INVESTIGATION ON WEARING OF BLADE OF SAND MIXER USED IN FOUNDRY INDUSTRY TO ENHANCE THE LIFE OF THE BLADE

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ABSTRACT

The Foundry sand mixer is very ruggedly constructed from heavy steel sections, with a fixed mixer pan, all mounted on substantial base frame. The motor is installed horizontally, driving the gearbox through a flexible coupling. The rotating mixer unit consist of mixing rotor, which rotate on their own axis and simultaneously revolve around the tank circumference. Rotor consist of three mixing arm with replaceable wear blades. The integral charge hopper, built into the top of the mixer cover, feeds sand into the mixer. Discharge of the regenerated sand from the mixer is achieved by means of a large opening in the pan of the unit. This consists of a circular segment, which opens to allow for the rapid discharge of sand to take place in 10 to 12 seconds. The blade rotation compresses and cascades sand from the ribbed walls to the centre dome. The continuous vortex action created by this tumbling motion produces highly effective mixing. The batch is prepared in a short cycle time, and is discharged as a completely aerated and perfectly homogenous mixture. The present paper analyzes wear causes of a revolving-blade mixer with the most important of them- sticking of grains between the blade end and the bottom. Various hardfacing operations are recommended to reduce the wearing of blade.

Keyword : - *Sand mixer, blades ,wear, foundry sand , hardfacing , SAW*

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1. INTRODUCTION

The Indian Foundry Industry is well established. According to the recent World Census of Castings by Modern Castings, USA India Ranks as 2nd largest casting producer producing estimated 7.44 Million MT of various grades of Castings as per International standards. Sand casting, also known as sand molded casting, is a metal casting process characterized by using sand as the mold material. It is relatively cheap and sufficiently refractory even for steel foundry use. A suitable bonding agents are mixed with the sand with the help of sand mixer. Quality uniform silica sand is used to make moulds and cores for ferrous and nonferrous metal castings. The metal casting industry annually uses an estimated 100 million tons of foundry sand for production. The proper blending of these materials enhances desirable properties for moulding. The properties of moulding materials are very vital to the production of sound dimensionally accurate castings Therefore, Sand mixing is process of concern during production of casting. The objective of sand mixing using a mixer is to achieve a uniform distribution of sand grains, since this affects permeability and surface fineness. Uniformly mixed sand gives high flowability. The grain size distribution also influences strength properties of bonded mixtures. An inverse relation exists between compression strength and grains size with a uniform bond coating.

This property is necessary to be maintained under mixer operation when its all elements are constantly affected by wear. Under intensive wear of separate mixer elements (blades, fretting, blade holders, bolt, shafts) its operation parameters change. Upon increase of the gap between the blade end and the mixer body fretting, grains of various sizes get into the gap and get stuck and crushed, thus increasing power consumption, intensifying wear of the device elements and decreasing substance mixing quality.

In Jayswal NECO Industries limited two moulding lines are used for the casting production i.e. HSP line and ARPA line. Sand mixer of 1500 Kg capacity is used on HSP line. 700 kg of prepared sand is required per mould box. 130 such moulding boxes are prepared per shift during production. Thus 91000 kg sand is mixed per shift with the help of sand mixer. As mixer has to work continuously, mixer blades wear out frequently which need to be replaced or repair after 50 to 60 days. Hence the clearance gap between side of the blades and bottom of the mixing pan increases because of which improper mixing takes place and desired properties will not be imparted in prepared sand. Also power consumption of the mixer increases as torque increases. 1-2 % of castings are rejected due to sand related defects. Also life of the mixer decreases because of frequent maintenance.

2. LITERATURE REVIEW

The main causes for wearing-out of a revolving blade mixer like Loads occurring at transmission starting; Accidental occurrence of hard grains together with Mixed substance; Intensive wearing of blades and bottom[1]. Three body abrasive wear is the wear in which particles are trapped between two solid surfaces but are free to roll as well as slide. With increase in sliding distance and load, wear volume increases for three-body abrasive wear. The specific wear rate increases with increase in load in case of three-body wear [2]. The amount of the removed material can be estimated with the aid of the wear depth and the wear profile. They are useful measures of the wear process, and they can be described with the aid of the wear laws [3]. Hardfacing is the most versatile process to improve the life of the worn-out component, Different alloying elements can be introduced in to the base metal in the form of weld consumables to achieve any desired property like hardness, wear resistance, abrasive resistance, crack resistance etc. [4]. Hardfacing, also known as “Hardsurfacing”, is the application of build-up of deposits of specialized alloys by means of welding process to resist abrasion, corrosion, high temperature, or impact. Shielded metal arc welding (SMAW) is most commonly used process for hardfacing due to its easy availability and versatility .From this paper, a detailed study was done to study the effect of different compositions of iron based hardfacing electrodes on stainless steel, deposited by SMAW process [5]. Chromium-rich electrodes are widely used due to low costand availability; however, more expensive tungsten or vanadium-rich alloys offer better performance due to a good combination of hardness and toughness. Complex carbides electrodes are also used; especially when abrasive wear is accompanied by other wear mechanisms [6]. A wide variety of hardfacing alloys are commercially available for protection against wear [7].

3. FOUNDRY SAND MIXER WORKING PRINCIPLE

The Sand Mixer was designed to quickly, uniformly and mechanically manipulate a heterogeneous mass of sand materials, of varying aggregate sizes, into uniformly blended and bonded homogenous product. Improper mixing of sand is the root cause for the defects associated with moulding sand produced in casting. To maintain the permeability, green compression strength of the sand all the additives like bitumen, coal dust, moisture content must be properly mixed with sand within the time. One cycle of mixing takes 180 sec for the mixing process completion. General process characterization is as follows

TIME (S)	ADDITIVES/CONSTITUENTS
0-5	Idle rotation of mixer
5-20	Sand addition from hopper
20-25	Betonite addition

25-30	coal dust addition
30-35	Water addition
35-170	Mixing
170-180	Sand discharge

Table 1- Mixing process characterization

Fig. 3.1 Foundry sand mixer used in HSP line

3.1 GEOMETRICAL PARAMETERS OF FOUNDRY SAND MIXER

Following are the geometrical parameters for the sand mixer used in HSP line.

Sr. No.	Component	Specification
1	Mixer pan	Diameter= 1670mm, Height= 1250mm
2	Shaft	Diameter= 105 mm
3	No. of blades	3
4	Electric motor	75 HP, 3 Phase
5	Mixer capacity	1500 kg/ cycle
6	Cycle time	180 sec
7	Angle of inclination of blade with bottom	35 degree

Table 3.1- Geometrical parameter of mixer

4. GENERAL PROCEDURE TO INVESTIGATE WEARING OF MIXER BLADE

Wear is a systems problem. The process of accurately detailing an abrasive wear failure consists of a series of defined tasks undertaken by the failure analysis specialist. Each task is designed to obtain specific information from the failed components and system. These tasks are generic to most failure analysis investigations and can be summarized in the following list

1. Identify the actual materials used in the worn part, noting also the operating environment.
2. Identify the specific wear mechanism, or combination of wear mechanisms, that caused the loss of material or change in the surface dimensions: adhesive wear, abrasive wear, corrosive wear, surface fatigue, erosive wear, and so on.
3. Determine the change in the overall dimensions to the surface configuration between the worn surface and the original surface.
4. Determine the force or contact pressure between mating surfaces or between the worn surfaces that is, the counter faces and the abrasive particles, on both the macroscopic and the microscopic level.
5. Determine the wear rate by calculating the material loss over some unit of time or distance.
6. Establish whether the observed wear is normal or abnormal for the particular application.
7. Devise a solution.

4.1 BLADE MATERIAL ANALYSIS

Chemical analysis of the blade material is carried out with the help of spectro machine. Following constituents are obtained in the analysis:

Constituents	Quantity (%)
Carbon	**0.19**
Silicon	**0.44**
Manganese	**1.39**
Phosphorus	**0.013**
Sulphur	**0.012**
Chromium	**0.028**
Nickel	**0.046**
Titanium	**0.029**

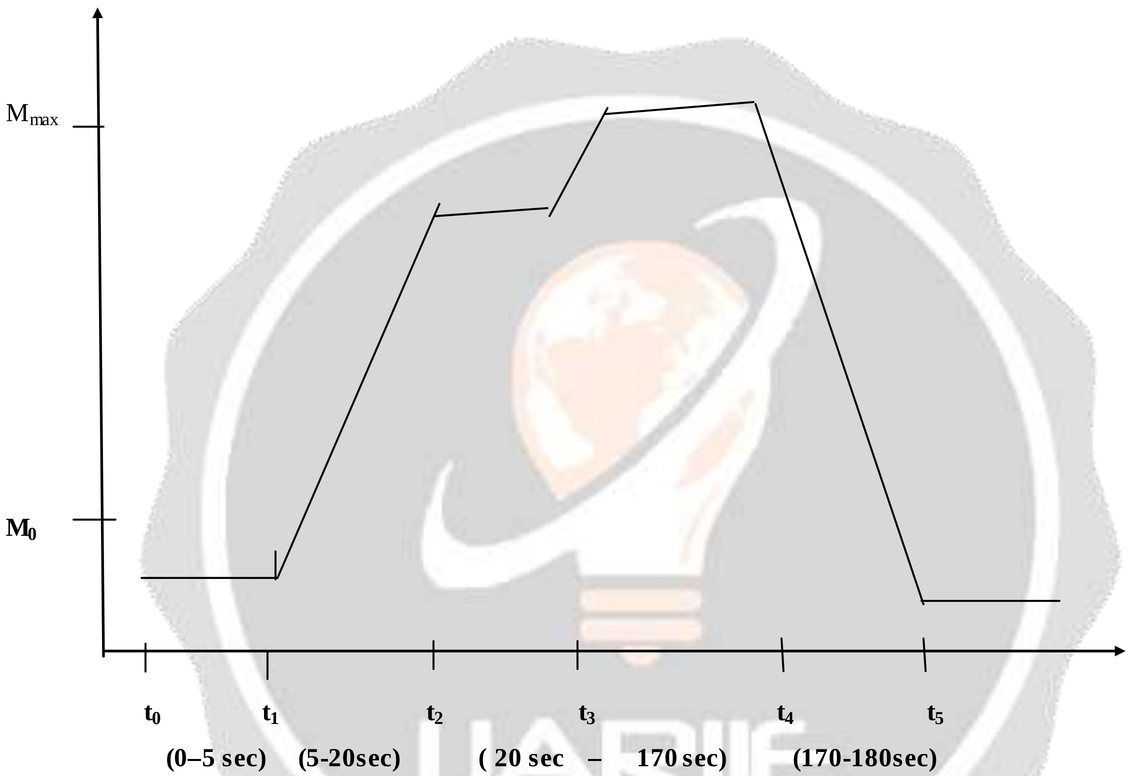
Table- 4.1. Spectroanalysis of the existing blade

From the above analysis it is concluded that the material of the blade is medium carbon steel with **EN8** grade and **hardness is 170 Rc.**

4.2. MECHANISM OF WEARING OF FOUNDRY SAND MIXER BLADES

During mixing operation mixer blades rotates against the mass of the sand cutting the mass of the sand. As sand is abrasive material it wears out the blade surface. The mechanism of wearing is abrasive.
After no. of cycles the clearance gap between edges of the mixer blade and bottom increases which results in deposition of sand layer at the bottom of the pan. Thus it causes excessive friction between blade edge and deposited sand layer which results in wearing of the blade

The mixer operating cycle consists of technological operations performed according to a specified sequence. The lowest moment needed to rotate an empty mixer is *M0*. After loading it with dry sand (MM) and adding bitumen afterwards, the moment of resistance to rotate mixer shafts increases to Mmax· After mix is completed and upon unloading this mixture from the mixer torsion moment rapidly decreases from *Mmax* to M0. Below figure represents the variation in torque according to time.



Graph- variation in moment with respect to time

4.3 WORN BLADE SURFACE IDENTIFICATION

Usually Blade bottom and side edges wears out which is the basic cause of failure. As the gap between mixer bottom and blades bottom edge increses sand properties changes which results in casting defects. It is often responsible for rapid wearing of the blade. It has been observed that 8 to 10 mm material worn out due to wearing of the blade.

Fig 4.3.1. Worn Mixer Blade

5. EXPERIMETATION TO IMPROVE HARDNESS OF THE BLADE

Several welding techniques such as oxyacetylene gas welding (OAW), gas metal arc welding (GMAW), shielded metal arc welding (SMAW) and submerged arc welding (SAW) can be used for hardfacing. The most important differences among these techniques lie in the welding efficiency, the weld plate dilution and the manufacturing cost of welding consumables. In this study submerged arc welding process is used for hardfacing.

A. Base Metal

Identification of base metal is very essential in deciding what alloy to use for hardfacing deposit. Since welding procedure differs according to the base metal. The base metal identified is mild steel with EN8 grade which composes the main elements of carbon, silicon, manganese, sulphur, and phosphorous. The chemical composition is shown in Table 3.10.1.

C	Cr	Si	Mn	P	S	Ni	Ti
0.19	0.028	0.44	1.39	0.013	0.012	0.046	0.029

Table5.1 Chemical composition of blade material

B. Hardfacing Alloys

Fig. 5.1 EL8 Electrode Wire

Electrode EL8 is selected as hardfacing alloy used for overlaying. These alloy is selected due to its low cost and easy availability in the local market and suitability for the service condition (low stress abrasion). They are basically iron based alloys having varying amount of chromium, carbon, silicon and other alloying elements as they are more suitable for submerged arc welding process. Chemical compositions of the electrode are presented in Table 5.1.

C	Mn	Si	S	P
0.10	0.25-0.60	0.07	0.03	0.03

Table 5.2 Chemical composition of electrode EL8

Whilst the wire is relatively simple and is designed to match the parent metal composition and/or mechanical properties, the flux is far more complex. The functions of the flux are:

- To assist arc striking and stability
- To form a slag that will protect and shape the weld bead
- To form a gas shield to protect the molten filler metal being projected across the arc gap
- To react with the weld pool to provide clean high quality weld metal with the desired properties
- To deoxidize the weld pool
- To provide deoxidants
- In some circumstances, to provide additional alloying elements into the weld pool

The agglomerated flux is used during the operation. It may be neutral, basic or highly basic. They are made from a wet mix that is corned, dried and baked to achieve a low moisture content. This low temperature process means that strong deoxidants and ferro-alloys can be incorporated without being lost. The binders used in the corning process, however, are hygroscopic so that moisture pick-up can be a problem on the shop floor. Baking of the flux prior to use may be necessary and if the flux is not used within a specified (short) timeframe, the flux hoppers on the welding equipment should also be heated, to limit moisture pick-up during storage. Although a small particle size is capable of carrying a higher current, too many fines in the flux will give rise to gas being trapped between the slag and the weld pool. This will result in unsightly gas flats or pockmarking on the weld surface. To avoid this, the recirculating system should be equipped with filters to remove both large particles of detached slag and the fine dust.

Figure 5.2 Agglomerated flux

C. Welding Conditions

The standard size test specimens of with the dimensions of 250×100×12 mm were selected for the experiment. The following precautions are taken before hardfacing.

• The electrodes are perfectly dried in the furnace and baked at 250oC one hour before the use
• Area of the weld is properly cleaned
• Preheated the hardfacing area to a minimum of 200^0C

D. Methodology

The experiment was carried out to investigate the effect of current, travel speed and voltage on hardfacing electrodes, and the corresponding hardness was determined. Standard specimen of size 200X80 mm used for the test is shown in figure. Also Process parameters selected for the process is shown in table

Standard test specimen of size

PROCESS PARAMATERS SELECTED FOR THE SAW WELDING

Sr. No.	Parameters	Values
1	Current	200- 300 Amp
2	Voltage	25-30 V
3	Diameter of electrode	3 mm
4	Traversing speed	2.5 mm/ sec

Table5.3- SAW Process Parameters

E. Testing Results

After hardfacing testing was carried out to analyse the chemical composition of all weld composition. After chemical analysis of hardfaced plate following composition is obtained

C	Si	Mn	P	S
0.04	0.19	1.14	0.024	0.011

TABLE-5.4 All weld chemical composition

Density	Young's modulus	Tensile Yield Strength	Tensile ultimate strength	elongation
7800 kg/m^3	205 GPa	432 GPa	485 GPa	32%

TABLE- 5.5 Mechanical properties of all weld composition

Thus the hardness of the blade after hardfacing increases up to 300 Rc

6. CONCLUSIONS

The investigation on wearing of sand mixer blades demonstrates that blades are most often replaced compared to other mixer elements, and need to be replaced 2 to 3 times more frequently than other replacement elements. Their surfaces are mostly affected by abrasive mix components. Under the effect of abrasive environment the geometry of blades changes. Average operation time of such blades does not exceed approximately 1440 hours.
As we discuss in comparative evaluation and in result section, the wear resistance properties of the mixer blades increases by improving the hardness of the blade. Hardfacing done by Submerged arc welding is the automatic hardfacing process in which desirable wear resistant properties are diluted on base metal by selecting proper electrode and flux.

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