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# Re-Utilization of Shots for Shot Blast Machine by Design of Experiment: Solution for Environment Friendly disposition & better sustainability.

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***Abstract***
*The aim of this paper is to determine the importance of re-utilization of waste shots over shot blast process. During this shot blast process, we use shots as a abrasive media made of steel, aluminum, stainless steel, lead, zinc to prepare the input material ready for further processing like painting, black oxide or to remove the mild scaling, rust from the surface of the material to make material rust free, clean off containment particles like dust, oil or even to smooth the surface by removing burrs or sharp edges. These shots disposition is tedious and even very costly and hazardous to environment as shots having diameter from range less than 0.2mm to 3mm.*
***Keywords:*** *Shot blast, shots, disposition, 3R*

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## I. INTRODUCTION

Shot blast process consist of a centrifugal drum which rotates on certain specified RPM with material which need to be shot blast, during this shot with high velocity bombarded over the surface of material to achieve the desired result. By doing so, material on which shot blasting done, following results achieved:

- Target material become rust/scaling free.
- Target material become containment free from dirt/oil.
- Target material surface become free from burr/sharp edges.
- Target material surface become ready for further process like black oxide, painting etc.

Shot blast process mainly used in below mention industry:

- Aerospace industry
- Automobile industry
- Foundry industry
- Ship Building industry
- Construction industry

## II. SHOT BLAST OPERATION AT NEI

### 2.1 Why Shot Blast Operation Required?

NEIL facing issue of rust/scaling over the surface of the components like Cup/Cone of Taper Roller Bearing, Inner/Outer of Ball Bearing, and Cages of Needle Bearing for removing burr/sharp edges & to make material surface ready for further processing for Black Oxide operation.

### 2.2 Consumption of Shots

In Needle Bearing plant of NEIL, we are using Shot Blast machine of M/S Sinto Bharat Manufacturing model no. CNDX-01. On this machine monthly consumption of shots are approximate 500kg per month for running machine in single shift.

### 2.3 What is Steel Shot?

Steel shot is used as an abrasive media commonly used for shot blast process across the industry. Steel shots are spherical in size having diameter range or we can also define it as granularity from 0.125mm to 3mm. These sizes of shots are used as per the application requirement. Currently we are using 0.2mm shots for this application.

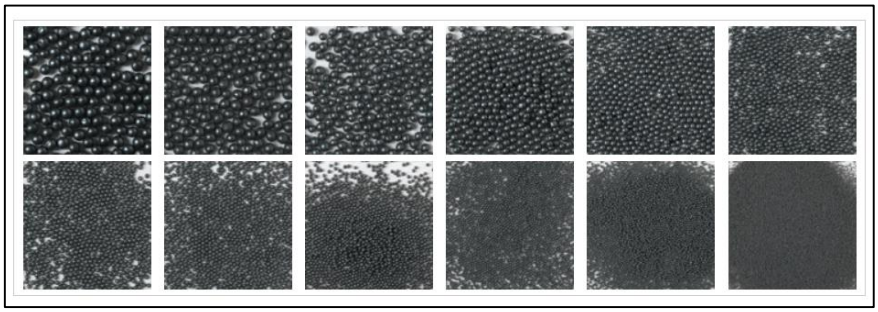

Fig1.1 Steel Shots according to Diameter Size/Granularity

### 2.4 Disposition Method of Steel Shots

**Recycling:** Steel shots can be recycled which reduces the amount of wastage and it also saves energy & resources. Recycling of shots can be done by sending shots to respective agencies.
**Landfilling:** If recycling is not possible then shots can be disposed of through government agencies and send to landfill sites which is also a threat to environment sooner or later.
**Incineration:** During this process shots burnt at higher temperature and during this process generation of air pollutants and greenhouse gases released due to which this process become less environment friendly and now a days after concern for carbon credit raised become obsolete.

### 2.5 Re-Utilization of Shots

As shots can be disposed of only in 3 ways i.e. recycling, landfilling & incineration. In view of carbon credit system and environment friendly & sustainable way of working we in NEIL develop the way to re-utilize the shots without doing any recycling over shots. For the same we tried certain number of experiments after doing brainstorming over process parameters of shot blast machine.

### 2.6 Brainstorming for Identification of parameters affecting Shot Blast Operation

For identification of shot blast operation parameters, brainstorming session conducted with metallurgy team. Following parameters identified during brainstorming session:

(1) Blasting Mode
(2) Drum Rotation Speed
(3) Blasting Time
(4) Impeller Speed
(5) Quantity of Shot during blasting

### 2.7 Operational Definition for Process Parameters

(1) **Blasting Mode**: Blasting mode is an angle on which shots bombardment done or drum swing angle. There are 3 angles i.e., 30-degree, 35-degree, and 30~35 degree.
(2) **Drum Rotation Speed**: Drum rotation speed means on which speed drum rotates during running cycle to agitate the product which can be shot blasted. In machine 2 options are given to run at "High" speed and "Low" speed.
(3) **Blasting Time**: Blasting time is the time during which shots bombardment done during running cycle i.e. duration of shot blasting cycle.

(4) **Impeller Speed**: The shot blasting operation is performed by the impeller rotating at a high speed, and the abrasive at the center of the impeller is pre-accelerated by a Regulator and an impeller, and is sent to the blade area to throw the abrasive at a high speed, and the speed can exceed 100 m/s. Impeller speed has 3 options i.e. High, Medium & low.

(5) **Quantity of Shots during Blasting**: Quantity of shots entered from blades in closed periphery of operation i.e. job, in the drum. For the same a gate is provided in machine from which shots entered the drum.

## 2.8 Experiments Planned on Shot Blast Machine over Used Shots

To plan the experiment for re-utilization of shots, job no. MLJL53949 identified. This job is continuously running over furnace and grinding line and having phenomenon of scaling during Heat Treatment operation due to criticality involved in maintaining environment of furnace. Total 72 number of experiments identified based on the variability in process parameters as shown in below mention table.

| Experiment No. | Job No | Blasting Mode | Drum Rotation Speed | Blasting Time | Impeller Speed | Gate Opening for Quantity of Shots |
|---|---|---|---|---|---|---|
| 1 | MLJL63949 | 30° | High | 8 Min | High | 50mm |
| 2 | MLJL63949 | 30° | High | 8 Min | High | 70mm |
| 3 | MLJL63949 | 30° | High | 8 Min | Medium | 50mm |
| 4 | MLJL63949 | 30° | High | 8 Min | Medium | 70mm |
| 5 | MLJL63949 | 30° | High | 8 Min | Low | 50mm |
| 6 | MLJL63949 | 30° | High | 8 Min | Low | 70mm |
| 7 | MLJL63949 | 30° | Low | 8 Min | High | 50mm |
| 8 | MLJL63949 | 30° | Low | 8 Min | High | 70mm |
| 9 | MLJL63949 | 30° | Low | 8 Min | Medium | 50mm |
| 10 | MLJL63949 | 30° | Low | 8 Min | Medium | 70mm |
| 11 | MLJL63949 | 30° | Low | 8 Min | Low | 50mm |
| 12 | MLJL63949 | 30° | Low | 8 Min | Low | 70mm |
| 13 | MLJL63949 | 30° | High | 10 Min | High | 50mm |
| 14 | MLJL63949 | 30° | High | 10 Min | High | 70mm |
| 15 | MLJL63949 | 30° | High | 10 Min | Medium | 50mm |
| 16 | MLJL63949 | 30° | High | 10 Min | Medium | 70mm |
| 17 | MLJL63949 | 30° | High | 10 Min | Low | 50mm |
| 18 | MLJL63949 | 30° | High | 10 Min | Low | 70mm |
| 19 | MLJL63949 | 30° | Low | 10 Min | High | 50mm |
| 20 | MLJL63949 | 30° | Low | 10 Min | High | 70mm |
| 21 | MLJL63949 | 30° | Low | 10 Min | Medium | 50mm |
| 22 | MLJL63949 | 30° | Low | 10 Min | Medium | 70mm |
| 23 | MLJL63949 | 30° | Low | 10 Min | Low | 50mm |
| 24 | MLJL63949 | 30° | Low | 10 Min | Low | 70mm |
| 25 | MLJL63949 | 35° | High | 8 Min | High | 50mm |
| 26 | MLJL63949 | 35° | High | 8 Min | High | 70mm |
| 27 | MLJL63949 | 35° | High | 8 Min | Medium | 50mm |
| 28 | MLJL63949 | 35° | High | 8 Min | Medium | 70mm |
| 29 | MLJL63949 | 35° | High | 8 Min | Low | 50mm |
| 30 | MLJL63949 | 35° | High | 8 Min | Low | 70mm |

| Experiment No. | Job No | Blasting Mode | Drum Rotation Speed | Blasting Time | Impeller Speed | Gate Opening for Quantity of Shots |
|---|---|---|---|---|---|---|
| 31 | MUL63949 | 35° | Low | 8 Min | High | 50mm |
| 32 | MUL63949 | 35° | Low | 8 Min | High | 70mm |
| 33 | MUL63949 | 35° | Low | 8 Min | Medium | 50mm |
| 34 | MUL63949 | 35° | Low | 8 Min | Medium | 70mm |
| 35 | MUL63949 | 35° | Low | 8 Min | Low | 50mm |
| 36 | MUL63949 | 35° | Low | 8 Min | Low | 70mm |
| 37 | MUL63949 | 35° | High | 10 Min | High | 50mm |
| 38 | MUL63949 | 35° | High | 10 Min | High | 70mm |
| 39 | MUL63949 | 35° | High | 10 Min | Medium | 50mm |
| 40 | MUL63949 | 35° | High | 10 Min | Medium | 70mm |
| 41 | MUL63949 | 35° | High | 10 Min | Low | 50mm |
| 42 | MUL63949 | 35° | High | 10 Min | Low | 70mm |
| 43 | MUL63949 | 35° | Low | 10 Min | High | 50mm |
| 44 | MUL63949 | 35° | Low | 10 Min | High | 70mm |
| 45 | MUL63949 | 35° | Low | 10 Min | Medium | 50mm |
| 46 | MUL63949 | 35° | Low | 10 Min | Medium | 70mm |
| 47 | MUL63949 | 35° | Low | 10 Min | Low | 50mm |
| 48 | MUL63949 | 35° | Low | 10 Min | Low | 70mm |
| 49 | MUL63949 | 30°-35° | High | 8 Min | High | 50mm |
| 50 | MUL63949 | 30°-35° | High | 8 Min | High | 70mm |
| 51 | MUL63949 | 30°-35° | High | 8 Min | Medium | 50mm |
| 52 | MUL63949 | 30°-35° | High | 8 Min | Medium | 70mm |
| 53 | MUL63949 | 30°-35° | High | 8 Min | Low | 50mm |
| 54 | MUL63949 | 30°-35° | High | 8 Min | Low | 70mm |
| 55 | MUL63949 | 30°-35° | Low | 8 Min | High | 50mm |
| 56 | MUL63949 | 30°-35° | Low | 8 Min | High | 70mm |
| 57 | MUL63949 | 30°-35° | Low | 8 Min | Medium | 50mm |
| 58 | MUL63949 | 30°-35° | Low | 8 Min | Medium | 70mm |
| 59 | MUL63949 | 30°-35° | Low | 8 Min | Low | 50mm |
| 60 | MUL63949 | 30°-35° | Low | 8 Min | Low | 70mm |
| 61 | MUL63949 | 30°-35° | High | 10 Min | High | 50mm |
| 62 | MUL63949 | 30°-35° | High | 10 Min | High | 70mm |
| 63 | MUL63949 | 30°-35° | High | 10 Min | Medium | 50mm |
| 64 | MUL63949 | 30°-35° | High | 10 Min | Medium | 70mm |
| 65 | MUL63949 | 30°-35° | High | 10 Min | Low | 50mm |
| 66 | MUL63949 | 30°-35° | High | 10 Min | Low | 70mm |
| 67 | MUL63949 | 30°-35° | Low | 10 Min | High | 50mm |
| 68 | MUL63949 | 30°-35° | Low | 10 Min | High | 70mm |
| 69 | MUL63949 | 30°-35° | Low | 10 Min | Medium | 50mm |
| 70 | MUL63949 | 30°-35° | Low | 10 Min | Medium | 70mm |
| 71 | MUL63949 | 30°-35° | Low | 10 Min | Low | 50mm |
| 72 | MUL63949 | 30°-35° | Low | 10 Min | Low | 70mm |

During the experiment, qty of jobs remain fixed during all 72 experiments i.e., 450 pcs.

## 2.9 Results Observed During Experiments

| Experiment No. | Job No | Blasting Mode | Drum Rotation Speed | Blasting Time | Impeller Speed | Gate Opening for Quantity of Shots | Results |
|---|---|---|---|---|---|---|---|
| 1 | MUL63949 | 30° | High | 8 Min | High | 50mm | NOK |
| 2 | MUL63949 | 30° | High | 8 Min | High | 70mm | NOK |
| 3 | MUL63949 | 30° | High | 8 Min | Medium | 50mm | NOK |
| 4 | MUL63949 | 30° | High | 8 Min | Medium | 70mm | NOK |
| 5 | MUL63949 | 30° | High | 8 Min | Low | 50mm | NOK |
| 6 | MUL63949 | 30° | High | 8 Min | Low | 70mm | NOK |
| 7 | MUL63949 | 30° | Low | 8 Min | High | 50mm | NOK |
| 8 | MUL63949 | 30° | Low | 8 Min | High | 70mm | NOK |
| 9 | MUL63949 | 30° | Low | 8 Min | Medium | 50mm | NOK |
| 10 | MUL63949 | 30° | Low | 8 Min | Medium | 70mm | NOK |
| 11 | MUL63949 | 30° | Low | 8 Min | Low | 50mm | NOK |
| 12 | MUL63949 | 30° | Low | 8 Min | Low | 70mm | NOK |
| 13 | MUL63949 | 30° | High | 10 Min | High | 50mm | NOK |
| 14 | MUL63949 | 30° | High | 10 Min | High | 70mm | NOK |
| 15 | MUL63949 | 30° | High | 10 Min | Medium | 50mm | NOK |
| 16 | MUL63949 | 30° | High | 10 Min | Medium | 70mm | NOK |
| 17 | MUL63949 | 30° | High | 10 Min | Low | 50mm | NOK |
| 18 | MUL63949 | 30° | High | 10 Min | Low | 70mm | NOK |
| 19 | MUL63949 | 30° | Low | 10 Min | High | 50mm | NOK |
| 20 | MUL63949 | 30° | Low | 10 Min | High | 70mm | NOK |
| 21 | MUL63949 | 30° | Low | 10 Min | Medium | 50mm | NOK |
| 22 | MUL63949 | 30° | Low | 10 Min | Medium | 70mm | NOK |
| 23 | MUL63949 | 30° | Low | 10 Min | Low | 50mm | NOK |
| 24 | MUL63949 | 30° | Low | 10 Min | Low | 70mm | NOK |
| 25 | MUL63949 | 35° | High | 8 Min | High | 50mm | NOK |
| 26 | MUL63949 | 35° | High | 8 Min | High | 70mm | NOK |
| 27 | MUL63949 | 35° | High | 8 Min | Medium | 50mm | NOK |
| 28 | MUL63949 | 35° | High | 8 Min | Medium | 70mm | NOK |
| 29 | MUL63949 | 35° | High | 8 Min | Low | 50mm | NOK |
| 30 | MUL63949 | 35° | High | 8 Min | Low | 70mm | NOK |
| 31 | MUL63949 | 35° | Low | 8 Min | High | 50mm | NOK |
| 32 | MUL63949 | 35° | Low | 8 Min | High | 70mm | NOK |
| 33 | MUL63949 | 35° | Low | 8 Min | Medium | 50mm | NOK |
| 34 | MUL63949 | 35° | Low | 8 Min | Medium | 70mm | NOK |
| 35 | MUL63949 | 35° | Low | 8 Min | Low | 50mm | NOK |
| 36 | MUL63949 | 35° | Low | 8 Min | Low | 70mm | NOK |
| 37 | MUL63949 | 35° | High | 10 Min | High | 50mm | NOK |
| 38 | MUL63949 | 35° | High | 10 Min | High | 70mm | NOK |
| 39 | MUL63949 | 35° | High | 10 Min | Medium | 50mm | NOK |
| 40 | MUL63949 | 35° | High | 10 Min | Medium | 70mm | NOK |
| 41 | MUL63949 | 35° | High | 10 Min | Low | 50mm | NOK |
| 42 | MUL63949 | 35° | High | 10 Min | Low | 70mm | NOK |
| 43 | MUL63949 | 35° | Low | 10 Min | High | 50mm | NOK |
| 44 | MUL63949 | 35° | Low | 10 Min | High | 70mm | NOK |
| 45 | MUL63949 | 35° | Low | 10 Min | Medium | 50mm | NOK |
| 46 | MUL63949 | 35° | Low | 10 Min | Medium | 70mm | NOK |
| 47 | MUL63949 | 35° | Low | 10 Min | Low | 50mm | NOK |
| 48 | MUL63949 | 35° | Low | 10 Min | Low | 70mm | NOK |
| 49 | MUL63949 | 30°-35° | High | 8 Min | High | 50mm | NOK |
| 50 | MUL63949 | 30°-35° | High | 8 Min | High | 70mm | OK |
| 51 | MUL63949 | 30°-35° | High | 8 Min | Medium | 50mm | NOK |
| 52 | MUL63949 | 30°-35° | High | 8 Min | Medium | 70mm | Partial OK |
| 53 | MUL63949 | 30°-35° | High | 8 Min | Low | 50mm | NOK |
| 54 | MUL63949 | 30°-35° | High | 8 Min | Low | 70mm | NOK |
| 55 | MUL63949 | 30°-35° | Low | 8 Min | High | 50mm | NOK |
| 56 | MUL63949 | 30°-35° | Low | 8 Min | High | 70mm | NOK |
| 57 | MUL63949 | 30°-35° | Low | 8 Min | Medium | 50mm | NOK |
| 58 | MUL63949 | 30°-35° | Low | 8 Min | Medium | 70mm | NOK |
| 59 | MUL63949 | 30°-35° | Low | 8 Min | Low | 50mm | NOK |
| 60 | MUL63949 | 30°-35° | Low | 8 Min | Low | 70mm | NOK |

| Experiment No. | Job No | Blasting Mode | Drum Rotation Speed | Blasting Time | Impeller Speed | Gate Opening for Quantity of Shots | Results |
|---|---|---|---|---|---|---|---|
| 61 | MUL63949 | 30°-35° | High | 10 Min | High | 50mm | NOK |
| 62 | MUL63949 | 30°-35° | High | 10 Min | High | 70mm | OK More than Specs |
| 63 | MUL63949 | 30°-35° | High | 10 Min | Medium | 50mm | NOK |
| 64 | MUL63949 | 30°-35° | High | 10 Min | Medium | 70mm | OK |
| 65 | MUL63949 | 30°-35° | High | 10 Min | Low | 50mm | NOK |
| 66 | MUL63949 | 30°-35° | High | 10 Min | Low | 70mm | NOK |
| 67 | MUL63949 | 30°-35° | Low | 10 Min | High | 50mm | NOK |
| 68 | MUL63949 | 30°-35° | Low | 10 Min | High | 70mm | NOK |
| 69 | MUL63949 | 30°-35° | Low | 10 Min | Medium | 50mm | NOK |
| 70 | MUL63949 | 30°-35° | Low | 10 Min | Medium | 70mm | NOK |
| 71 | MUL63949 | 30°-35° | Low | 10 Min | Low | 50mm | NOK |
| 72 | MUL63949 | 30°-35° | Low | 10 Min | Low | 70mm | NOK |

### 2.10 Finalization of Parameters for Used Shots

Based on the above trial results, experiment no. 50,62 & 64 give OK results.

| Experiment No. | Job No | Blasting Mode | Drum Rotation Speed | Blasting Time | Impeller Speed | Gate Opening for Quantity of Shots | Results |
|---|---|---|---|---|---|---|---|
| 50 | MUL63949 | 30°-35° | High | 8 Min | High | 70mm | OK |
| 62 | MUL63949 | 30°-35° | High | 10 Min | High | 70mm | OK More than Specs |
| 64 | MUL63949 | 30°-35° | High | 10 Min | Medium | 70mm | OK |

From this summarized table, OK results observed on blasting mode 30°-35°, Gate opening for quantity of shots at 70mm. Blasting time we keep at 8 Min to maintain the cycle time of process at minimum level with impeller speed at High. Based on that following parameters are finalized on used shots:

Blasting Mod: 30°-35°
Drum Rotation Speed: High
Impeller Speed: High
Blasting Time:8 Min
Gate opening for Quantity of Shots:70mm.

### 2.11 Conclusion

Based on the above experiments, we can utilize used shots without any recycling and at same cycle time without affecting productivity and desired quality. Blasting mode and gate opening for quantity of shots are the main critical parameter for re-utilization of used shots. By doing this experiment, we are able to save around 3600kg shots which in turn reduce over process cost, scrap cost and also make our environment green and clean bu reducing the consumption of shots.