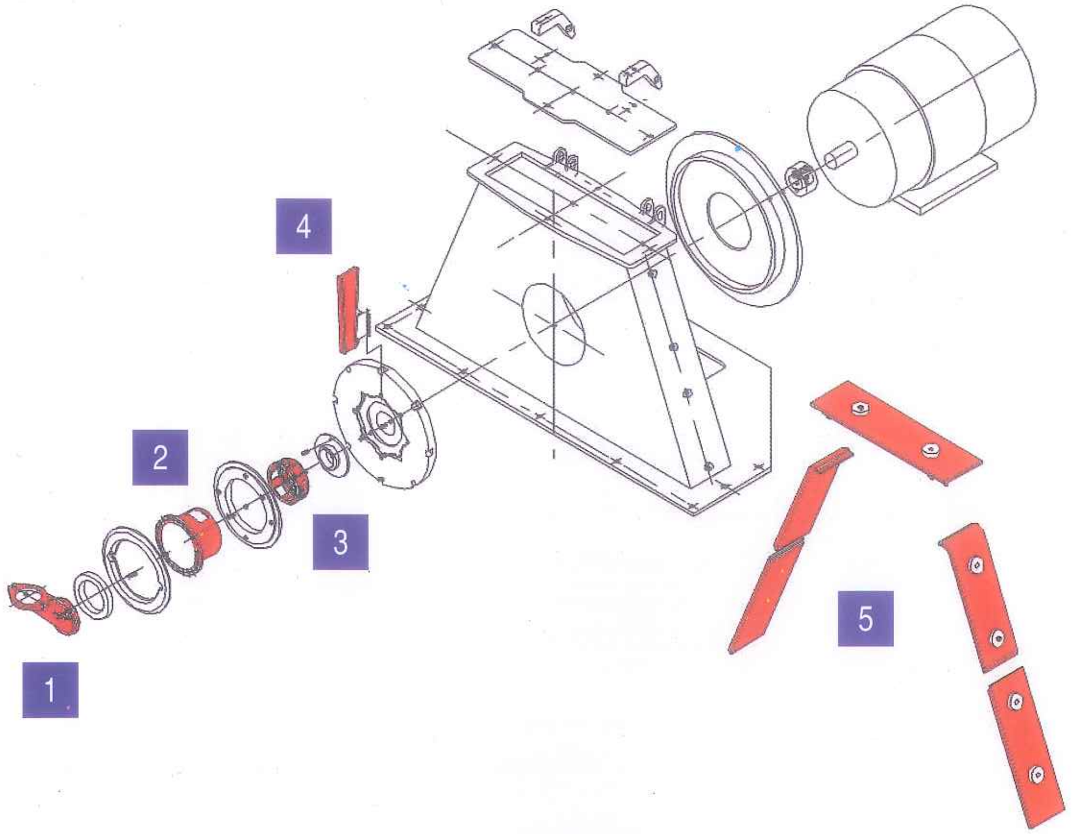
BÖLÜM 1

UMIT CASTING FACILITY AND PRODUCTION TECHNOLOGY

1.5 UMIT CASTING MATERIAL RANGE

STAINLESS STEEL	1.4301	X5CrNi18-10	304	
	1.4833	X12CrNi24-12	309 S	
	1.4841	X15CrNiSi25-20 X15CrNiSi25-21	310 / 314	
			310 W	
	1.4401/ 1.4436	X5CrNiMo17-12-2 X5CrNiMo17-13-3	316	
	1.4571	X6CrNiMoTi17-12-2	316 Ti	
	1.4404/ 1.4435	GX2CrNiMoN18-10	316 L	
	1.4541	X6CrNiTi18-10	321	
	1.4460	X3CrNiMoN27-52	329	
	1.4006	GX12Cr13	410 (CA 15)	
	1.4021	X20Cr13	420	
	1.4016	X6Cr17	430	
	1.4113	X6CrMo17-1	434	
	1.4762	X10CrAl24 X10CrAlSi25	446	
	1.4865	GX40NiCrSi38-18		
	1.4852	GX40NiCrSiNb35-25		ASTM ST 37
MEDIUM CARBON STEEL	1.0037			
	1.0443 1.0446	GS 45		
	1.7225	GS-42CrMo4	4140	
HIGH CARBON STEEL	1.2601			
	1.2602			
	1.2291			
	1.3344.3			
HIGH ALLOY IRON				NIHARD - 1
				NIHARD - 2
				NIHARD - 3
				NIHARD - 4
		GX300CrMo15-3		TEMPER (15Cr3Mo)
				BF - 204
NODULAR IRON		GGG 40	60 - 40 - 18	ASTM A 536
		GGG 50	65 - 45 - 12	ASTM A 536
		GGG 60	80 - 55 - 06	ASTM A 536

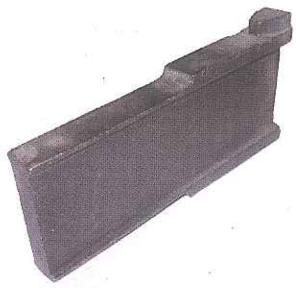
1.6 Product Range



(1) Feed Funnel

(2) Cage

(3) Impeller



(4) Blade

(5) Cover

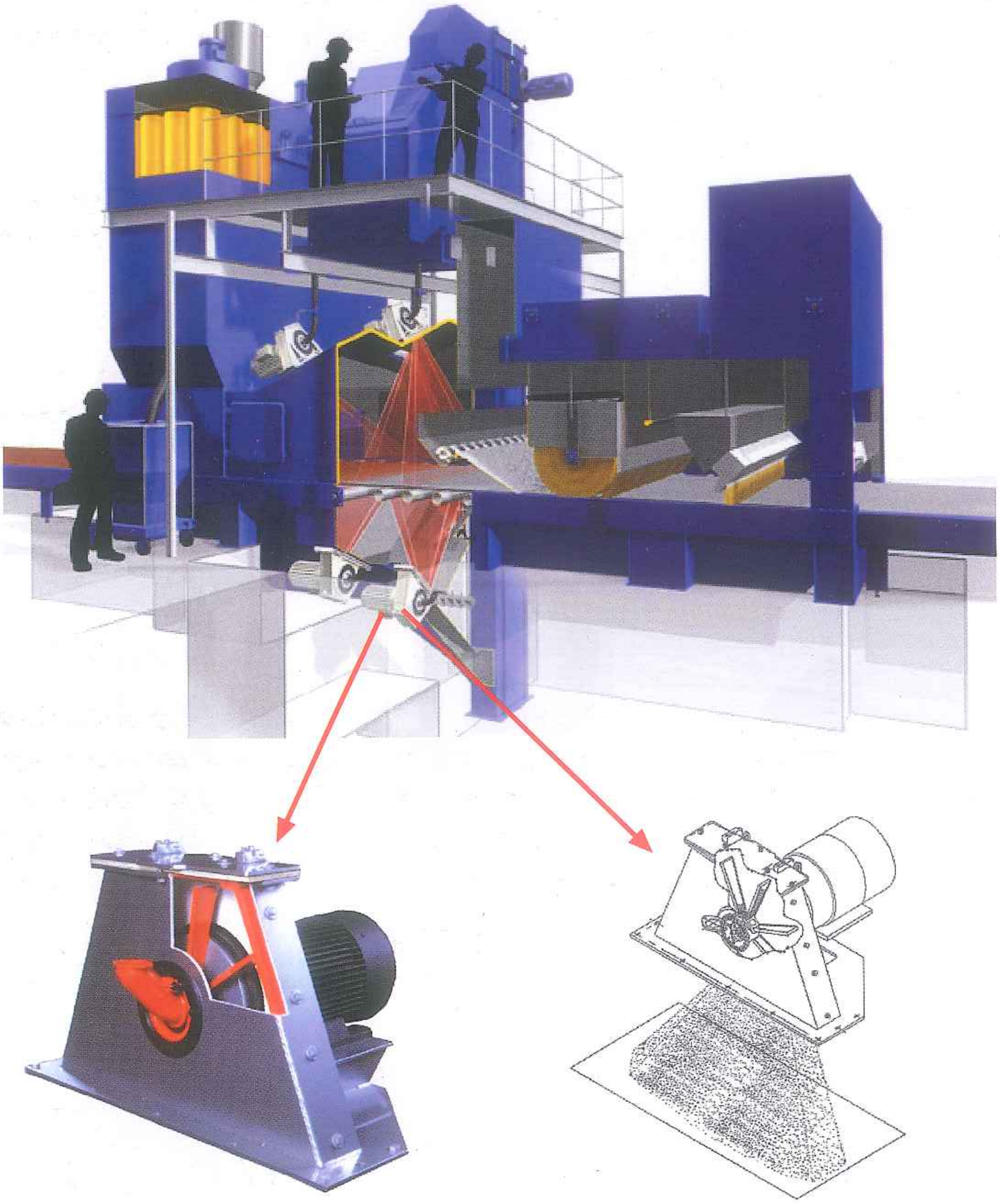
(6) Liner Plate

SECTION 2

SHOT BLAST MACHINES

2.1. GENERAL INFORMATION

Shot blasting consists of attacking the surface of a material with one of many types of shots. Normally this is done to remove something on the surface such as scale, but it is also done sometimes to impart a particular surface to the object being shot blasted, such as the rolls used to make a 2D finish. The shot can be sand, small steel balls of various diameters, granules of silicon carbide, etc. In general blasting is done by means of a centrifugal wheel that propels media.



(Figure 1) Shot blast machine and wheel.

Red colored parts in the figure should be made of wear resistant materials.

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Another method of blasting is to use air nozzles. However centrifugal wheel systems are being utilized more frequently. This can be explained by. following example; by using a wheel of 56 kW, a steel ball can be propelled with a speed of 73 m/s. This means a mass flow rate of 55800 kg/h. Under the same conditions, by using an air gun having a nozzle of 13 mm diameter, mass flow rate of steel shot is 2700 kg/h. This means one centrifugal wheel equals 20 air nozzles (20 X 2700 = 54000 kg / h) Considering air requirement of a nozzle is 0.120 m3 / h, total air requirement for 20 nozzles is 20 X 0.120 = 2.45 m3 / hrs (550 kPa) In order to obtain this air flow rate, energy requirement will be 700 kW. If we compare energy requirements of air nozzle and centrifugal wheel we see that, centrifugal wheel is operated 12.5 more efficient to air nozzles (700 kW / 56 kW)

Under these circumstances, it can be considered that air nozzles should not be used. However air blasting has its own advantages, such as parts that are too big to be placed into a blast machine, site works, ability to blast small holes, low first investment cost, mobility, ability to use of abrasives having very high hardness (Al_2O_3)

2.2. BLAST WHEEL MACHINE TYPES

Below mentioned criteria should be considered before choosing a blast machine.

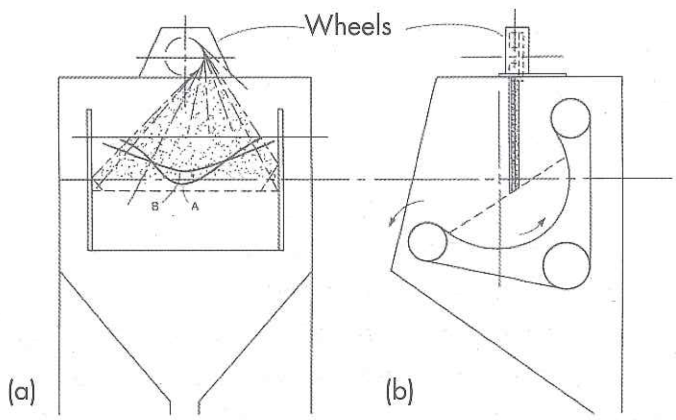
- Production requirements (such as continuous single type part production)
- Complexity of part.
- Tumbling ability of parts.
- Dimensions of part, shape and weight.

2.2.1. TUMBLE BLAST MACHINE

This type of machine is used for small and medium sized parts. Parts should be able to tumble. Most frequent type is cluster tumbling type (Figure 2 and Figure 3). Interior chamber volume is between 0.028 and 2.2 m3, however in general, it changes from 0.028 to 0,34 m3. This type of machine is generally used for shot blasting of small parts having weight of 11 - 45 kg. However heavy type tumble machines can blast parts having weight 230 - 400 kg. A belt turns around 3 rollers resulting in rotation of a virtual drum and steel shots are propelled from upside onto the parts.

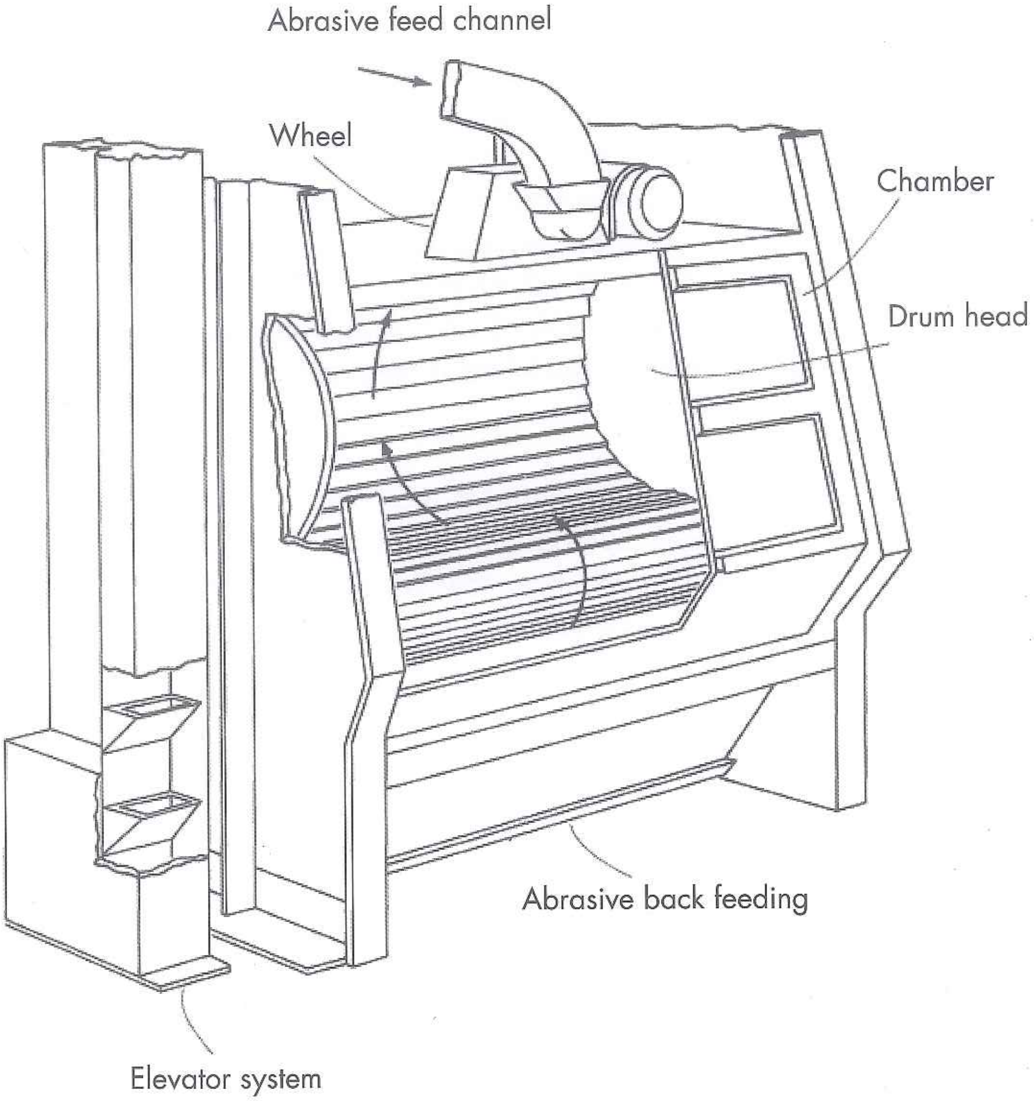
(Figure 2)

Sketch of a tumbling machine working principle. (a) front view (b) side view. Two different adjustments are possible; A is powerful in short area, B is powerful in long area.

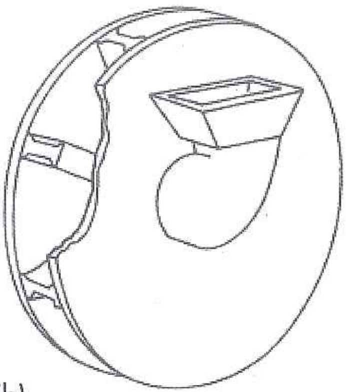


SECTION 2

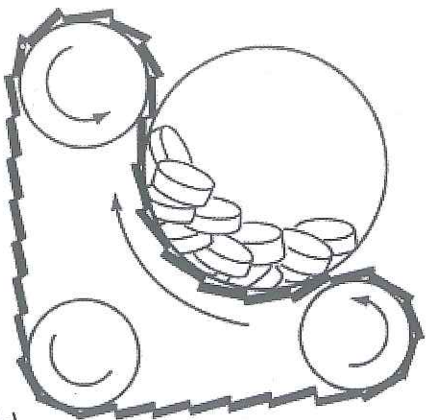
SHOT BLAST MACHINES



(a)



(b)



(c)

(Figure 3)
(a) Schematic diagram of tumbling shot blast machine.
(b) Wheel.
(c) Rubber belt conveyor system.

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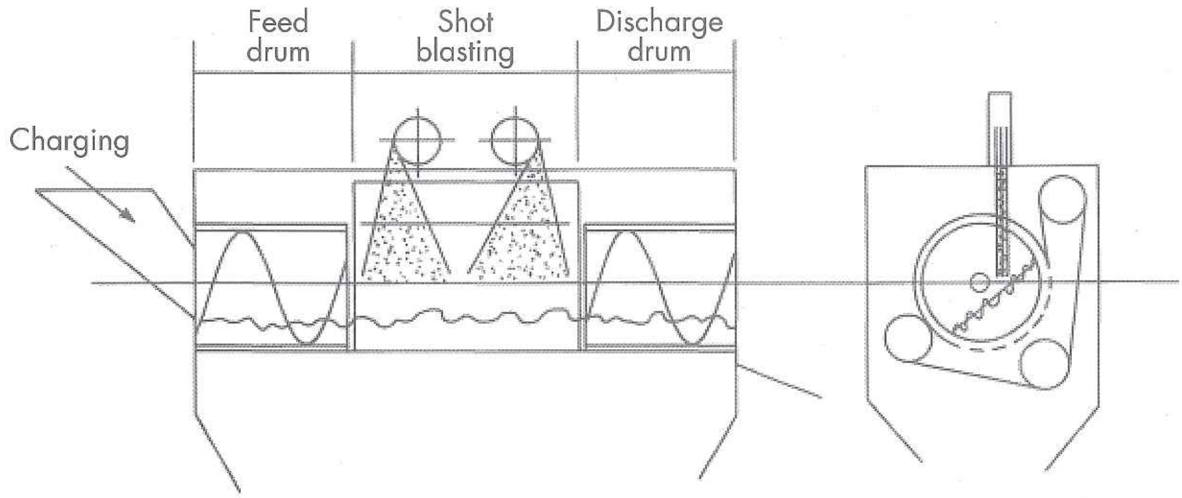
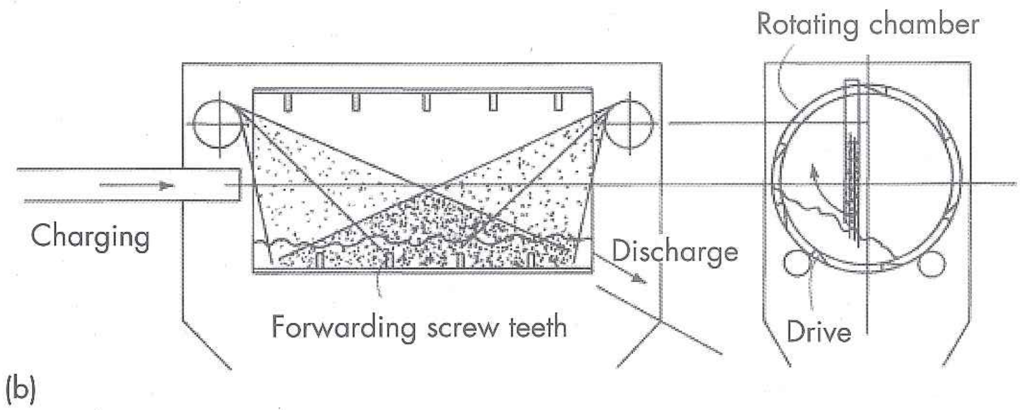
2.2.2. CONTINUOUS DRUM TYPE

Structure and working principle is similar to tumbling type. Only difference is charge and discharge operations are done without stopping the machine. Parts are charged from one end to belt and discharged from other end. Generally there are 3 types of continuous drum machine. The oldest type is rubber belt type (Figure 4)



(Figure 4) Internal charging type continuous drum machine

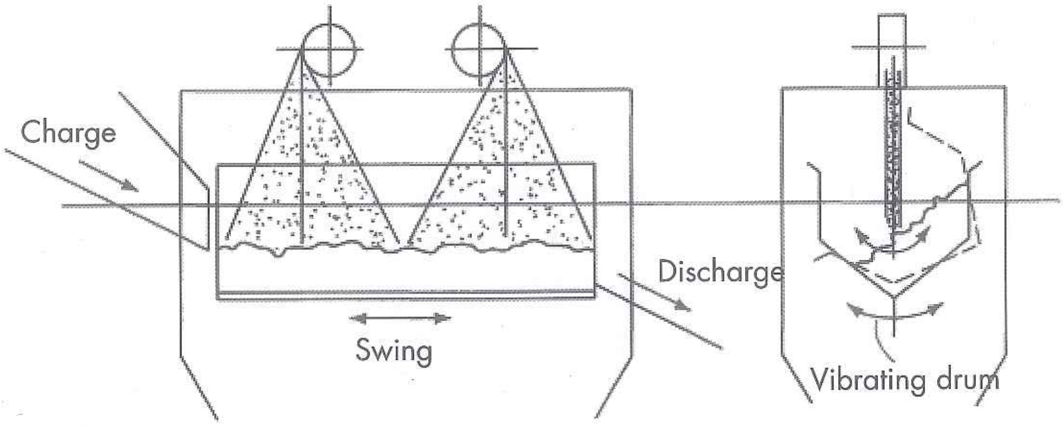
A new type (Figure 5) is chamber type. Driving gears at the bottom of chamber, rotates chamber by means of notches outside of chamber. In the meantime wheels positioned on the open sides of chamber shot blasts the parts. In this type, length of chamber should not be too long; otherwise blast angle becomes too small causing in reduction of blasting efficiency. This type allows blasting of all the bed. Forward movement is obtained by helical screw gear.



(Figure 5) Chamber type tumbling shot blast machine

SECTION 2
SHOT BLAST MACHINES

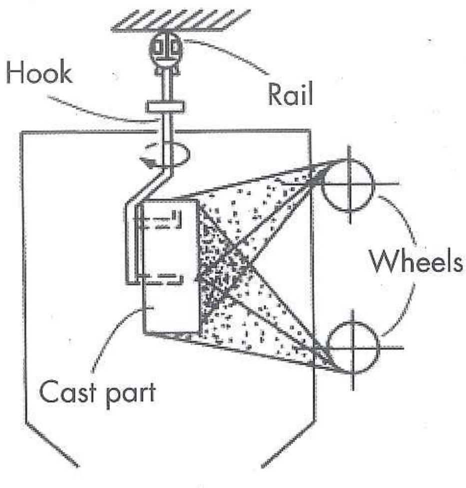
The newest type is shaker type (Figure 6) In the interior of machine there is a hexagonal chamber. This chamber is shaken from bottom and movement of parts is obtained whilst shot blast is applied by wheels located on the top openings. This type is more suitable, because it occupies less space and position of wheels result in higher efficiency.



(Figure 6) Shaker type tumbling machine

2.2.3. SPINNER HANGER TYPE

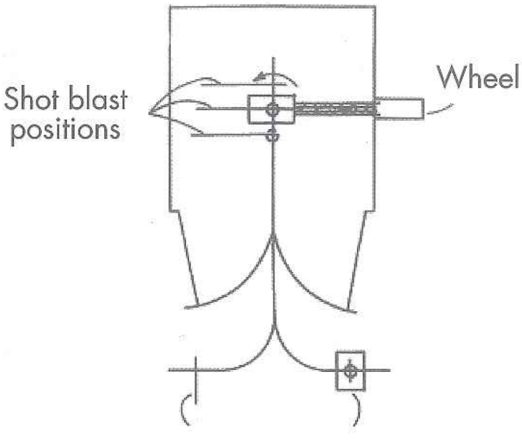
Wheels are stationary; therefore cast parts are needed to be rotated around themselves to be able to shot blast each side the castings. In tumbling types, this is obtained by means of rolling of cast parts, but most of the cast parts are not suitable for rolling. Especially if there are runners and feeders on the cast parts, rotating becomes more difficult. In that system hook turns around itself in front of the wheel and each side of cast parts are shot blasted. (Figure 7)



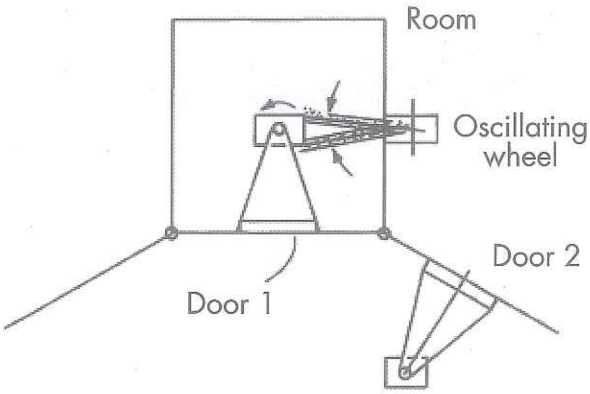
This machine has several other types. Under low production condition (20 - 30 hook / h) maximum weight of cast part is 2700 kg. For the type which has simple charge and discharge (Figure 8), cast parts enter into blast room by means of rail B and exist by means of rail A. Parts to be shot blasted are sequenced on rail B and enter to blast room one by one. Hangers may enter to room manually or automatically.

(Figure 7) Front view of monorail 360 degree rotating hook type blast machine

Another type is with 2 doors (Figure 9). This type has 2 doors and there are stationary rotating hooks on the top of the doors. Whilst cast part is being shot blasted which is hanged on the hook in the first door, a cast part is hanged to the hook of second door. First door is opened and second door is closed. The shot blasted cast part hanged in the first door is discharged and a new cast part is hanged to be shot blasted. Position is not as easy as free hook type, because parts should be close to door. Therefore, to obtain enough shot blasting wheel should swing enough horizontally.



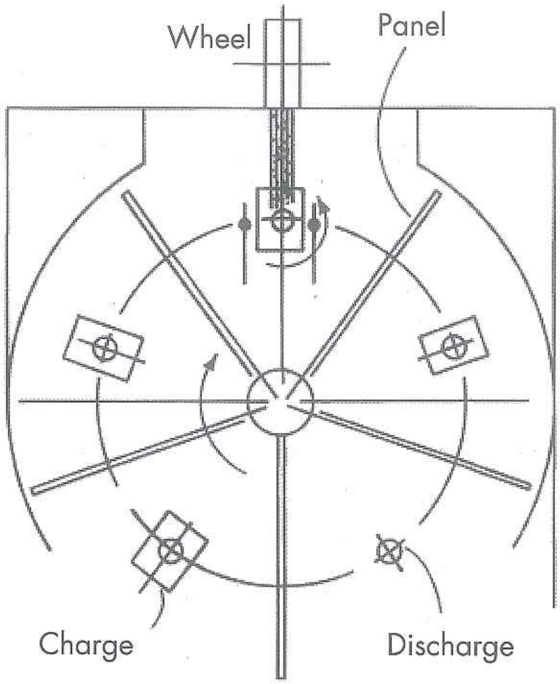
(Figure 8)



(Figure 9)

2.2.4. ROTATING HOOK TOURNIQUET TYPE

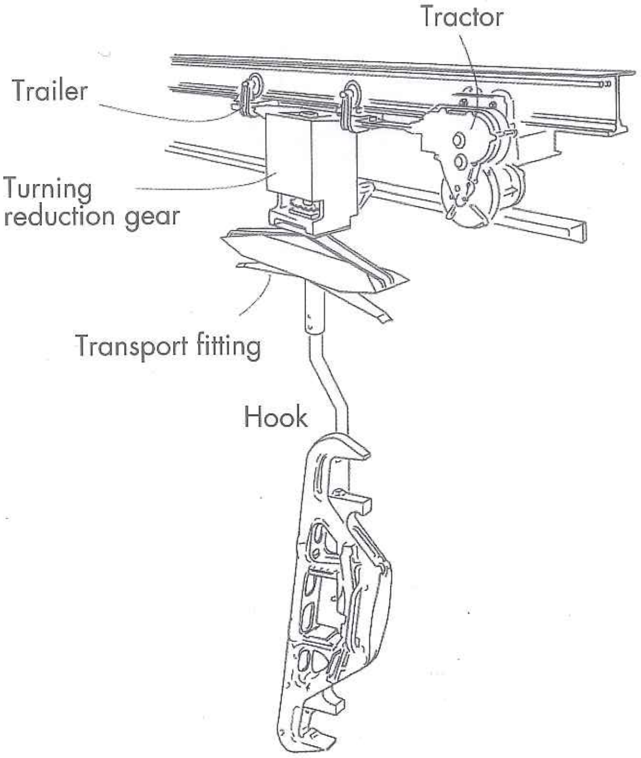
This type is used for high production capacities. Chamber is circular and there is a wheel at the back side of circle, front side is always open. Circular rotating chamber is divided into rooms by using panels (Figure 10) Charge and discharge is done from the front side at the same time whilst cast part is shot blast at the back side. Capacity is 40 - 70 hook / h and approximate cast part weight is up to 910 kg.



(Figure 10)

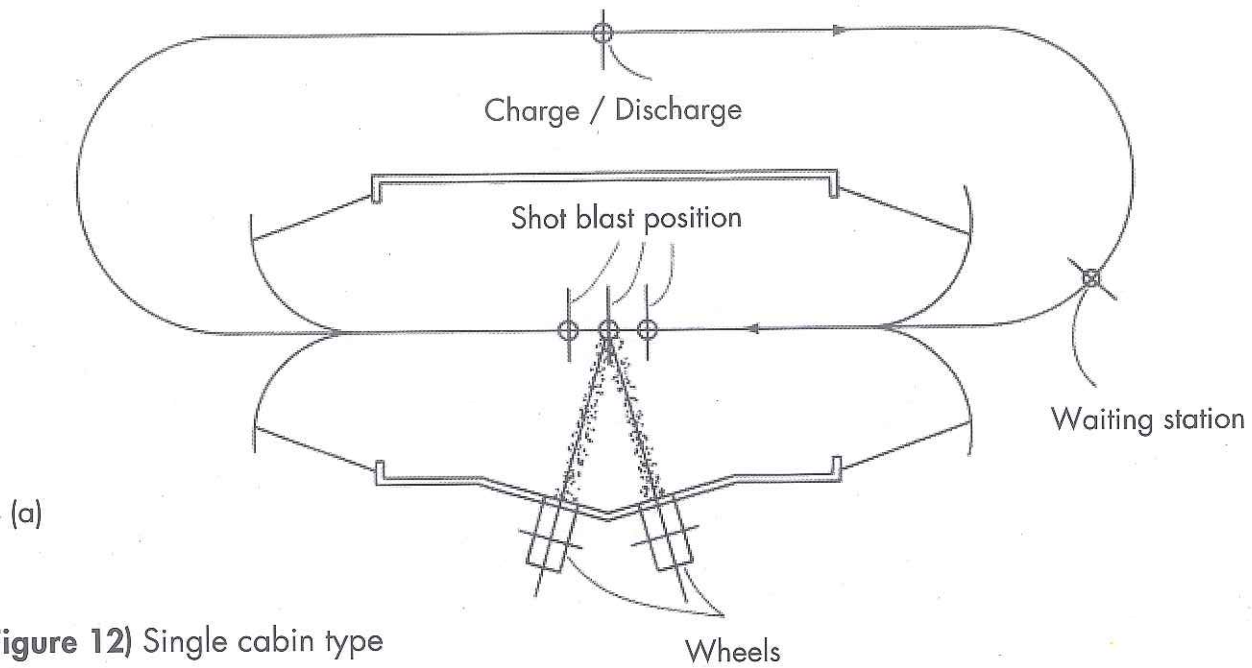
2.2.5. SELF PROPELLED OVERHEAD HOOK TYPE

Another one is frequently used and multi purpose self propelled overhead hook type shot blast machine. (Figure 11) Machine capacity is approximately 120 hook / h and hook capacity is 20 t. Distingushing characteristics of the hook of this machine is movement and rotation of hook is done by hook itself. Electrical tractor motor provides movement and reduction gear provides rotation. Two or more hook system moves together.

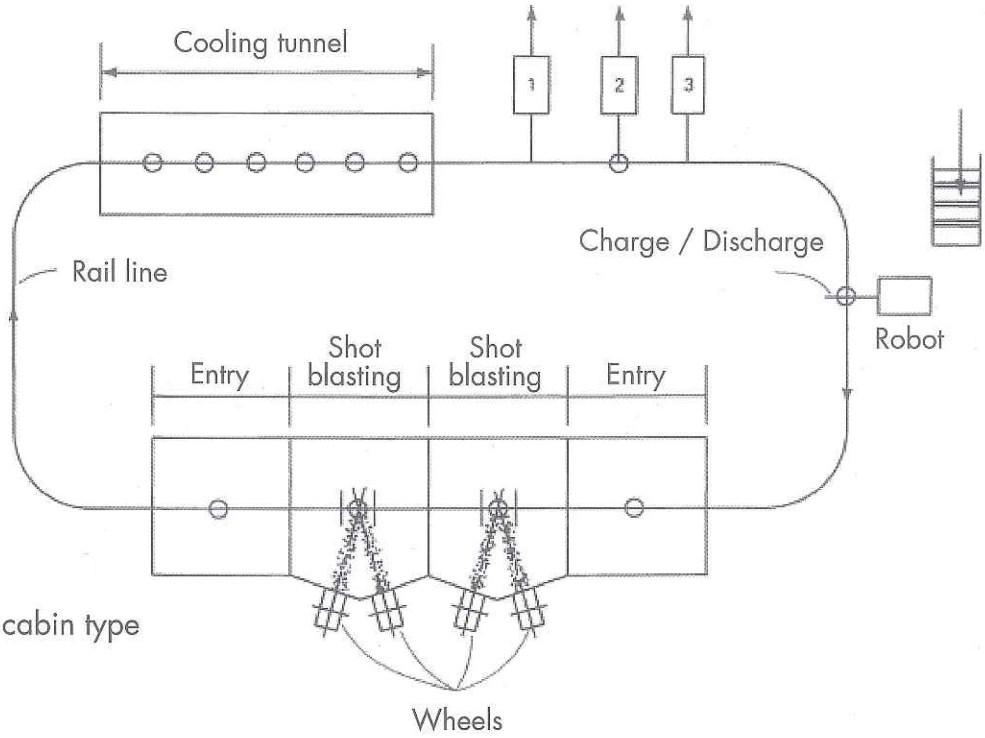


(Figure 11) Self propelled overhead hook type

Flow of the system can be in 2 different ways. First type is single cabin (Figure 12) Whilst charge and discharge is done on the back side of elliptical rail, shot blasting is done in the cabin. Second type has multiple cabins and parts are shot blasted in them and cooled on the same rail. Charge and discharge can be done manually or by means of robot.



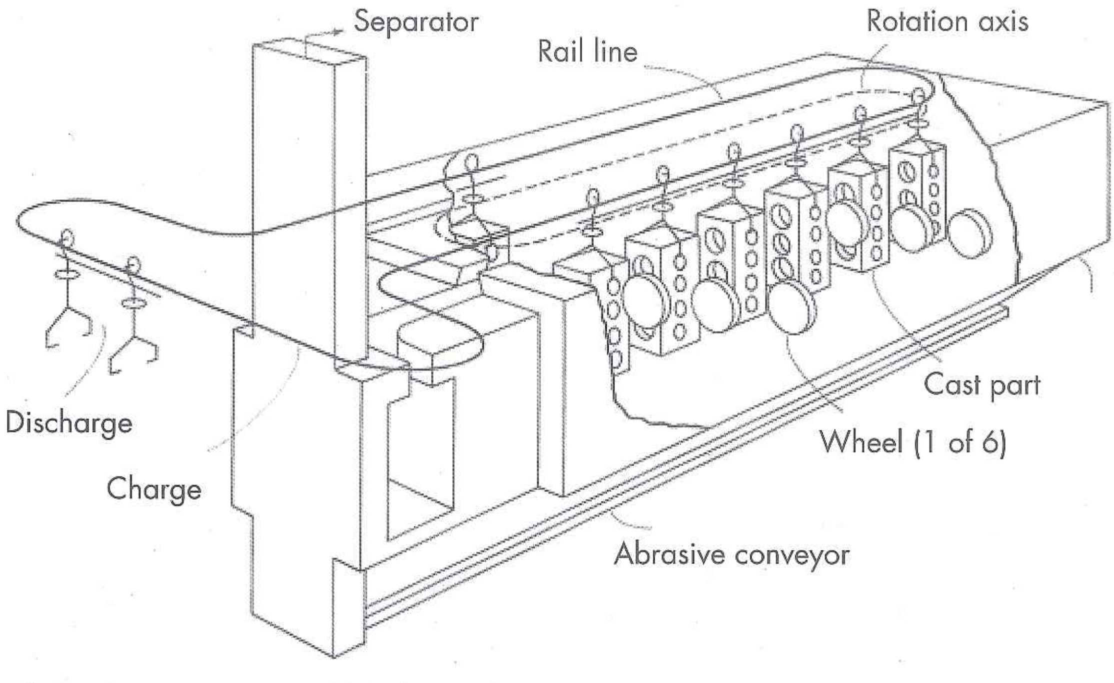
(Figure 12) Single cabin type



(Figure 13) Multi cabin type

2.2.6. CONTINUOUS MONORAIL HOOK TYPE

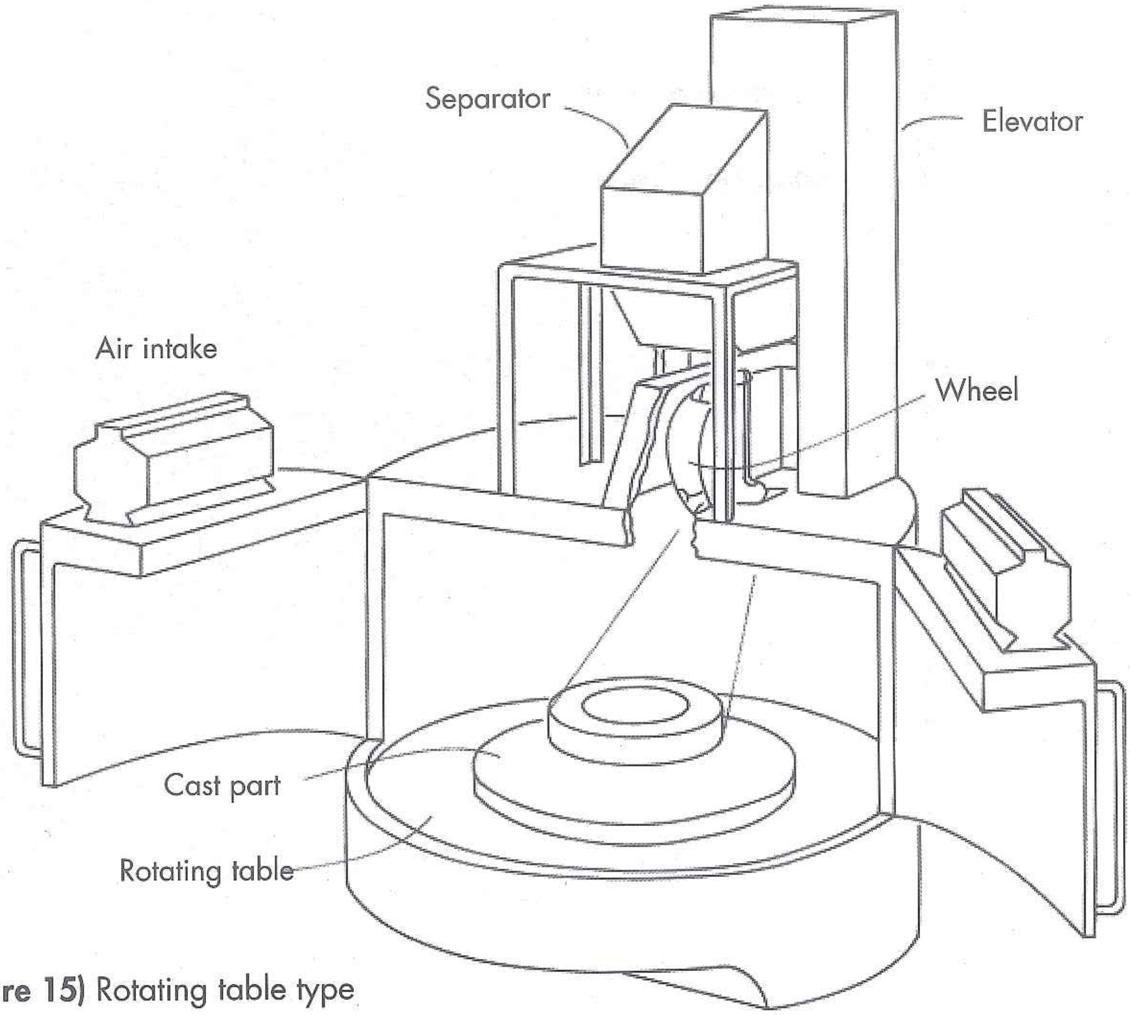
This machine is needed for high shot blasting capacity requirements (Figure 14). In this machine 750 or more hooks can be used and each hook can carry up to 2 tons. Conveyor speed can be slowed or accelerated if shot blasting zone (length of sequential cabins) is short or long respectively. Automation of this machine is difficult because hanging the cast parts onto hooks can not be automated easily. Parts rotating and moving on the rail line is shot blasted on blasting zone and discharged on the outside.



(Figure 14) Continuous monorail hook type

2.2.7 ROTATING TABLE TYPE

(Figure 15) Dimensions of cast parts to be shot blasted changes from 1 to 3.7 m. For small type machines, charging is done by manual positioning. For the large table machines, parts having dimension from 2.4 to 3.7 m and weighing from 5 to 20 tons can be shot blasted. After part is positioned onto table by crane, door is closed and blasting is done by 1 or 3 wheels. Disadvantage of this machine arises from sitting of part onto the table resulting in one side of part is not blasted. This process results in time, labor and energy loss.



(Figure 15) Rotating table type

2.2.8. ROOM TYPE

This machine is used for shot blasting of medium and very heavy sized parts. Machine is composed up of a room and a door which opens into that room. Car, which moves and rotates itself, caries part to be shot blasted into the room where shot blasting takes place by means of wheels located on the walls of the room. Parts up to 250 kg can be shot blasted by this machine. Part of the car that caries cast part to be shot blasted, rotates around on its own axis assuring that all the sides of the cast part is shot blasted. (Picture 1)

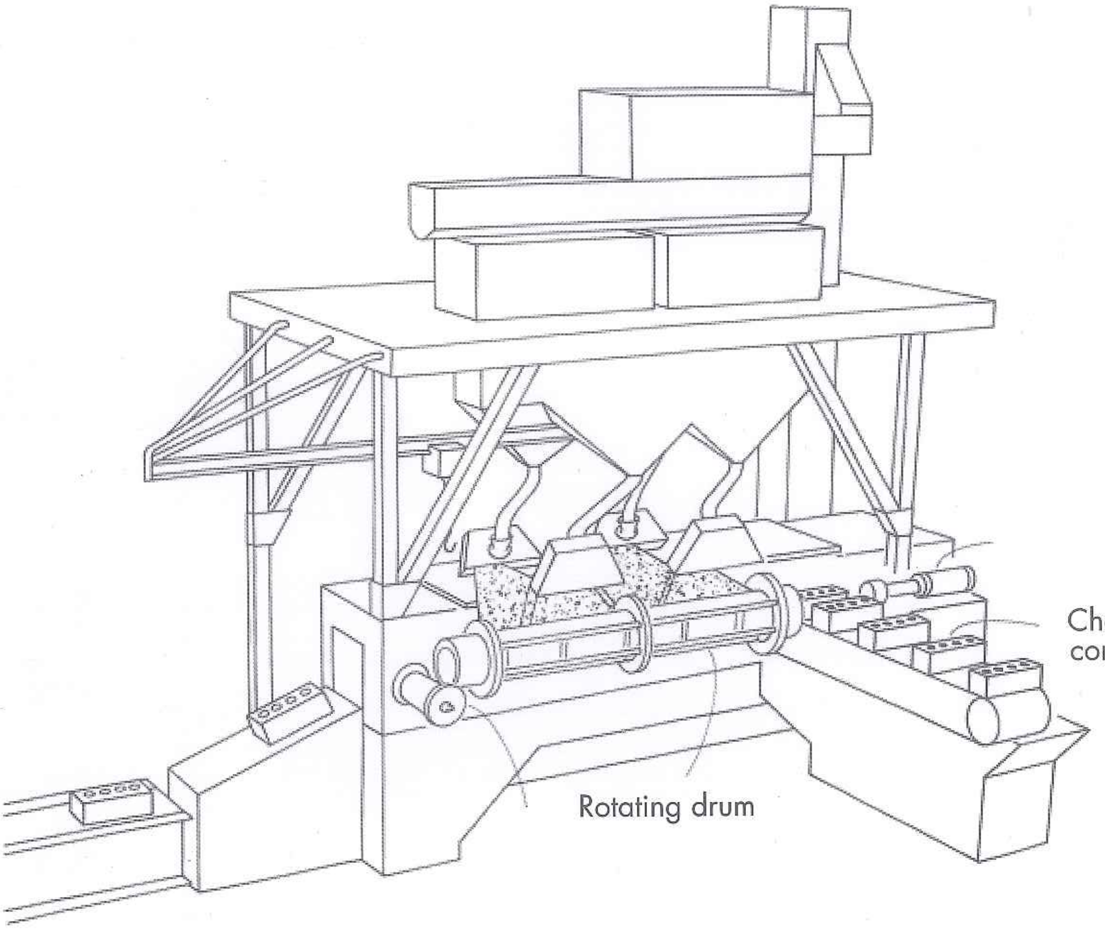
SECTION 2
SHOT BLAST MACHINES

(Picture 1) Room type shot blast machine

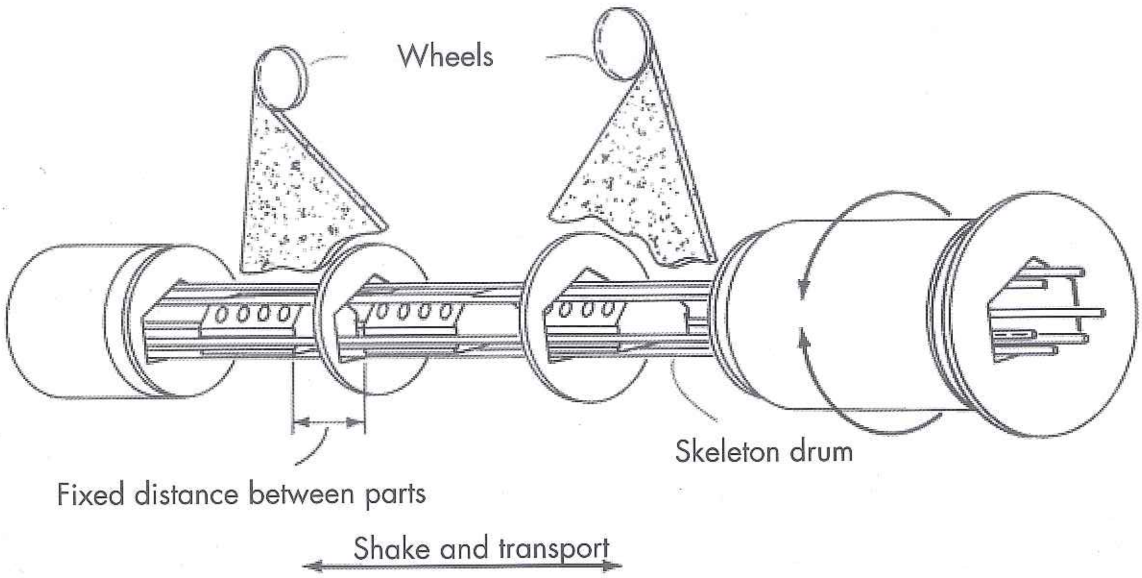
2.2.9. AXIAL FLOW TYPE

These types of machines are designed according to part to be shot blasted; otherwise they will not be effective. Generally they are used by foundries that are producing cast parts for automotive industry. For example a foundry which is casting machine parts can make shot blasting from 650 block / h to 1600 block / h depending on the machine type. There are parallel rods (skeleton drum) on which parts to be shot blasted are fixed. Part to be shot blasted moves forward and rotates around itself at the same. Part is shot blasted while it is passing under the wheels. This is a fully automated machine.

SECTION 2
SHOT BLAST MACHINES



(Figure 16) Axial flow type



(Figure 17) Details of skeleton drum of axial flow type

SECTION 3

SHOT BLAST MACHINE PARTS

Shot blasting machines consists of 5 main sections (Wheel, Cabin, Elevator, Separator, Dust Collector System). Cleaning of the surfaces is done by propelling steel shots in the system on to the surface of cast part by means of wheels. After impacting on the surface, steel shots are transported to separator as mixture of particles like dust, scales etc. by means of elevator in order to be separated from these unwanted particles.

(Figure 18) Shot blast machine

By means of filter suction of separator system , steel shots are reused for shot blasting again and again. Therefore there is a complete cycle in the cabin and a continuous air pressure.

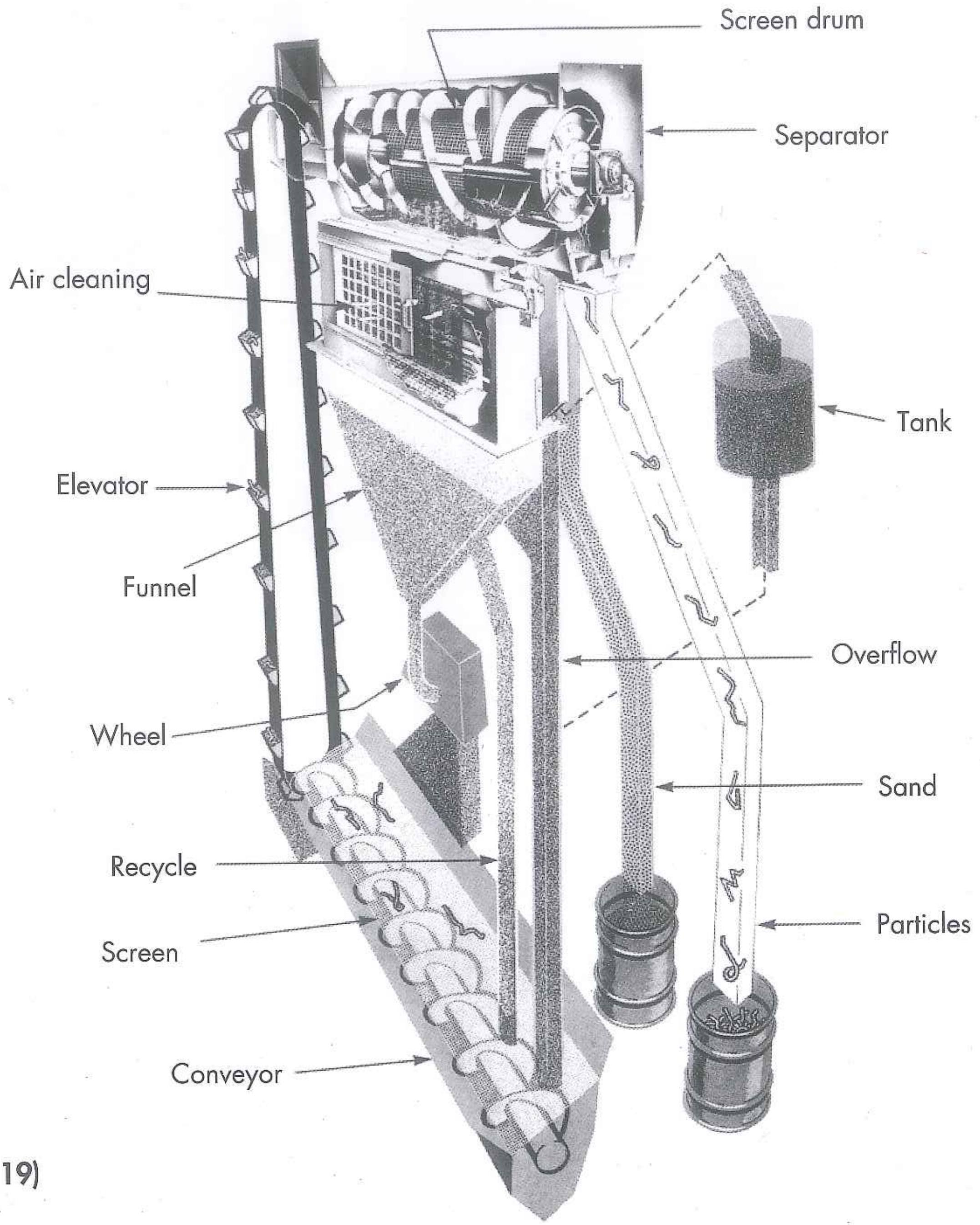
In the following drawing (Figure 19) , basic working principle of a shot blast machine is illustrated. Following steps are being carried out in given order;

1. Abrasive media is transported to feed funnel and than to impeller by means of cage.
2. Than dropped on the blades from the openings of impeller.
3. Steel shots that are dropped onto the blades are propelled to cast part and makes surface cleaning by impacting on to surface.

SECTION 3

SHOT BLAST MACHINE PARTS

4. Particles that come off from cast part such as sand, steel shots and others go to cone shaped bunker and a helical gear transports mixture to elevator bunker.
5. Elevator ladles takes the mixture from reservoir and transports up to separator.
6. Remaining particles coming from a drum shaped screen are sent out of system by means of a helical screw directly from the drum. Those particles that pass from screen are pushed by a helix and transported to pneumatic cleaning separator.
7. Little particles are removed from the mixture, which flows down like a curtain in the pneumatic cleaning separator, by means of vacuum.
8. Dust is transported to dust collector and sand is transported out system.
9. Purified steel shots are sent back to wheel again.



(Figure 19)

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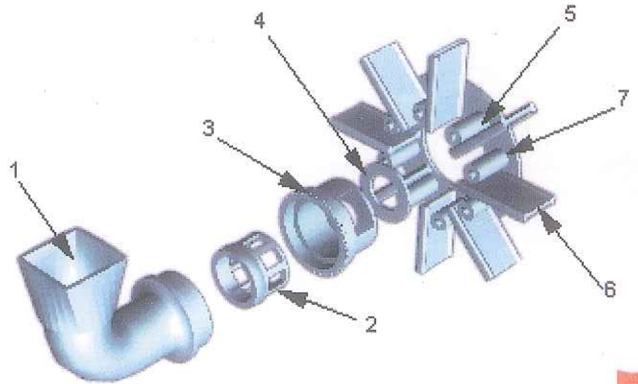
SHOT BLAST MACHINE PARTS

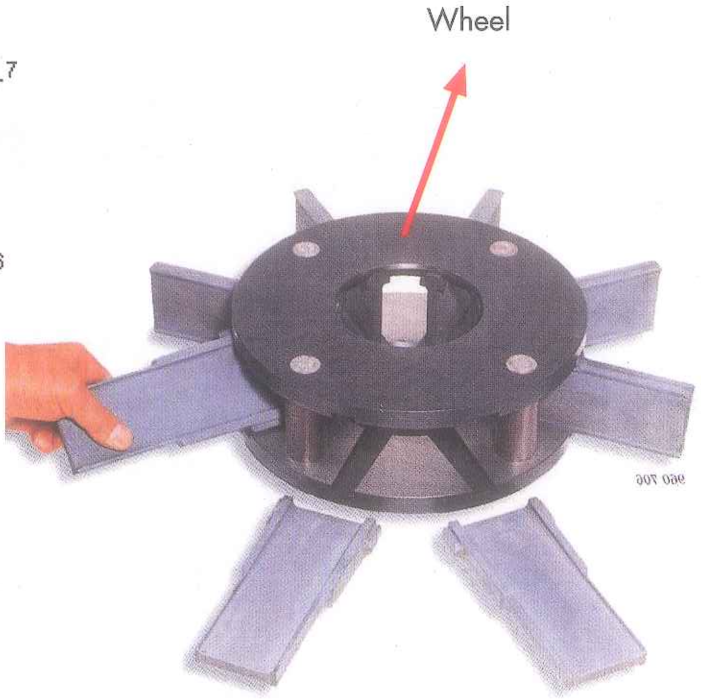
2.3.1 TURBINE

This is the most important part of the shot blast system that propels abrasive media on to the cast part at adjusted speed and direction. Mostly 6 and 8 blades are located on turbines although these numbers can change.



(**Figure 20**) Turbine parts

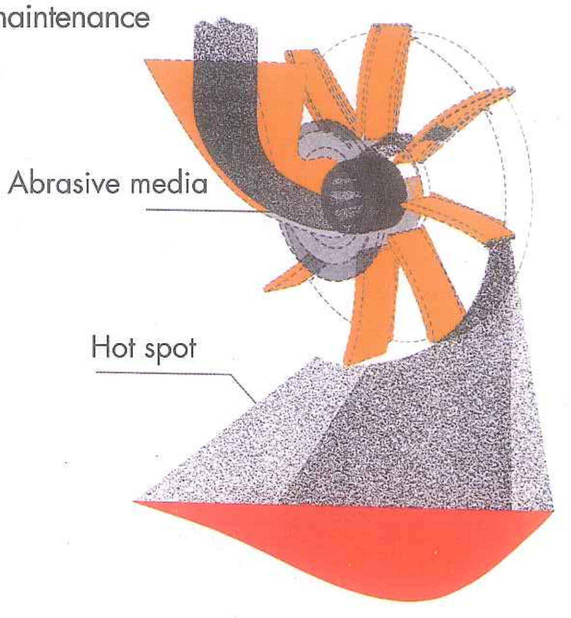
1. Feed spout
2. Impeller
3. Case
4. Fixing apparatus
5. Sliding plate
6. Wheel blade
7. Panel



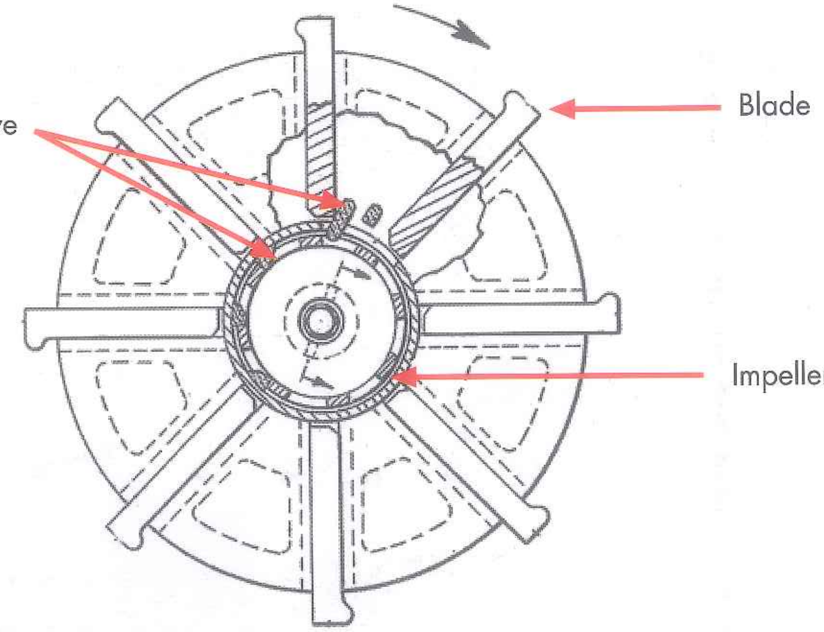
Turbines are the main parts of the machine that fulfills the main function of the machine. Therefore correct adjustment and maintenance is very important.

WORKING PRINCPLE OF TURBINE

Steel shots go into the impeller from feed spout. Impeller and blades continuously rotates at high speed by means of motor, cage does not turn. Steel shots in the impeller come out of cage and drop onto rotating blade. Blade throws steel shots with high speed from the opening located at the bottom of wheel. In order to assure a good operation, impeller, cage and blades should be correctly adjusted; otherwise steel shots will not be thrown to target properly. Abrasions that occur on the parts that are in contact with abrasive media causes this adjustment become wrong.



(**Figure 21**)
Schematic illustration of hot spot



(Figure 22)

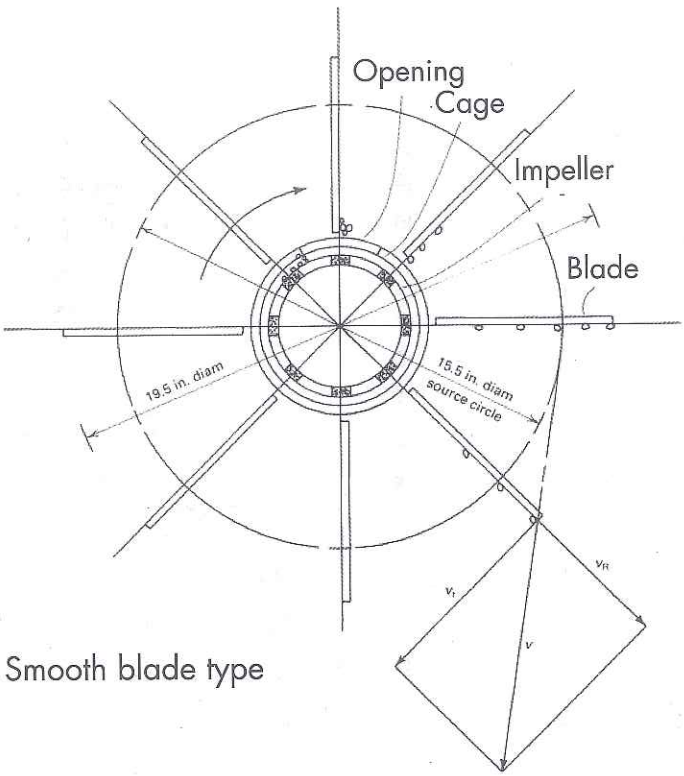
Steel shots that come into impeller are propelled after rotating between bars.

TYPES OF TURBINE

Although several types of wheel blades have been developed for shot blast machines, working principle of all of them are the same as explained above. Difference can be in plates, impellers or blades. Most distinctive basic wheel types are defined according to blades that are used; smooth, curved or double faced blades.

SMOOTH BLADE WHEEL

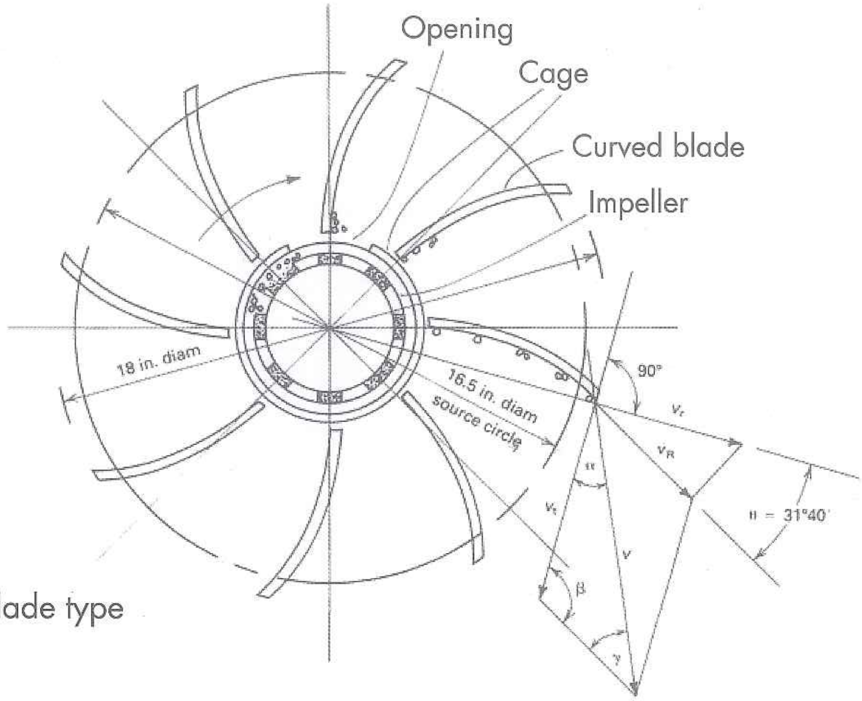
This is most frequently used turbine type (Figure 23) Most common type is having diameter of 495 mm. Blast speed is 73 m / s at 2250 rpm. Generally works at a value of 1035 kg / h / kW.



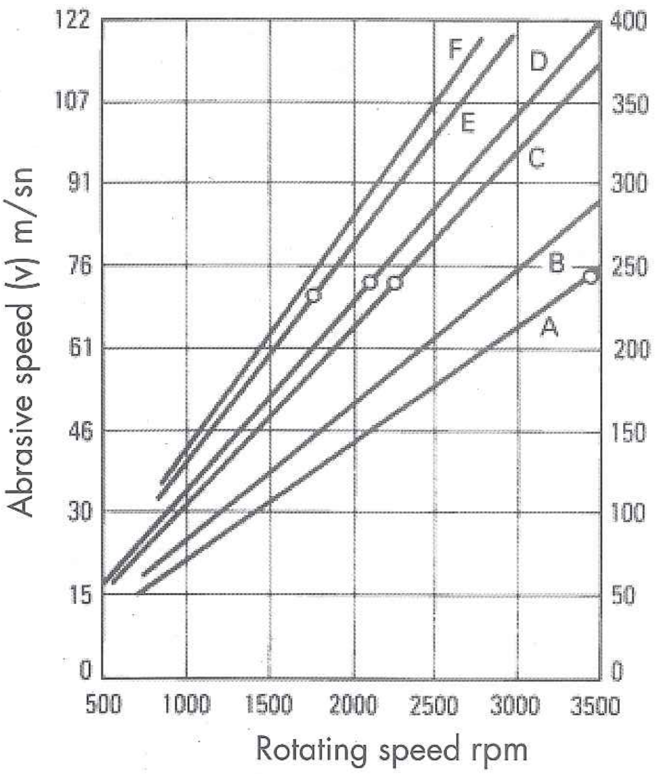
(Figure 23) Smooth blade type

CURVED BLADE TURBINE

This is developed later than smooth type. At a diameter of 457 mm, whilst the speed at blade tip is 50.2 m / s, steel shot reaches to a speed of 73 m / s. Vector analysis of a curved blade is shown in figure 24. Curved type blades have following advantages comparing to smooth types; smaller diameter, less noise and less rotating speed (that means less energy requirement). Key points that should be taken into consideration about these blades are; sand should be removed better by separators and steels shots should not have high hardness (should be between 55 and 65 HRc)



(Figure 24) Curved blade type



(Figure 25)

Plots for several diameters of smooth blades
A, 330 mm
B, 381 mm
C, 495 mm
E, 610 mm

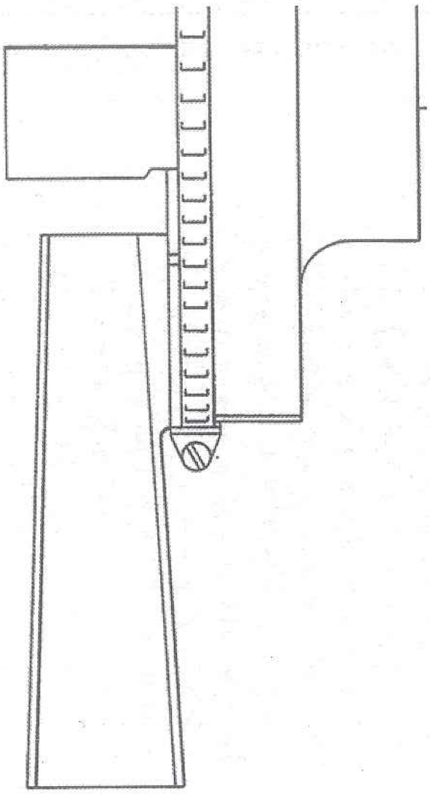
Plots for several diameters of curved blades
B, 330 mm
D, 457 mm
F, 599 mm

Note: Diameters for plot B is 381 mm for smooth type and 330 mm for curved type.

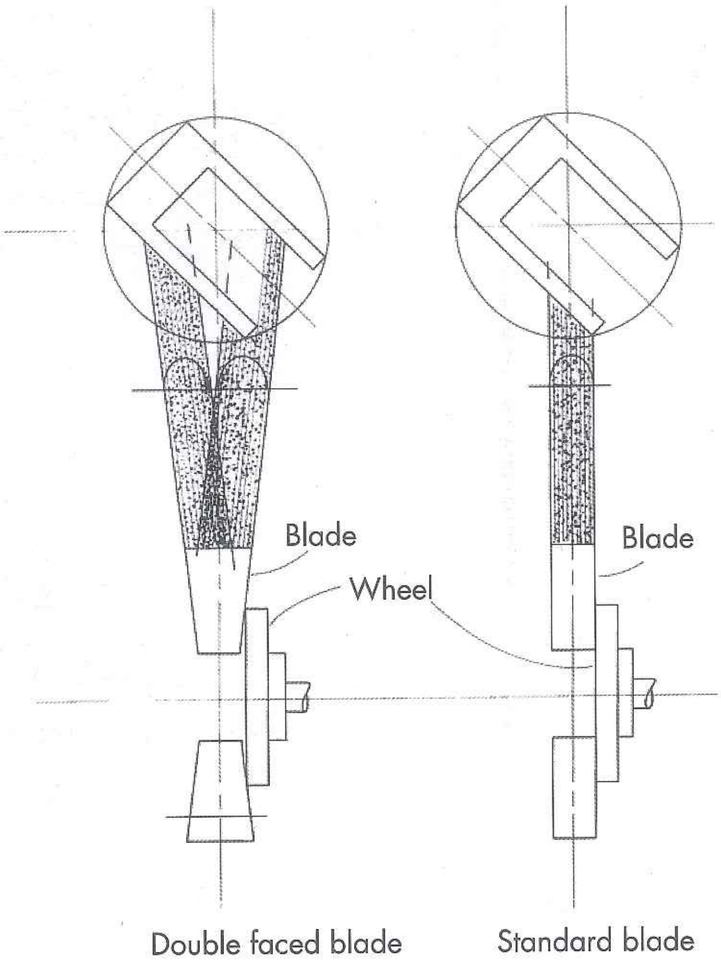
SECTION 3
SHOT BLAST MACHINE PARTS

DOUBLE FACED TYPE

This is developed to obtain a wider hot spot at a time. There is an angle difference of 3 to 6 degrees between front and back sides of blade and there is a feeder at the sides of blades. These types are used at high horse power. Blasting time decreases considerably. Generally used for overhead hook types. There are smooth and curved types. Differences in operation between these types are illustrated in below figures. Because of its structure this type is used with wheels which have fixing from one side only.



(Figure 26) Double faced blade



(a) (b)

(Figure 27)

Difference between hot spots of double faced and standard blades

SHOT BLAST MACHINE PARTS

3.1.3. FACTORS EFFECTING PRODUCTIVITY OF WHEELS

Proper operation of wheel depends on below factors;

1. Flow rate of abrasive into wheel and abrasive blast speed.
2. Abrasive mixture
3. Size of abrasive
4. Propelling direction of abrasive, width and hot spot.
5. Condition of wheel parts.

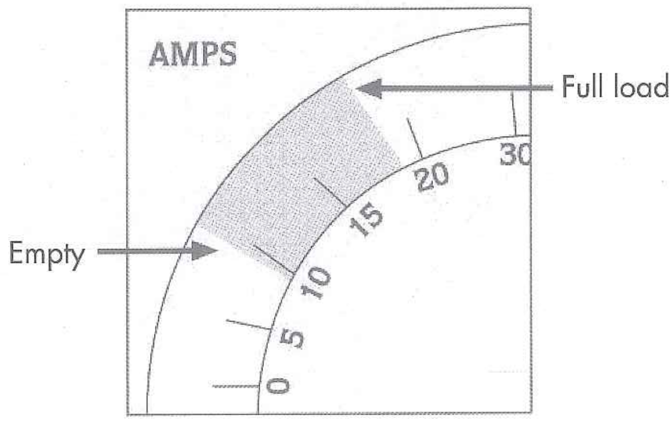
3.1.3.1. FLOW RATE OF ABRASIVE INTO TURBINE AND PROPELLING QUANTITY

Flow rate means flow of steel shots, that are turned back to wheels by means of feed spout, after being cleaned in separator. Therefore flow rate and productivities of wheel and motor is determined. If system does not propel, steel shot can not make cleaning. This can be followed by periodical abrasive addition form. Depending on shot blast machine type and specifications, following criteria affects flow rate;

- Motor power.
- Dimensions of blades.
- Wheel rotation speed.
- Blade number of wheels.

AMMETER CONTROL

Turbine clock indicates the operation period of wheels under load and does not indicate the time when machine is off. Modern shot blast machines have appropriate measuring equipments. Apart from these, ammeter of machine should be controlled.



(Figure 28) Wheel ammeter

Quantity of abrasive media to be blasted is arranged by means of ammeter and it also indicates load of motor. Abrasive amount to be loaded to wheel is adjusted according to value read on the ammeter. Ammeter indicates current that motor is using. Whilst motor capacity is at the top during blasting, fastest and most productive shot blasting should be done. According to high or low value read from ammeter, other adjustments should be done.
If system is not working with %100 productivity, ammeter indicates a lower value than it should normally be. In that case, by reading the value of ammeter, operator realizes that there is a malfunction and tries to fix possible problems.

SECTION 3

SHOT BLAST MACHINE PARTS

There is a definite ampere value to be drawn for each wheel motor under full load and empty conditions. These values are given in below motor ratios table. Ammeter may not always show the actual current used. Therefore it should also be controlled manually. Real full loads of motors can be read from the plates on them.

MOTOR RATIOS				
Motor Power		380 V		
KW	h.p.	I_o	I_{max}	I_u
7,5	10	5,8	17	11,2
11	15	8,1	24,5	16,4
15	20	10,5	31	20,5
18	25	11,6	38	26,4
22	30	14	45	31
30	40	19,8	59	39,2
37	50	23	74	51
44	60	27	86	59
55	75	35	106	71

Utilization of 1 amp less current during shot blasting means 12 kg less steel shot propelling for each minute.

Let's consider a 50 HP (37 kW) motor working at 50 ampere. By using above motor ratios table we see that currency of this motor under full load is I_{max}= 74 amp and under empty conditions, when there is no steel shot flow in the wheel, I_o= 23 amp. Now by using productivity formula

$$\textbf{Productivity} = \frac{\text{Current read} - \text{Current under empty condition}}{\text{Current under full load} - \text{Current under empty condition}} \times 100\ \%$$

Therefore; $\frac{50-23}{74-23} \times 100 = \%\ 53$ Productivity

In that case 74 - 50 = 24 Ampere less is being drawn from the system. At 380 Volts and at 1 Ampere, a wheel propels only 12 kg steel shot. In the below table, propelled quantity per minute of a 8 blade wheel is shown.

STEEL SHOT QUANTITY TO BE PROPELLED		
Kilowatt	**HP**	**Kg/Minute**
7,5	10	130
11,0	15	190
15,0	20	240
18,5	25	300
22,5	30	360
30,0	40	440
37,0	50	580
45,0	60	700
55,0	75	810

SECTION 3

SHOT BLAST MACHINE PARTS

If we continue with our example, 24 X 12 = 288 kg less steel shot is propelled. If that motor runs under full load, as it can be seen in the table, 580 kg steel shot would be thrown in a minute. As it can be seen by this example, if enough steel shot is not flowing to wheels; utilization of high quality steel shots does not make any sense.

Electrical motors are designed for working under full load and should run in most productive way. If they do not work under full load, than running cost increases.

CAUSES OF REDUCTION OF AMPERE AND SOULTIONS

PROBLEM 1: Abrasive is not feeding the wheels enough.

If abrasive quantity that comes into wheel decreases than load of motor decreases and ampere decreases as well.

SOLUTIONS

- Check if there is enough abrasive in storage funnel that feeds wheels.
- Abrasive transport system (conveyor) may not operate good.
- There can be a problem in feed spout or feed pipe which prevents abrasive from flowing.
- In the elevator system, there can be a problem in conveyor belt or elevator ladle. Ladles might be worn through.

PROBLEM 2: Choke of wheel by steel shot overflow.

If steel shot quantity that enters to wheel increases, ampere also increases, because load on motor increases. If there is too much steel shot flow, steel shots are trapped in the impeller and can not flow to wheels. This results in the reduction of drawn current and ampere value decreases. Under normal conditions, 20 ampere should be read for a 10 kW motor.

SOLUTIONS

- Abrasive flow passage should be adjusted and feeding should not exceed capacity of wheels. When shot blasting stops, cap on the feeding spout should cut off feeding and abrasives should not stay in the wheels.
- Worn out parts of wheel should be controlled periodically. Wear of cage, blades and feed spout might cause over flow of steel shots.
- For the belt driven wheels, loosening of belt results in productivity loss of wheel. Belt should be tightened. In that problem, there may be releases in return drive of wheel and incoming steel shots can not be propelled and accumulated in wheel resulting in insufficient feed to blades. Ampere decreases.
- If particles like wire, nail etc. enters into wheel, they stuck between impeller and cage resulting in strain of motor. Ampere increases. Screen should be controlled.

Insufficient Feed of Wheels, Prevention of Overfeed and Choke;

By using a simple test, it can be found out whether reduction in ampere is caused by choke or overfeed. During the shot blasting operation, steel shot feed is stopped. If ampere value drops suddenly, reason of low ampere is choking. If ampere is not changing much when abrasive feed is stopped, reason of low ampere is insufficient feeding. If ampere value is higher than it should be, reason is excessive feed.

3.1.3.2. MIXTURE OF ABRASIVE

The most important factor that affects cleaning efficiency is abrasive mixture. Abrasive mixture should always be homogeneous and small and coarse grains should be together. In order to be able to do this;

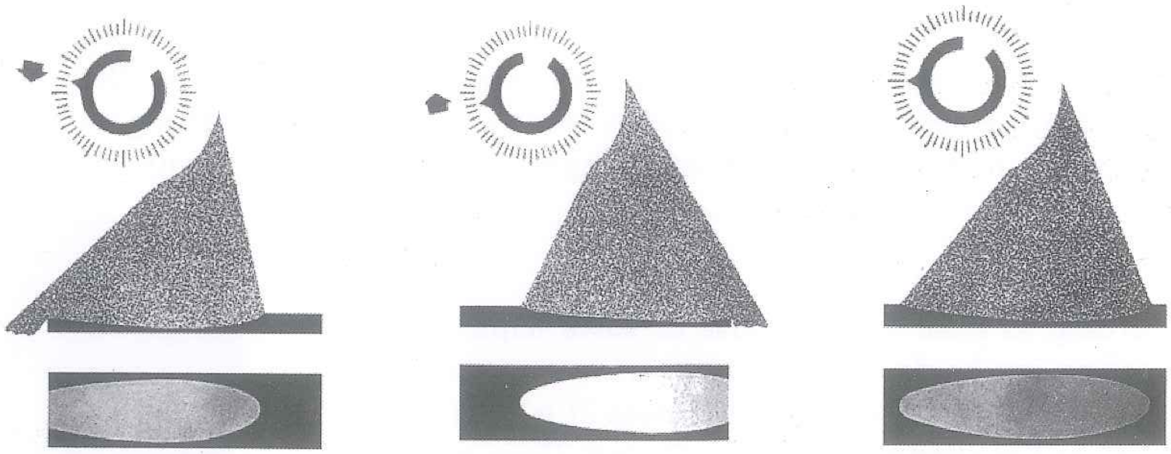
- A sieve analysis should be done each week.
- 2/3 of bunker should always be full.
- Additions to system should be little by little and frequent.
- Leakage of abrasive should be prevented daily.
- Separator and air suction system should be controlled daily.

3.1.3.3. SIZE OF ABRASIVE

In order to keep mixture level in the machine at steady level, addition of steel shots should be done regularly. Desired quality can be obtained only in this way. If steel shot addition is only done at the empty condition of machine, than the operation mixture remains at the nominal beginning size. With a mixture lack of middle and small size steel shots and having only big sizes, rough and dirty surface is obtained. If operating mixture is too fine, lack of big sized steel shots having high energy results in insufficient cleaning and cleaning time becomes considerably longer. Weekly regular maintenance helps to make most suitable adjustments to be done. Time by time analysis of dusts collected, should be done as well as sieve analysis of operating mixture. These analyses give considerable information about cleaning efficiency and cleaning economy.

3.1.3.4 PROPEL DIRECTION, WIDTH AND HOT SPOT OF ABRASIVE

In the blast operation, sensitive adjustment of steel shot flow direction is very critical for cleaning efficiency. Hot spot means most intensive flow region of steel shots.
Direction of steel shots propelled from the wheel is set by adjusting control cage and defined as blast pattern. Without considering direction of wheel rotation, it is set by adjustment of control cage clockwise or counterclockwise. In order to make sure that control cage setting is true, blast pattern control should be done regularly especially whenever any wheel part is relocated. Control procedure for blast pattern is given below;
A steel plate is located in a fixed position in front of wheel to be controlled. Blasting is done for 5 - 10 seconds or more and as soon as it finishes blast pattern is marked. For multi wheel machines, this control should be done for each wheel one by one.



(Figure 29) Shifted to left **(Figure 30)** Shifted to right **(Figure 31)** Correct

Attention! For this testing, materials like cardboard or plywood must not be used which block the parts of the machine which provides flow of media.

Practically blast pattern is to the just opposite of cage opening and makes an angle of approx. 170 with cage opening. As it can be seen in the following diagram, most suitable blast pattern should be 200 mm ahead of wheel center.

Factors affecting the propel direction are as given below;

- Overheating of wheel interior parts.
- Wrong adjustment of control cage.
- Loose wheel V belts.
- Worn out wheel blades.
- Unsteady abrasive working conditions.

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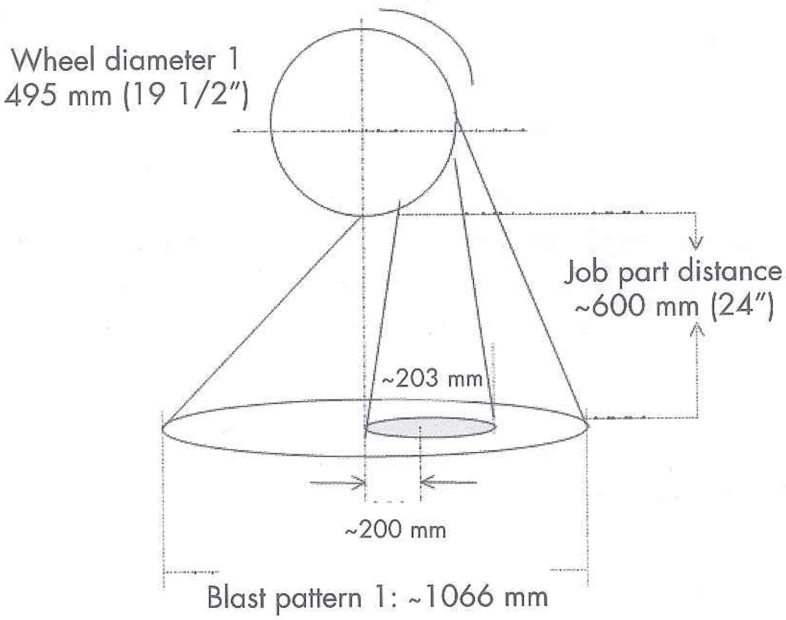
SHOT BLAST MACHINE PARTS



(Figure 32) Blast pattern

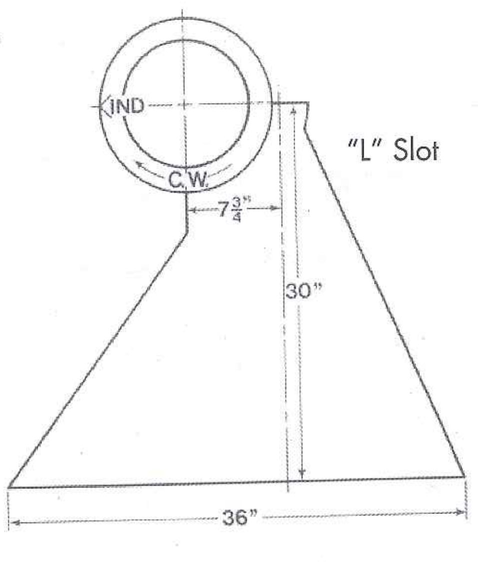
Dark region in the middle is described as " hot spot " at which impact of the steel shots is most effective.

Correctly directing steel shot concentration is a very important factor that should be taken into consideration. In other words, propelled steel shots should find the target. These adjustments are done by trained personnel of machine producer. By means of marking on the surface of the target material, necessary propel direction adjustment can be done.

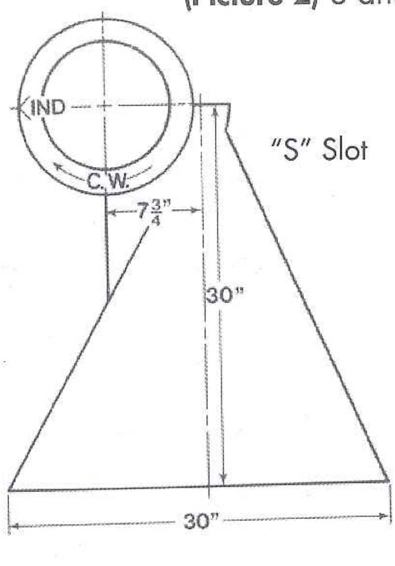
PROPEL WIDTH

According to mounting positions of some impellers, propelling can be done to a wider or narrower region. Slots at the back side of impeller (Picture 2) is mounted so that long or short type can be adjusted. There are S and L letters between the notches meaning S for Short and L for long.

(Picture 2) S and L markings



(Figure 34) Wheel adjusted as L



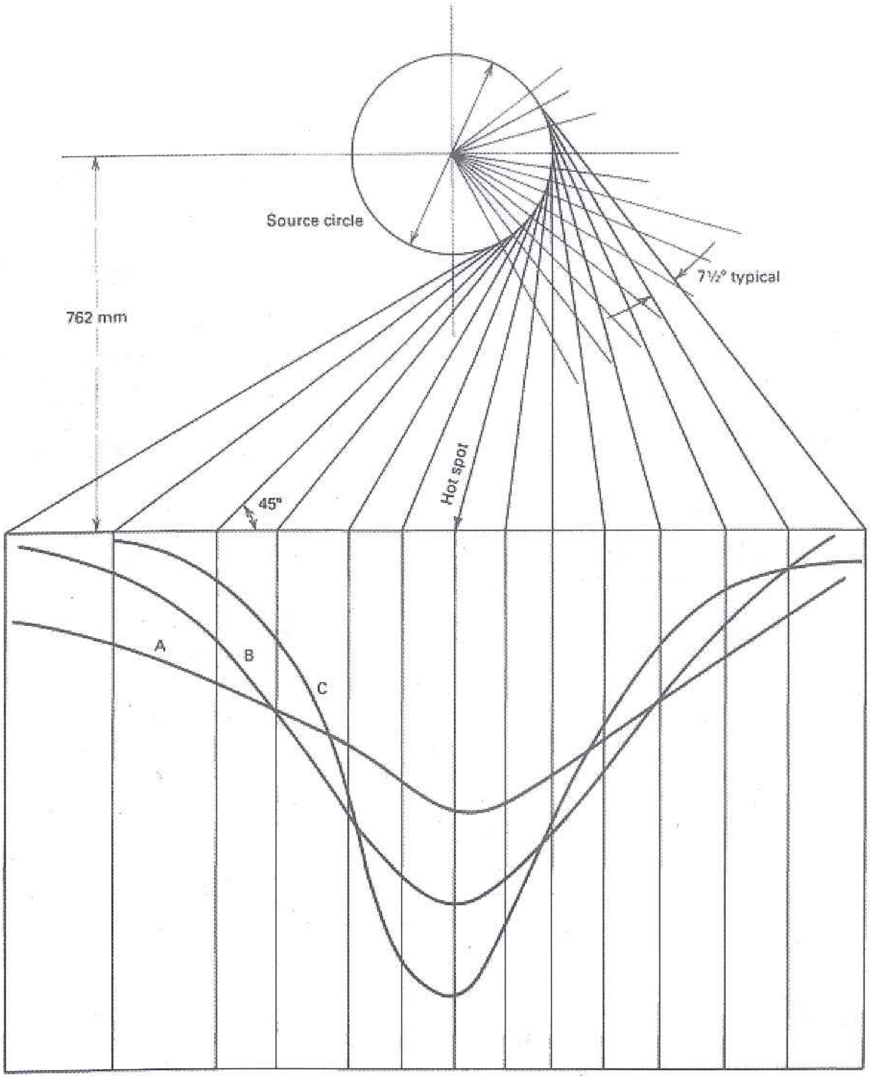
(Figure 35) Wheel adjusted as S

SECTION 3
SHOT BLAST MACHINE PARTS

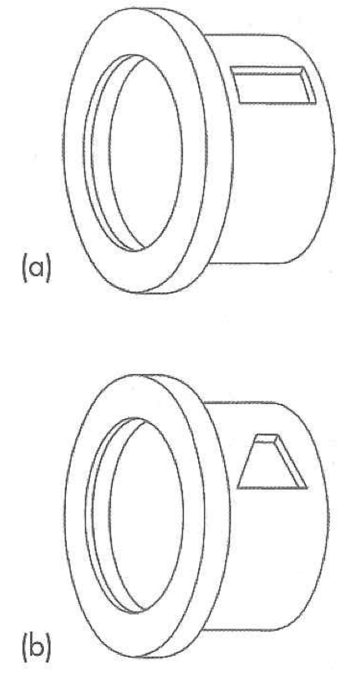
HOT SPOT AND BLAST PATTERN

Below figure (Figure 37) indicates changes in blast pattern efficiency of various cage diameters and types. In that instance, cages are rectangular and trapezoid.

A: 610 mm having rectangular opening smooth bladed wheel, 457 mm having trapezoid opening smooth bladed wheel and 495 mm having rectangular opening smooth bladed wheel.
B: 457 mm having rectangular opening curved bladed wheel, 495 mm having rectangular opening smooth bladed wheel.
C: Special impeller design (U.S. Patent 4, 164, 104)



(Figure 37) Variation of blast pattern

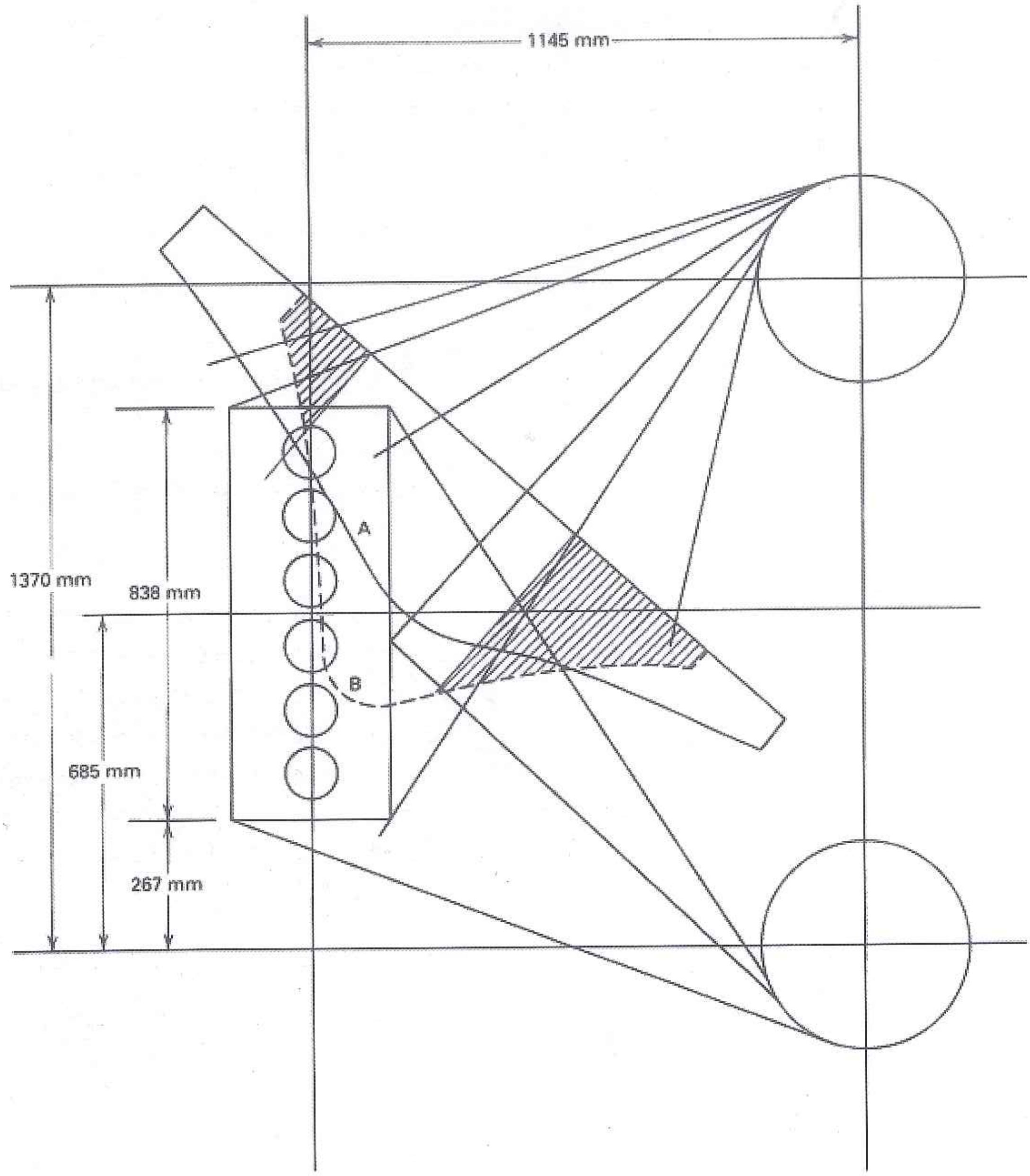


(Figure 36)
Rectangular and trapezoid openings

SECTION 3

SHOT BLAST MACHINE PARTS

Blast pattern should be chosen according to part that will be shot blasted. In the following figure (Figure 38) if blast pattern is indicated as A, 43% of steel shots impacts to part and 53% goes out. If B is chosen as blast pattern, 71% of steel shots impact to part and 29% goes out. In this example type B should be chosen. This option can be chosen by changing wheel type or changing wheel adjustments. Each turbine is not adjustable type.

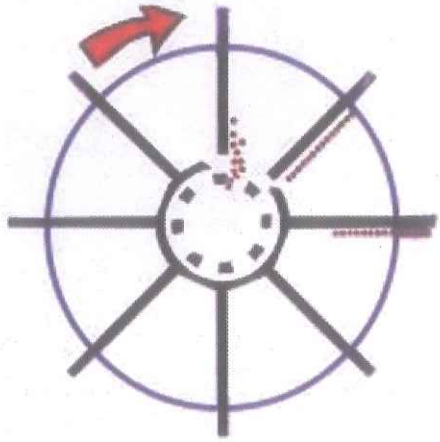


(Figure 38) Selection of blast pattern according to cast part

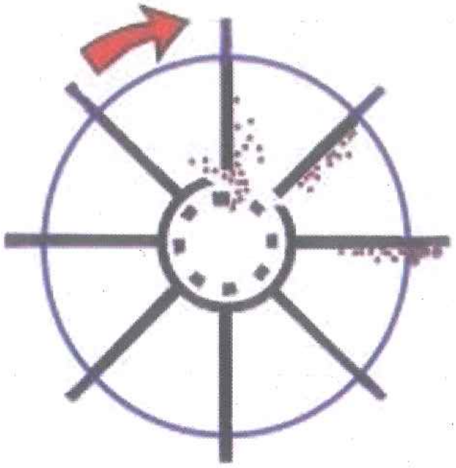
3.1.3.5. CONDITION OF TURBINE PARTS

Why worn wheel parts should be changed?

Feed rate of wheel is adjusted according to shot blast machine. Problems that occurred in the wheel cause this adjustment to be deteriorated. Under normal conditions, opening of impeller is adjusted in such a way that, steel shots are just in front of the blade when they come to opening of impeller. By this way, steel shots drop on to blade in homogeneous way and blade propels these steel shots to the part to be cleaned. As it can be seen on the figure, steel shots are positioned in a regular order and propelled on to the surface.



(Figure 39) Correctly operating wheel



(Figure 40) A misbalanced, worn out wheel

When the parts are worn, cage can not let the steel shots drop just on to the blade. Depending on degree of wear, steel shots drop a little to the back of blade. This causes increase of wear in mainly plates and other parts and steel shot quantity propelled to part decreases. Because the steel shots will be positioned in a regular order on the wheel, they will hit each other during propelling to cast part resulting in breakage of steel shots and causing more wheel wear.

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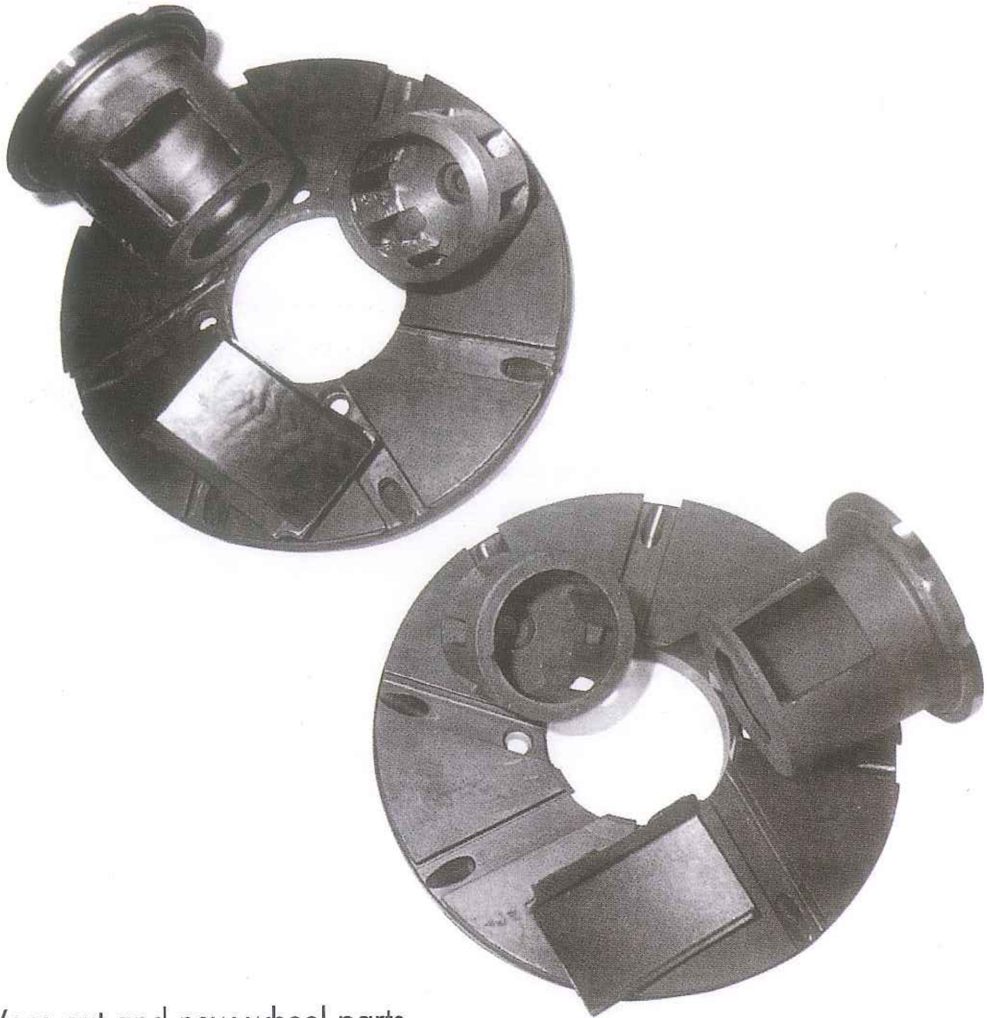
SHOT BLAST MACHINE PARTS



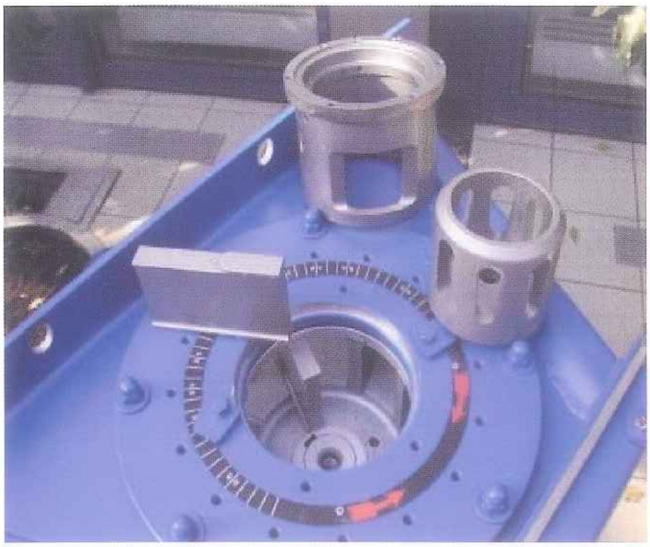
(Picture 3) Worn out and new wheel parts

Parts that are in contact with steel shots are worn in time. These parts are feed spout, protective panels, impeller, cage, fixing bolt and blades. These parts should be produced by using wear resistant material. Additionally, parts are also exposed to dynamic strains, like nails entered into wheel. Therefore material of these parts should be resistant to wear and should have impact strength. Because these two specifications are inverse to each other in general, an optimal combination should be obtained. Another important aspect is that, balancing should be done to prevent oscillating of blades in the wheel (they should be at same weight)

In order to replace wheel parts, machine should be stopped causing stop of production process. Therefore replacement of parts should be as less as possible. Cheap and nondurable parts are considerably expensive comparing to good quality parts even we only consider maintenance cost. For production of these parts, high alloy white cast iron is used all around the world. Production of these parts by means of powder metallurgy has recently started.

SECTION 3

SHOT BLAST MACHINE PARTS

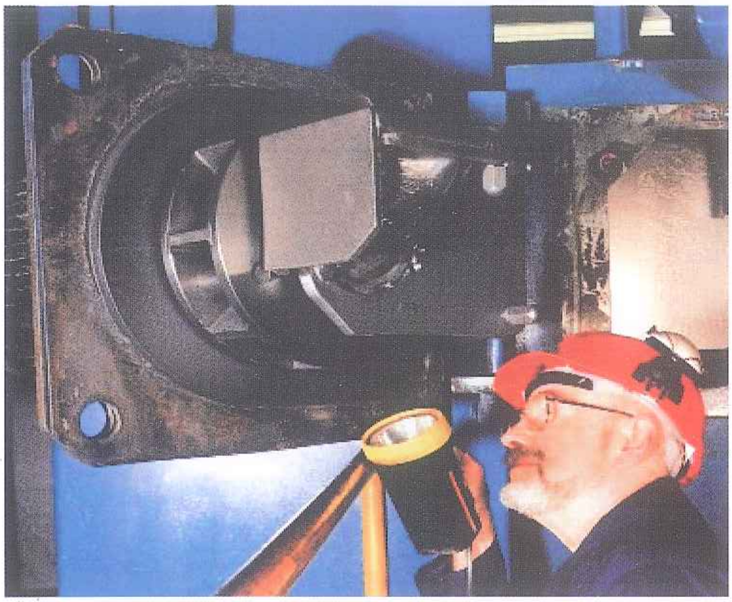


(Picture 4) Wheel spares

Life time of wheel parts to be used is directly proportional to other factors mentioned in this booklet. For example if maintenance of separator is not done properly and periodically, no mater how good qualities that wheel spares have; they will be worn out quickly. If you can take these factors under control, you can determine real life time of wheel spares. Although replacement cost of wheel spares is normally %15 of shot blasting cost, frequent replacements caused by insufficient maintenance and bad quality materials are causing high costs.

Considering only prices of spares to calculate the shot blast cost is definitely misleading. Life time should be followed and calculation should be made as "cost = price / life cycle" Additionally stop of machine also stops production causing high costs to company. Worn wheel spares should be examined, wear type of parts gives information about system.

We can consider this like symptoms appearing on human skin. Problem appears on the skin surface whereas problem is caused by internal plants. In the same manner, problems of wheel spares give information about system. For example if a part of blade is worn more than other sides, that means steel shots are not propelled properly, in other words blades are imbalanced. Under normal conditions every side of blades should be worn uniformly.

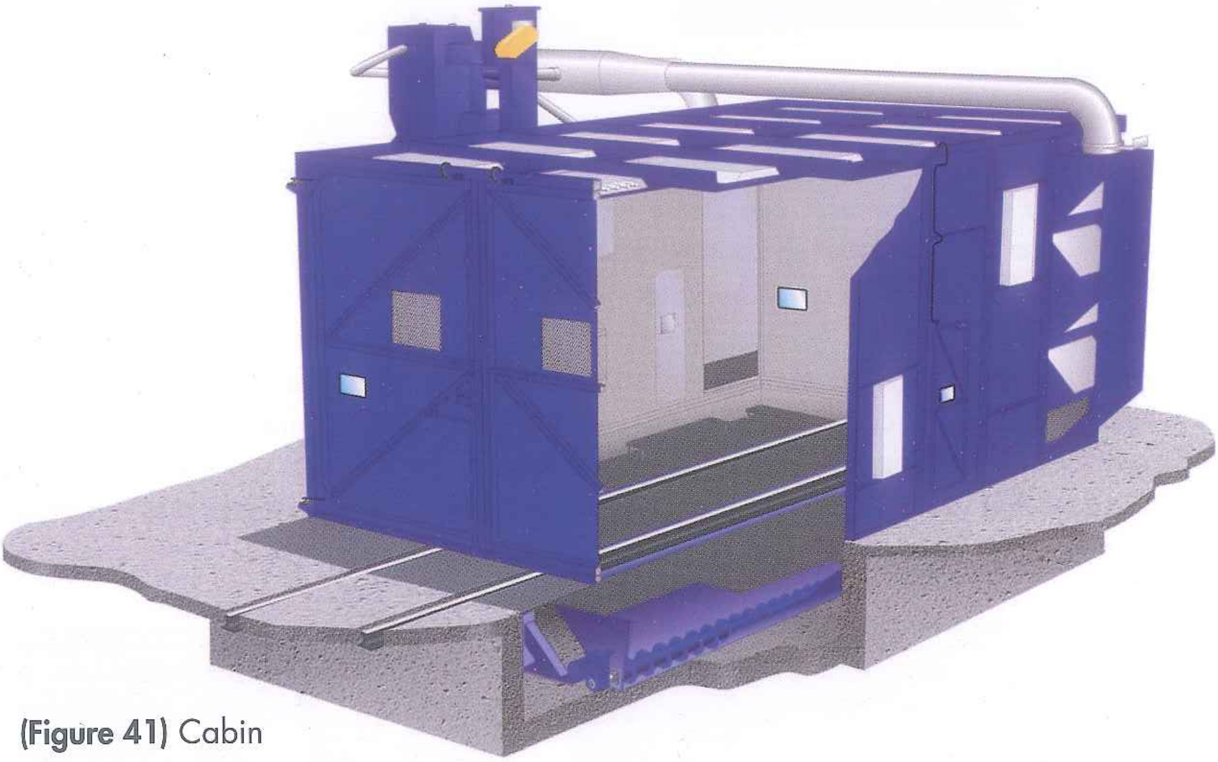


(Picture 5) Key to long life cycle: proper and periodical maintenance

SECTION 3
SHOT BLAST MACHINE PARTS

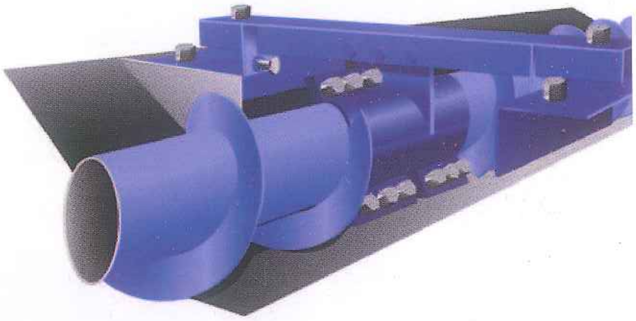
3.2. SHOT BLASTING CABIN

Cabin has 2 main functions. First it contains abrasive media, second stores abrasive that is propelled. There is a bunker under cabin in which steel shot is stored. Under that bunker, there is a rotating helical screw which transports steel shots to elevator system. Regions in the cabin where steel shots impact directly are covered by wear resistant material. Preventing of steel shot leakage from damaged zones and worn connections is very important. Steel shot leakages reduce the operating level of abrasive depot. This causes insufficient feed of wheel, insufficient operation of separator system and early wearing of bunker. Worn out parts should always be examined. Repair of worn parts is not enough. Cause of problem should be defined and necessary measurements should be taken to prevent problem reoccurrence.



(Figure 41) Cabin

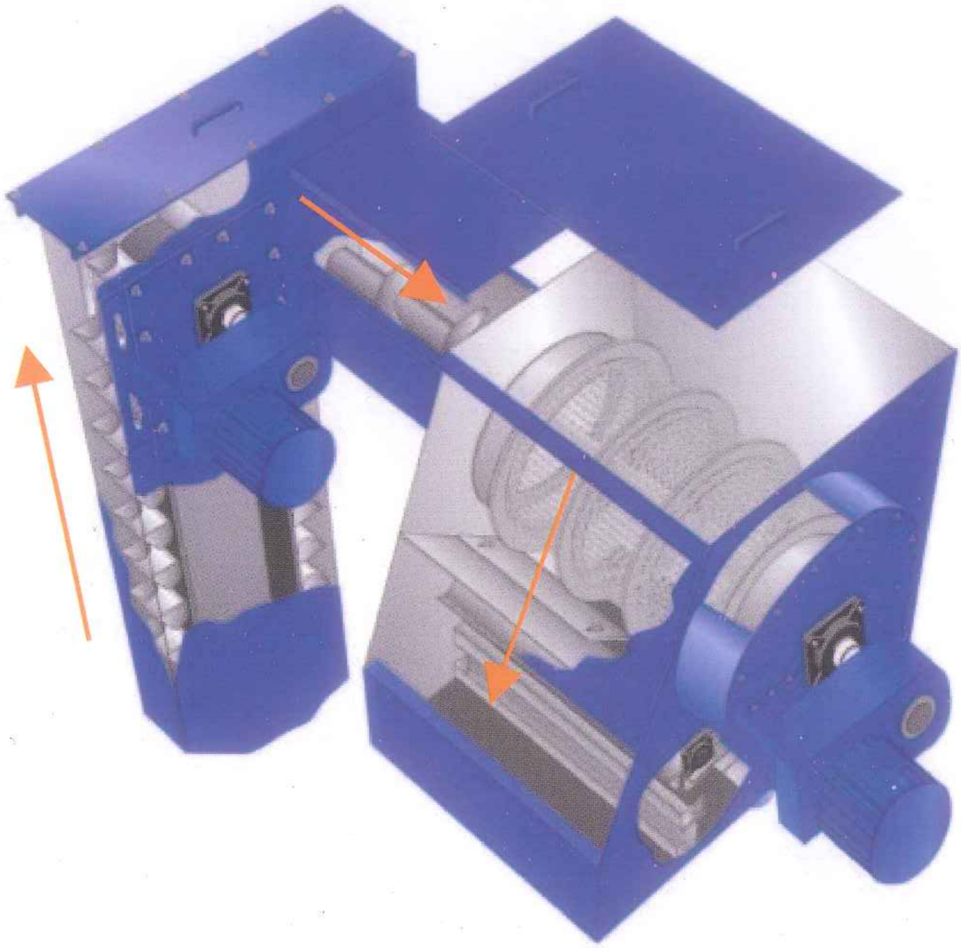
(Figure 42) Bunker



(Figure 43) Conveyor system

3.3. ELEVATOR SYSTEM

After shot blasting, steel shots in the form of a mixture with dust and other particles on the cast part are transported up to the elevator system with ladle or bucket elevator system. These elevator ladles should be made of wear resistant material; otherwise it can be easily worn by steel shots and can be punctured. Important point in this issue is elevator motor power should be chosen in such a way to work in accordance with wheel motors to provide most effective steel shot circulation. Therefore elevator motor size should be suitable to work with wheel motors. Otherwise elevator motor burning or fusing takes place. Problems taking place in elevator system, that are generally puncture of ladles and leakage of steel shots, cause insufficient steel shot feed to system.



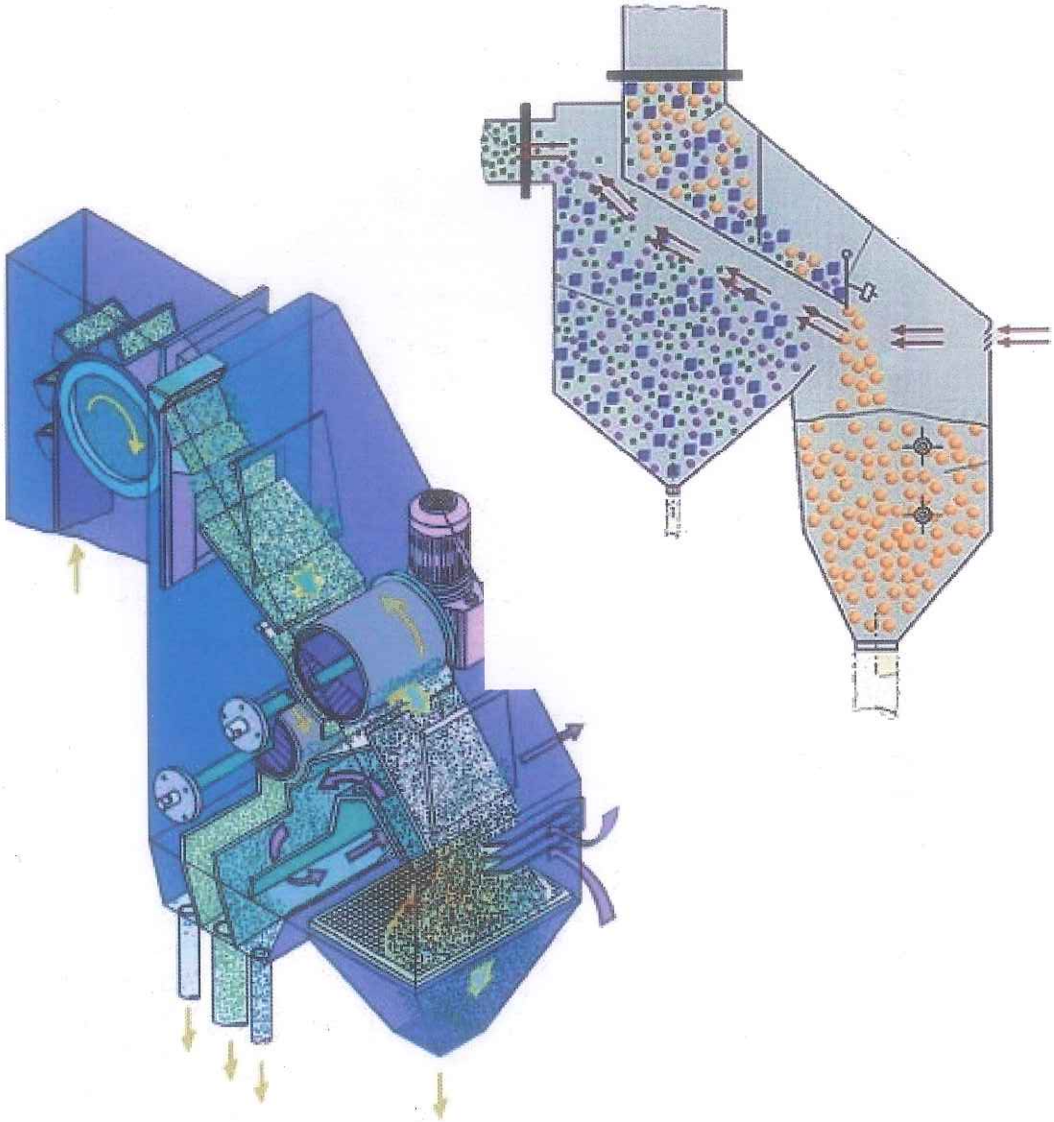
(Figure 44) Elevator and Separator (arrows indicates direction of steel shot movement)

SECTION 3
SHOT BLAST MACHINE PARTS

SEPERATOR SYSTEM

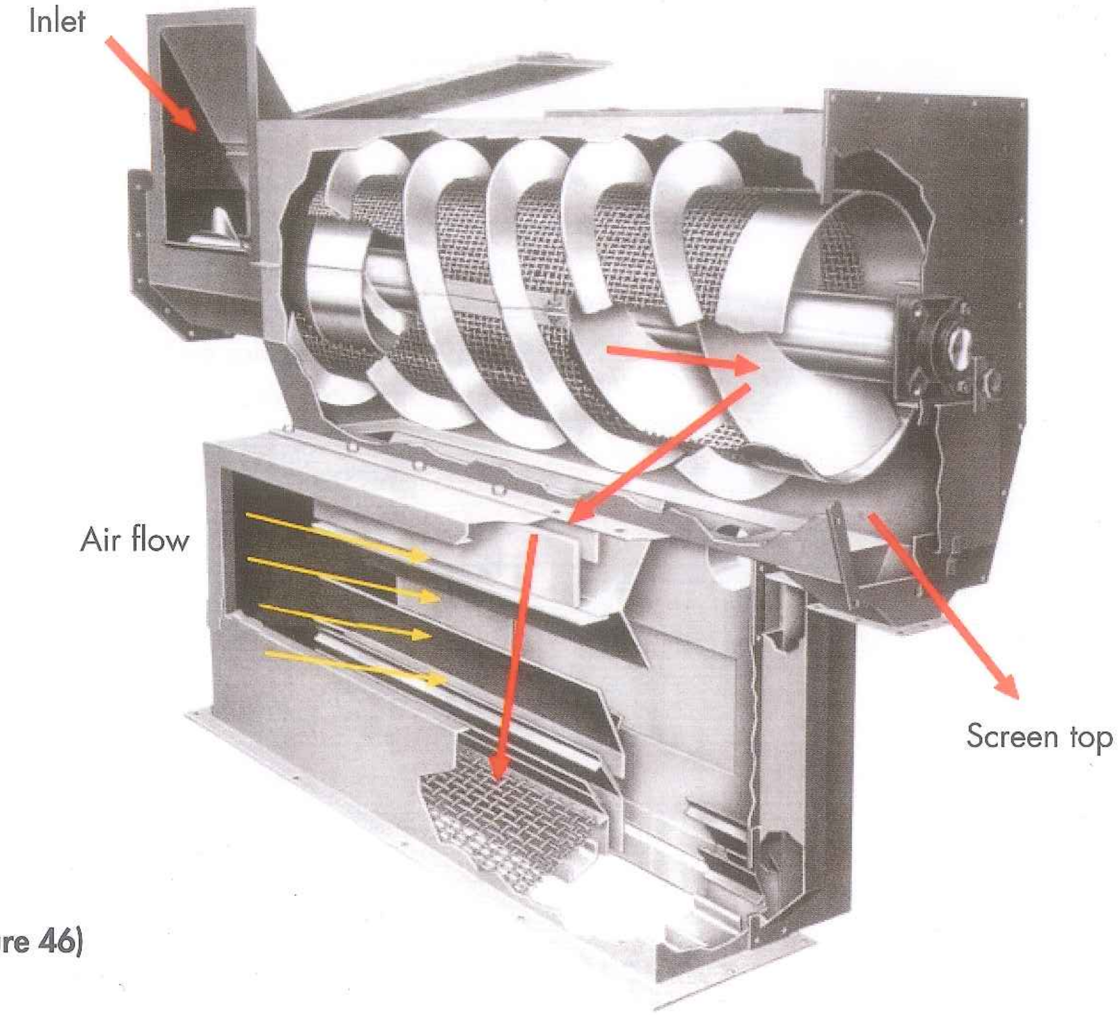
Separator has 3 main functions;

1. Controls cleaning speed and correspondingly size of the abrasives which directly affects production costs.
2. Controls removal of dust and other particles.
3. Controls size distribution in the mixture.



(Figure 45) Working principle of separator

As it can be seen in following figure, separator pours down the mixture coming from bottom as a smooth curtain while air passes through and removes unwanted particles from system. Dust is sent to dust collector, sand and other particles are sent to separate storages. Before mixture comes to separator, it passes through a few more screens and big sized particles are removed.



(Figure 46)

5% unwanted particle in the mixture reduces life cycle of wheel parts by 50%. If the sizes removed by separator is coarser one degree, abrasive cost increases by 10 %.

Separator operation removes polluted abrasives by means of air washing. In this system, following controls should be made;

1) Management of speed of abrasive through channel.
2) Maintaining smooth and complete abrasive curtain in front of all the width of air washing orifice.
3) Transporting the fine abrasives behind curtain.
4) Control of air flow through the system.

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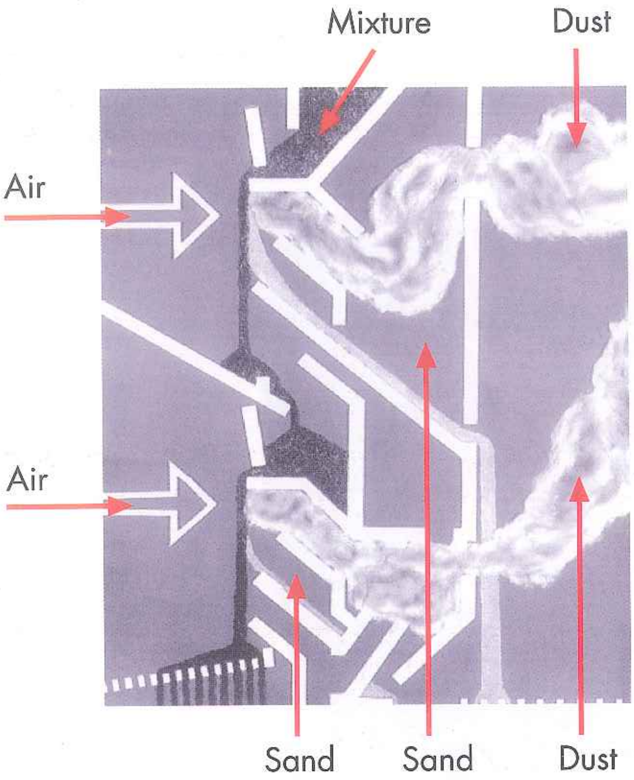
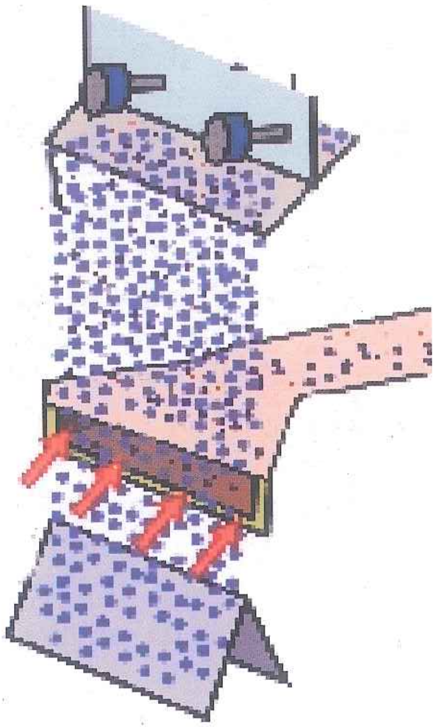
If air flow is not controlled, abrasive does not drop vertically on to opening of channel and all the unwanted particles can not be removed from system.



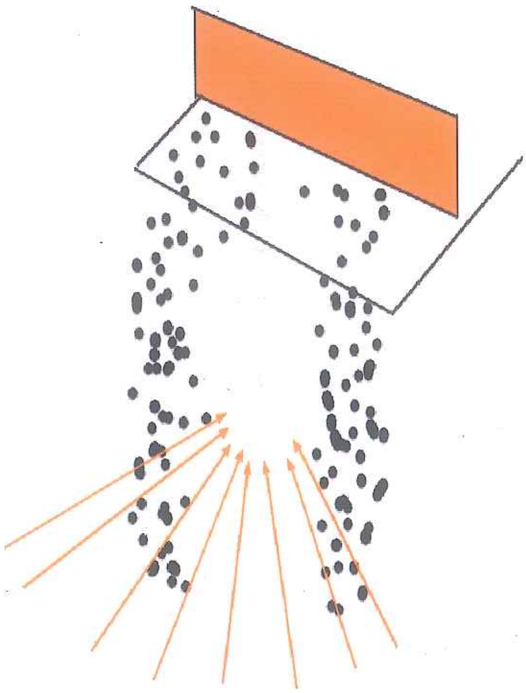
Air condenses in the sections of curtain where there is disintegrateion as in figure 49 and enters into hole. This causes usable steel shots to be thrown away and causes inadequate cleaning of mixture.

Air flow in the separator is reduced by means of dust collecting system. In order to obtain a good operation function dust collector system should be kept in a effective working condition. Because a separator without regular air flow can not fulfill its main function, cost reduction.

Installation of separator should be done by someone who knows its working principle and controls.



(Figure 48) Correct flow



(Figure 49) Wrong flow

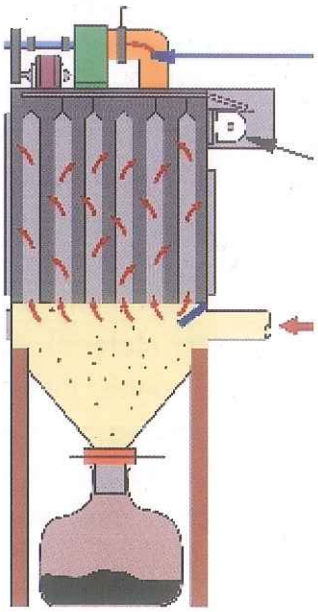
SECTION 3

SHOT BLAST MACHINE PARTS

5- DUST COLLECTOR SYSTEM

Duty of the system is to remove unwanted particles and dusts flying in the machine by means of a air pressure. Therefore there is an air flow in the system.

Cleaning is done by 2 methods depending on type of dust collection system. Shaker type systems clean by means of mechanical shake and ultra jet type uses high pressure air. In order to make a proper and effective cleaning, filters should be cleaned very well. In this way almost a steady air flow is obtained in the shot blast machine.



(Figure 50) Shaker type

Shaker Type:

Dust entering to system from bottom is hold by filter sacks and poured down.

Possible problems;

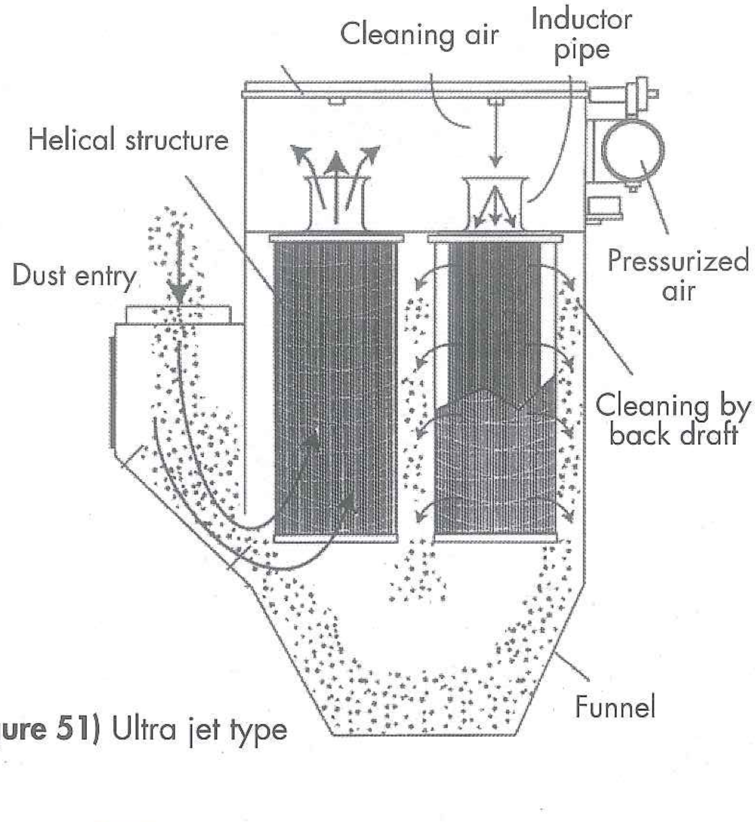
- Weak or broken shaker bars.
- Fallen filter sacks.

Ultra – Jet type:

Dust vacuumed into the system is caught by filters and cleaning is done by air pressure applied from up.

POTENTIAL PROBLEMS

- Low air pressure
- Wrong vibration frequency
- Stuck vibration valves.

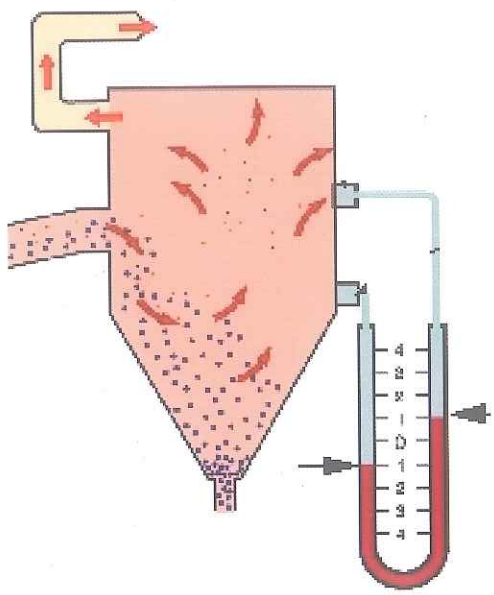


(Figure 51) Ultra jet type

SECTION 3

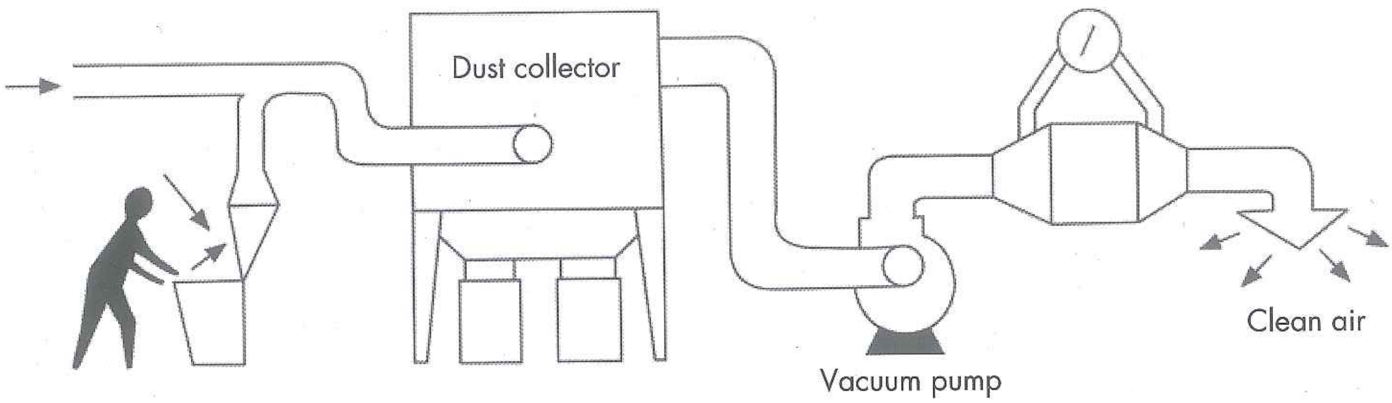
SHOT BLAST MACHINE PARTS

Shot blasting machine producers design dust collector systems according to machine specifications and type of the unwanted particles to be removed. Pressure of most of the systems, which are working with a vacuum fan, is 200 mm Hg. If pressure value decreases to 150 mm Hg during operation, this means filters are choked and needs to be cleaned. Pressure in collector filters is a measure of air flow rate in the filters. It is expressed as quantity of dust collected on the filters. Average pressure difference in new filters is 12.5 mm Hg.



(**Figure 52)** Pressure measurment

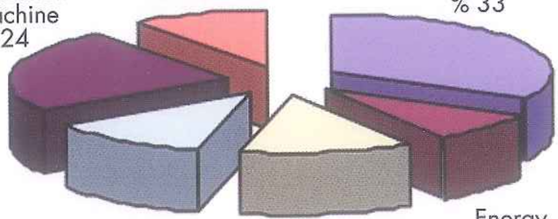
If pressure change is less than 150 mmHg, this means air flow is not adequate. Filters might be torn out or sealing is inadequate. Dusts on the cell level of clean side of apparatus leaks from torn parts of filter or from parts that have not enough seal. If all the cell level is covered by solid dust particles, this shows that wrong filter material has been used. Dust emission from exhaust outlet indicates puncture, leakage or wrong filter material. Although we have given some pressure values, there will be different pressure values depending on machine or filtering method. You should obtain these values from your own machine supplier and make the controls according to these values.



(Figure 53) Dust collector system

4.1.3. ABRASIVE LEAKAGES

- Separator leakages, regulation of air suction system.
- Putting back to system of abrasives spread around.
- Removal of abrasives from system together with work part.
- Leakages in blasting system.



Leakage of steel shot increases costs. A steel shot leaves wheel with a velocity of about 70-80 m/s. This causes a dangerous situation for personnel and also for surrounding equipments. Type of abrasive is one of important factors in abrasive consumption. If any scratch is not required on the part surface, angular grits should not be used in the mixture. For low carbon steel shots, abrasion behavior of abrasives in the blast machine is such that, they loose their round shape as they gradually becomes smaller. For angular grits, abrasion behavior is quick angular abrasion. This causes fast consumption resulting in high consumption cost.
If grit-steel shot mixture is requested in the machine, grit ratio should not exceed 25%. Higher percentage causes malfunction of separator flow system that keeps operation mixture at balance and results in choke.
Losses caused by choosing wrong type of abrasive media can simply be explained as following; A company consuming abrasive of 5 t / month purchases 60 tons / year. Considering price as 500 $ / t, annual purchase amount is 30000 $. If a 20% more durable abrasive is chosen, cost saving is 6000 $ / year which is a significant amount.

4.1.2. SUGGESTED MAINTANACE AND INSPECTION METHOD

All the shot blasting equipment is self abrasive. The most important key to reduce operation cost is protective maintenance. Protective maintenance requires a schedule for repairs and takes measurements. Also requires training of operators and maintenance personnel about correct utilization and repair of equipments. Leakages reduces abrasive amount resulting in cost increase of shot blasting operation. Abrasive consumption increases and a dangerous environment occur for surrounding equipments and personnel. Basic of protective maintenance is regular inspection of equipment.

Purposes of inspection are as follows;

- Detection of repairs and preventing big damages.
- Assisting to repair operations by detecting possible malfunction cause.
- Preparation of a repair schedule for most suitable times.
- Preventing production stops.
- Assuring that certain equipments are working at highest efficiency

SECTION 4

REDUCTION OF SHOT PEENING COSTS BY MAINTENANCE

In the surface cleaning process, economical operation is as important as surface quality of the cast part. Ideal consumption figures are given below for several utilization areas;

Steel or cast iron:	5 – 7 kg / ton
Forged parts:	4 – 6 kg / ton
Steel plate & construction	2 – 4 kg / ton
Radiator production	250 g / m2

Surely these figures change depending on contamination level, size and desired surface quality.

In order to increase cleaning efficiency, to minimize steel shot consumption per unit area of cleaning surface and wear of machine spares and also to prevent production stops, process should be regularly and consciously inspected.
In modern wheel type shot blast machines, steel shots are propelled onto cast part with a velocity of 75 - 85 m / s and cast part is exposed to a heavy hammering effect. After impact on to cast surface, steel shots are cleaned in the system than collected and sent back to wheels again and same cycle is repeated. Steel shots should endure during this circulation as long as possible. Life cycle is the number of cycles that a steel shot remains in the machine. It can be understood by quantity of new steel shot addition into the system with every working hour. Under normal conditions a steel shot remains in the system about 2500 - 3000 times.

4.1. TOTAL CLEANING COST

Cost of cleaning can be divided into 3 groups for wheel cleaning systems. These are;

1. Abrasive consumption
2. Cleaning cost distribution
3. Abrasive leakage

4.1.1. ABRASIVE CONSUMPTION

Propelled quantity of abrasive (propel speed being proportional to quality and hardness of steel shots) varies depending on consumption quantity per hour (related to abrasive flow rate) and characteristics of part to be cleaned.

4.1.2. CLEANING COST DISTRIBUTION

Ratios of all parameters that are related to shot blasting costs are shown in following diagram. Amortization portion of 24% in this diagram is shifted to labor, worn out parts and maintenance costs in the following years for shot blast machines older than 5 years old. As it can be seen, in the total cleaning cost, steel shot cost is appearing as a small number of 13 % max.

SECTION 4

REDUCTION OF SHOT PEENING COSTS BY MAINTENANCE

OPERATING DIAGNOSIS LIST OF SHOT BLAST MACHINES

ERROR	OBSERVATION PLACE	CAUSE	EFFECT	PREVENTION
1- Ammeter draws low current	Ammeter	Lack of steel shot	Low wheel effectiveness, bad cleaning	Addition of new steel shot
2- Ammeter draws low current	Ammeter	V belts are loosen	Low wheel effectiveness, bad cleaning	Normal adjustment
3- Bad separation of steel shots	Observation of usable steel shot in discarded material	Choked holes in separator, worn separator, wrong adjustment of separator plates	Discard of usable steel shots, excessive steel shot consumption	Check separator holes frequently
4- Steel shot mixture and sieve analysis is not suitable	Steel shot size in system is too big Steel shot size in system is too small	Excessive new steel shot addition. Separator and dumper adjustment is not good. Propel angle is not correctly adjusted.	Cleaning is not good. Breakage of steel shots.	Arrangement of 50% new and 50% old steel shot. Add new steel shot periodically. Check separator.
5- Wrong wheel angle	Fast wear of cabin wear plates and not good cleaning of parts	Worn blades, there is excessive sand among steel shots	Low wheel efficiency	Periodical control
6- Steel shot circulation system is choked. Cabin ceiling is worn through. Storages and bucket elevator feeder is chocked.	Ammeter draws low current	There are wire pieces, bolts and nuts in the system.	Low cleaning efficiency	Clean all the system frequently
7- Lack of steel shot in the system	Ammeter draws low current	Steel shots are being thrown out of cabin or they are being transported out of cabin in cast	Low cleaning efficiency	Collect all steel shots thrown or transported out of cabin and give back to system

REDUCTION OF SHOT PEENING COSTS BY MAINTENANCE

PERIODIC PROTECTIVE MAINTANANCE PERIODS	DAILY	WEEKLY	MONTHLY
CABINS			
1) Control of wear plates in cabin		X	
2) Cleaning of steel shots that are accumulated in indents of cabin		X	
3) Control of protective plates and replacement if necessary		X	
4) Control of charge - discharge doors and their leakages	X		
5) Control of each welds		X	
PART HANGING CONVEYOR			
1) Control of tightness of conveyor		X	
2) Conveyor smoothness adjustment		X	
3) Worn or missing bolts, nuts, screws		X	
STEEL SHOT TRANSPORT SYSTEM			
1) Control of steel shot collector bunkers, feed funnels, helical feeders		X	
2) Elevator with buckets		X	
a) Tightness		X	
b) Smoothness adjustment		X	
c) Missing or worn buckets		X	
3) Control of feeding valve of wheel to see if it is working freely		X	
WHEEL			
1) Wheel vibration control	X		
2) Control of wheel blades	X		
3) Vibration control of rotating wheel while blades are detached and wheel protection plate is closed			X
4) Wear control of impeller and replacement if necessary		X	
5) Control of cage and replacement if necessary		X	
6) Control of wheel protection plates and replacement if necessary		X	
7) Steel shot propel angle control		X	
8) Ampere control of drawn current	X		
9) Calibration control of ammeter			X
10) Control of wheel V belt	X		
STEEL SHOT SEPERATORS			
1) Control of screens and cleaning	X		
2) Abrasion control of steel shot directing plates	X		
3) Check if steel shots coming from separator is distributed to wheels evenly while wheel is operating	X		
4) Control of channel to which coarse material that can not be separated from separator is discharged and check if pipes are open	X		
5) Check if there is still usable material in discarded material	X		
DUST COLLECTORS			
1) Check the air around shot blast machines if it is clean and there is no dust	X		
2) Check if there is a leakage from suction pipes			X
3) Check the adjustments of dumpers		X	
4) Control and recording of suction pressure	X		
5) Discharging of dust collecting silos	X		
6) Control of V belts of fans			X
7) Control if fan blades are worn			X
8) Check if sack shakers are operating	X		

SECTION 5
ABRASIVE SELECTION

Before selection of abrasive, detection of utilization purpose of steel shots in general is the most significant factor.

Utilization Purpose of Steel Shots;

Surface cleaning (Shot blasting)
Stress relief (Shot peen)
Cutting
Etching

Although almost only round steel shot is used for blast cleaning and shot peen, for cutting and etching purpose round angular grit is used with 75:25 ratio.
Surface cleaning means cleaning of oxides, sand, burrs, grinding marks of cast parts (eg. nodular irons, aluminum, steel castings or stainless steel castings). In the meantime, all the metal and steel construction products having unwanted oxide, scales etc. on their surface are in this group.
Stress relief is generally applied to parts such as spring and gear, that are subject to fatigue, to increase their fatigue resistance and generally round steel shots or rounded cut wire shots are used.
Cutting is applied to big granite blocks by means of steel shot - steel grid mixture having special and high hardness.
Finally etching is done to increase adhesion of the surfaces prior to coating operation. For example etching of bathtub prior to enamel coating.

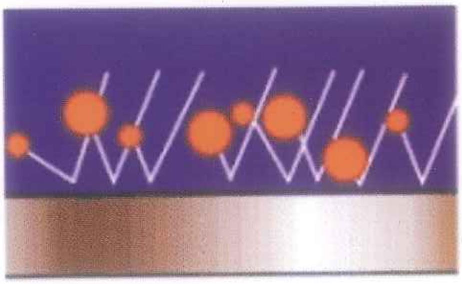
5.1. CORRECT SHAPE SELECTION

Abrasion behavior of round steel shots is layer by layer gradual abrasion. Surely surface profile obtained in this way is more soft and smooth.
Abrasion of angular grit is in the form of fast breakages because of its angular shape. In the grit blasting, surface profile is sharp angled, porous and grit consumption is very high.

SECTION 5
ABRASIVE SELECTION

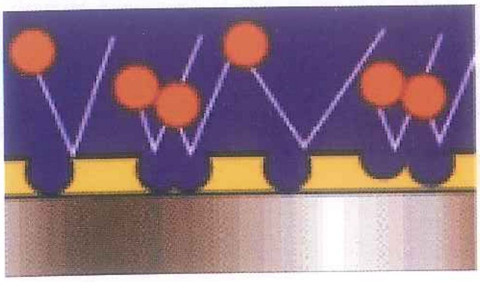
5.2. CORRECT SIZE SELECTION

In order to obtain a good surface quality there should be an optimal mixture of big and small shots as it can be seen in the below figure.

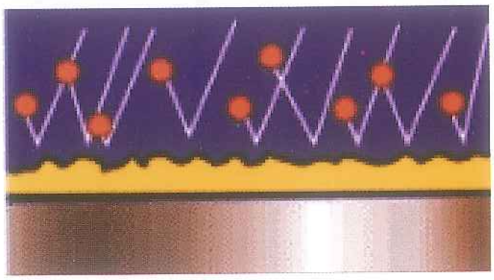


(Figure 55)

If there are mostly big sized shots in the mixture, even if it makes local cleanings it leaves hammering marks on the surface. Adversely if there are mostly very tiny particles in the mixture, requested cleanness can not be obtained. In the below figures these differences can be seen in detail.



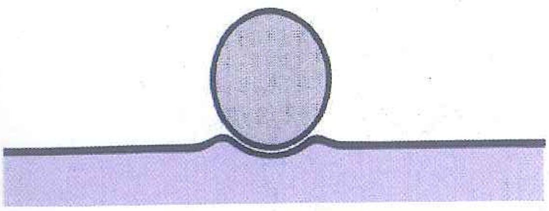
(Figure 56) Too coarse



(Figure 57) Too fine

5.3. CORRECT HARDNES SELECTION

General principal of shot blasting is that, steel shot is harder than cast part to be cleaned.



(Figure 58) Correct hardness

(Figure 59) Low hardness

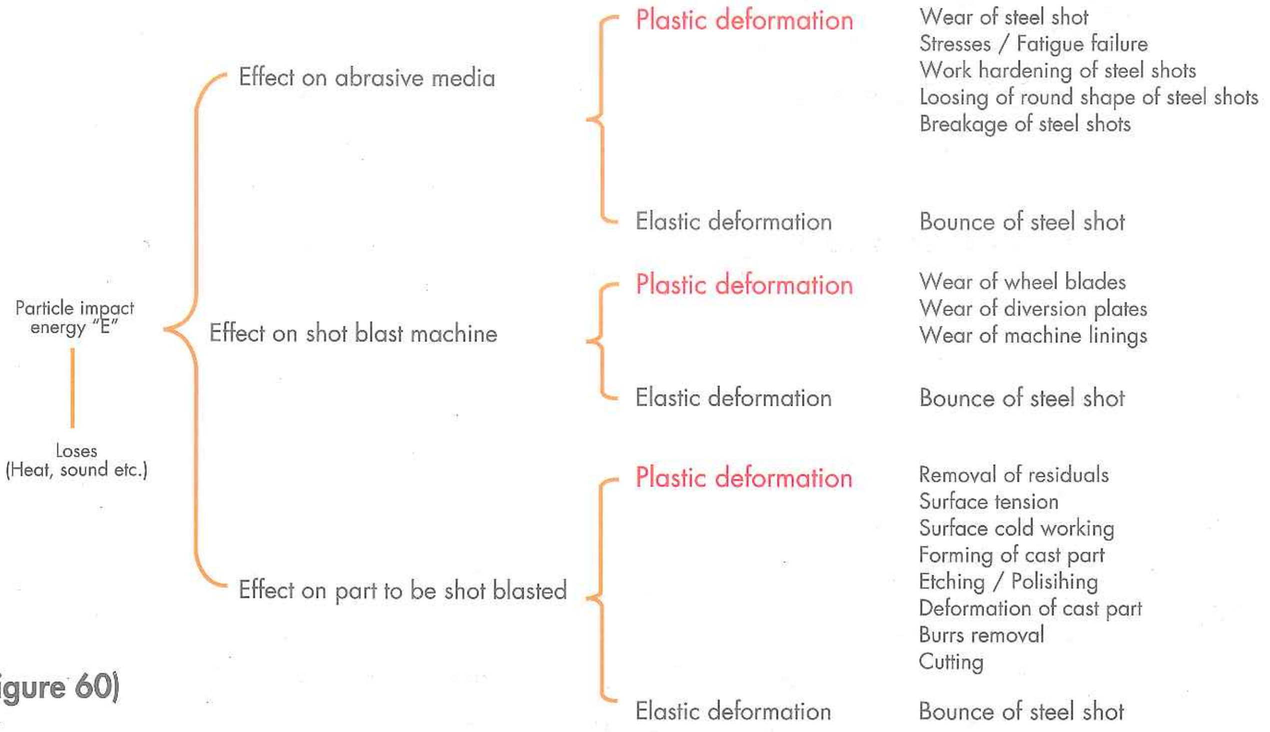
As it can be seen above, steel shots should not be contaminated by particles like sand, nail head, etc. During cleaning operation by using shot blast machines, physical interactions in the machine should also be metioned.

SECTION 5
ABRASIVE SELECTION

Propelled steel shots leave wheel blades with a certain kinetic energy.

Kinetic energy: $E = 1 / 2\ mv^2$
In this equation E is Energy , M is mass and v is velocity of the steel shot,
$m = Vs\ .\ d \Rightarrow Vs = 4/3\ p.r^3$ where Vs is volume, d is density and r is radius of steel shot.
Form here we obtain energy (E) as;
$E = 2/3\ p.r^3.d.v^2$

Energy transferred to part to be shot blasted is proportional to square cube and square of velocity of steel shot.
Kinetic energy of steel shot is continuously consumed during blasting operation. In the most ideal case energy will be consumed by the impact of steel shot on the surface of part. In Figure 60, it can be seen how this energy is spent and which interactions happen during blasting operation. On the other hand, in addition to interactions between abrasive and the part to be cleaned, there is also another interaction between shot blast machine and part to be shot blasted which is the least mentioned subject in literature. Important thing for the facility is selection of correct abrasive media and correct machine adjustments so that wear of machine and resulting maintenance stops will be minimized.
Each steel shot have a kinetic energy that is proportional to its mass and velocity. Steel shots that are accelerated by wheel transfers their its energy on the surface of metal.



(Figure 60)

SECTION 5

ABRASIVE SELECTION

Increasing the radius of steel shot by twice means energy will increase 8 times. For selection of steel shots, relation between radius increase of steel shot and energy transfer should be noticed. If we look at sizes of steel shots S780 and S390 we see that while 100 J energy is applied on cast part by on one S789 shot, S390 having half radius applies only 12 J.

Size	d (mm)	r (mm)	d (gr/cm3)	v (m/s)	E (joule)	New Abrasive	Operating Mix
S780	2,00	1,000	7,5	80	100.531	25.000	118.000
S660	1,70	0,850	7,5	80	61.739	42.000	198.000
S550	1,40	0,700	7,5	80	34.482	70.000	335.000
S460	1,18	0,590	7,5	80	20.647	121.000	558.000
S390	1,00	0,500	7,5	80	12.566	204.000	937.000
S330	0,85	0,425	7,5	80	7.717	336.000	1.572.000
S280	0,71	0,355	7,5	80	4.498	550.000	2.136.000
S230	0,60	0,300	7,5	80	2.714	924.000	4.971.000
S170	0,42	0,210	7,5	80	931	2.640.000	17.894.000
S110	0,30	0,150	7,5	80	339	7.481.000	37.593.000
S70	0,18	0,090	7,5	80	73	26.401.000	69.635.000

A part of the steel shots energy is used to remove residuals on cast part surface and remaining energy is used in breakage during bounce of steel shot from cast part surface. Energy transfer can be adjusted precisely by means of replacement of V belt transmission pulley. Best coordination is obtained by speed controlled wheel motors. Distribution of energy and deformation depends on physical properties such as surface hardness, elasticity, surface cracks and also depends on velocity, impact angle and metallurgical structure. For selection of shot blast machine, these criteria are very important. For an effective cleaning, selection of correct size of abrasive is the key factor.

Factors that shot blasting efficiency depend on;

- Nominal size of abrasive
- Sieve analysis of abrasive
- Hardness
- Morphology (spherical, angular, cylindrical)
- Propel velocity
- Flow rate
- Propel angle
- Blasting period

SECTION 5

ABRASIVE SELECTION

In the previous page, although first four factors are related to steel shot and its selection, other factors are completely related to correct adjustment of shot blast process and its settings. In other words, to obtain an effective and productive cleaning, only high quality steel shot utilization is not enough. All other parameters should be obtained at in the same time. General rule is to use finest possible steel shot that can remove residuals from cast surface.

As a result; In order to obtain a good surface, correctly selected steel shot should be used in a well adjusted machine. Together with cooperation of machine and steel shot producers, steel shot sizes that give best result for certain applications are indicated in following table.

STEEL SHOT SELECTION FOR SHOT BLAST MACHINES		
Part to be Cleaned	**Big and medium size**	**Small size**
CAST PARTS		
Steel castings	S 930 - S 780	S 660 - S 550
Heat treated steels	S 660 - G 12	S 550 - G 14
Surface cleaning and scale removal of ingots, blooms etc. in order to detect surface defects	S 280 S 230	S 230 S 170
Cleaning of sands from cast iron surface such as engine blocks, radiator, etc.	S 660 S 550	S 460
Cleaning before enameling of bathtubs and utensils	S 460 - G 16	S 390 - G 18
Cleaning of cast iron stoves, grill etc.		S 330 - G 25
Non ferrous metals and stainless steel cast parts	S 230 - S 210 G40 - 80	S 70 - G 80
STEEL CONSTRUCTION		
Heavy steel construction such as beam, angle iron etc (thickness 5-10 mm)	S 390 - S330	S 280-S 230
Britle and thin steel construction, pipe construction (thickness 2-6 mm)	S 230	S 170 - S 110 S 70 - G 80
Very thin steel sheets (0-2 mm), bolts, and nuts	S110 - G 50	
Cleaning before coating of wires, pressurized gas tubes	G 170 - G 25	S 110 - G 40
Stainless steel sheets		
3 - 5 mm.	S 170	G 40
1 - 2 mm.	S 110	G 50
0 - 1 mm.	S70	G 80 - 120
OTHER PRODUCTS		
Forged parts, forged blades etc.	S 660 - G 14	S 330 - G 18
Cleaning of worked parts after heat treatment	S 390 - S 330	S 230 - G 40
Sensitive cleaning of heat treated hand tools		S 230 - G 50
Cleaning of rolling mills after last pass and rectification Surface cleaning before hard metal coating	Angular grits having suitable size for requested surface cleaning and having hardness more than 60 HRc	
Shot blasting of metals to increase density	Fully spherical steel shot having suitable hardness for cast part.	
Parts to be coated by plastic material	G 18-G 25	G 40

SECTION 5

SURFACE CLEANESS AND ROUGHNESS

For evaluation of shot blast productivity of a cleaned part and surface quality; two criteria, surface cleanness and surface porosity are taken into consideration.

6.1. SURFACE CLEANESS

Surface cleaning is the removal of dirt, rust, scale, welding residuals etc from surface. Degree of surface cleaning is cleaning rate of all these impurities. Detection of this is completely visual and is made completely by comparison method. In general, Swedish standard SA (ISO 8501-1:1998) which is based on reference photos and comparison method is used.

Surface cleanness values corresponding to Swedish standards:

SA3	99% Completely cleaned
SA 2,5	96% Very good cleaned
SA 2	80% Good cleaned
SA1	< 80 % light cleaned

SWEDISH NORM	FRENCH NORM	ENGLISH NORM	USA	NACE	SSPC
SA 3	DS 3	1. Kalite	White Metal	Nace 1	SP5
SA 2,5	DS 2,5	2. Kalite	Almost White	Nace 2	SP11
SA 2	DS 2	3. Kalite	Commercial	Nace 3	SP6
SA 1	DS 1		Cleaned	Nace 4	SP7

Standards for surface cleanness

6.2. SURFACE POROSITY

This is the micrometric form also called as surface profile. It can be measured by devices having several reliabilities. For definition purpose, generally arithmetical porosity R_a and maximum porosity R max parameters are used. Apart from these R_z, R_t and P_c parameters are also used for more detailed analyses.

SOURCES

SOURCES

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