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# Analysis of Casting Defects and Identification of Remedial Measures – A Diagnostic Study

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***Abstract—Paper presents analysis of casting defects and identification of remedial measures carried out at Dakshin Foundry Ltd, Bangalore, India. Diagnostic study carried out on Trunion Support Bracket (TSB) Castings revealed that the contribution of the four prominent defects in casting rejections are sand drop, blow hole, mismatch, and oversize. It was noticed that these defects are frequently occurring at particular locations. Systematic analyses were carried out to understand the reasons for defects occurrence and suitable remedial measures were identified. Outcome of the validation trials showed substantial reduction in rejection of castings. Company has accepted the remedial measures and incorporated them in the standard operating procedure.***

## I. INTRODUCTION

Dakshin Foundry is facing casting rejections due to some chronic defects, after observing six months' data of the company the most frequently rejected castings identified were TSB, Converter Housing, and Gear Housing. Out of these three castings TSB casting was identified as most severely affected casting, hence it was considered for detail investigation. The work on Quality Improvement of castings was carried out in following steps.

- Identification of defects in the TSB casting and analysis
- Selection of most chronic defects which frequently occurred and carried out the analysis.
- Identification of root causes and finding the remedial measures.
- Production trials in the company with the remedial measures and validation.

## II. IDENTIFICATION OF CASTING DEFECTS AND ANALYSIS

The frequently rejected castings identified at Dakshin Foundry are Trunion Support Bracket (TSB), Converter Housing, Gear Housing etc. TSB casting comprises 15-20 percent of total production of the company. The number of castings produced in the month of June 2010 and their weight, quantity and cost per kg are given in Table 1. As the production of TSB is maximum and its cost of rejection is highest this casting was considered for detail study. TSB casting is having defects such as sand drop, blow hole, shrinkage, mismatch, sand fusion, core shift, parting line leak, oversize, flash, mould not filled, cold shut etc. The data observation of defects in TSB for six months period from June 2010 to Dec 2010 is plotted as Pareto Chart shown in Figure 1. It may be noticed that the most occurring casting defects are Sand drop, Blow holes, Mismatch, and Oversize hence they were picked up for diagnostic study. To understand the reason for causes of these four defects a detail study was carried out in foundry.

## III. PRODUCTION PROCESS OF TSB CASTING

Photograph of the TSB casting is shown in Figure 2. Details of sand systems used for mould and core making are explained hereunder [1], [2].

**Sand System used for Mould making:**
Sand: Silica sand 98.5 %
Binder: Urea Furan Resin 1% of sand
Catalyst: 0.5% of resin
Silica sand comprises 85% reclaimed sand and 15% new sand with AFS number 45 to 55, clay content 0.27% (max), and moisture 0.5% (max). Mixing of sand and binder along with catalyst is done in 20 tonne mixer for 3 to 4 minutes.

**Sand System used for Core making:**
Four cores are used in TSB casting, these are central core, breaker core, U cut core, flat core.
Sand system used for *central core, U cut core, breaker core* are;
Sand: Silica sand 98.5 %
Binder: Urea Furan Resin 1% of sand
Catalyst: 0.5% of resin
Sand system used for *flat core* are;
Sand: Silica sand 96.5 %
Binder: Sodium silicate 3.5 %

For all the cores fresh silica sand is used, in case of resin bonded core the sand system is prepared as explained above for moulding sand system. And for sodium silicate – Co2 sand system mixing of fresh silica sand and sodium silica is done in mixer for 3 minutes. Soon after the mixing core sand mix is taken to core box and adequately rammed, after the ramming Co2 gas is passed into core box for 60 seconds. After the moulds and cores are cured, and securing them properly the molten metal is poured and allowed to solidify. After 8 hours of pouring shakeout of casting is done and processed further. Inspection of casting is done at different stages as per the requirement [2].
Chemical constituents of TSB casting are: Fe 92-94%, C 3.20-3.60%, Si 2.20-2.60%, Mn 0.60%, P 0.05%, S0.015%, Mg 0.025-0.050%, etc.

## IV. CASTING DEFECTS ANALYSIS AND REMEDIAL MEASURES

Analysis for causes of most frequently occurring four defects of TSB casting are carried out. The reason for occurrence of these defects and their remedial measure are briefly given in Table 2. Due to nature of defects they were analysed by observation in the shop-floor for quite a long period and assessed. Wisdom of the experts in the company and long experience of the authors in the field of foundry technology has helped in identifying the nature of causes. Repeated trials were carried out in the foundry to arrive at appropriate remedial measures.

## V. VALIDATION WITH PRODUCTION TRIALS

Production trials on TSB casting were carried out in the company after incorporating the remedial measures identified and reported in section 4 above. There is a substantial improvement in quality resulting in reduction in rejection levels of castings, details are given in Table 3. For the purpose of comparison four months data of TSB Casting before implementation of remedial is compared with four months data after implementation of remedial measure, details of validation trials are presented here below. And it is noted that number of TSB castings produced during these four months period are; 2657 and 2730 respectively of the years 2010 and 2011. Since difference in production quantity is only about 2.7% it is considered as same for the purpose of comparisons of rejection quantity before and after implementation of remedial measure.

**(i) Remedial measure trial for sand drop defect**

As reported Table 2 loose sand at chill and moulds interface left un-cleaned at long member that was resulting in sand drop in this location. This was happening due to carelessness of operators. Strict instructions were given to the operators for ensuring the proper cleaning of moulds before closing and not cleaning the mould when two moulds are near. That suggestion is also revised in mould making checklist. By proper monitoring of cleaning moulds before closing, it was observed that before remedial measure 52 castings were rejected due to sand drop found around long member but after implementation of remedial measure only 18 castings were rejected during four months period. The reduction in castings rejection was observed as 65.4%.

The second reason for rejection of TSB casting due to sand drop found around square pad area. Due to sleeve top hole, the sand enters through sleeves and gets collected around the bottom of surface of top and bottom pad. Here also improper cleaning of sleeve hole was reason for rejection due to sand drop. The remedial measure taken was to cover the sleeve top hole by paper and clean the hole by air blowing and remove the paper before pouring. After implementation of this small correction, castings rejection reduced by 75.6%, details are given in Table 3.

Core oversize and core end broken were also found responsible for rejections of TSB casting, due to these reason sand drop observed around cross member. To overcome the problem loose piece design modified in core box, and also two pads were provided at the bottom face of core. The remedial measure implemented and observed the rejections data for last four month which showed 84.6% reduction in rejections.

**(ii) Remedial measure trial for blow-hole defect**

To overcome the TSB casting rejections due to blow holes observed at chill interface area the position of flow offs in gating design was modified. The placement of flow offs at the right position in gating system was very difficult but after taking 3 to 4 trials and observation, it was found that the correct position of flow offs on the top surface of long member only. This change brought down the rejection level by 67%.

**(iii) Remedial measure trial for mismatch defect**

The inadequate numbers of locators were found to be responsible for mismatch of TSB casting. Initially only three metallic locators were placed to locate bottom and top mould, but in order to resist mould or core movement some more locators were required. At the time of trials the mounting of extra number of locators was found difficult. During first trial only two locators were mounted in diagonally opposite direction, but this concept didn't show much improvement. Then in second trial three locators were placed in a triangular manner, the two locators were placed on a single line and third opposite side of the line. There are three cavities provided at the pattern and three self sand mould locators build for the cavity. Now the six locators (metallic and self sand) are used to overcome the problem of mismatch. The four month rejection data shows that before remedial measure the rejections were 43 castings due to mismatch but after remedial measures only 7 castings rejected, which show 83.7% improvement in mismatch.

**(iv) Remedial measure trial for oversize problem**

Oversize of casting was another reasons for rejection of TSB casting. Due to mould bulging and mould lift oversize of castings used to take place. This was happening due to improper clamping of moulds. Initially in the first trial only c- channel clamp was provided at sideways. But it was found that this measure was not suitable to control mould bulging at centre. Then in the second trial along with sideways channels an intermediate c- channel clamp was provided. This measure reduced the casting rejection by 77%.

After confirming with four months results by adopting remedial measures and noticing the substantial quality improvement, company accepted the measures suggested in the work. Standard operating procedures of the company were revised by incorporating the suggested measures.

## VI. CONCLUSION

Diagnostic study carried out on TSB Castings revealed that the contribution of the four prominent defects in casting rejections are Sand drop, Blow hole, Mismatch, and Oversize. It was noticed that these defects are frequently occurring at particular locations. Systematic analyses were carried out to understand the reasons for defects occurrence and the reasons identified are;

- The causes of **sand drop** were found due to improper cleaning of mould in the areas around chills and mould interface, sleeve, and breaker core.
- **Blow holes** occurrence around long member is due to failure to connect flow off in the gating design.
- The **mismatch** of castings is due to lack of locators and improper setting of cores.
- Casting **oversize** is due to mould lift and mould bulging.

Remedial measures identified to overcome the above defects are;

(i) *Sand Drop:* Proper cleaning of the mould before closing, ensure that sand don't enter into the sleeve, replace no-bake core with shell core, provide pads at bottom face, and modified the loose piece design to avoid core crushing.
(i) *Blow Hole:* Modification of gating system; flow offs are to be directly connected on top surface of long member.
(ii) *Mismatch:* Provided six locators for proper setting of cores - three are of metallic and three are self locators.
(iii) *Oversize:* Clamp the moulds properly to withstand the pouring pressure – Clamp centre channel with C-Clamps during metal pouring.

Production trials were carried out in the foundry for four months period by incorporating the above remedial measures and validated. Outcome of the results showed substantial reduction in rejection of castings. Company has accepted and adopted the remedial measures suggested in the production methods, also suitably modified the standard operating procedure.

## REFERENCES

**1.** British Cast Iron Research Association, 'BCIRA broadsheets', BCIRA, 1986.
**2.** Apex Company (Dhakshin Foundry) Manual.
**3.** American Foundry Men's Society, 'Analysis of casting defects', American Foundry Men's Society, USA, 1974.

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| Casting Name | Weight (Kg) (A) | Produc-tion Quantity | Rejection Quantity (B) | Cost (Rs) per Kg (C ) | Cost of Rejection, Rs (A×B×C) |
|---|---|---|---|---|---|
| TSB | 83 | 748 | 40 | 99 | 328,680 |
| Converter Housing | 250 | 70 | 5 | 95.5 | 119,375 |
| Gear Housing | 202 | 23 | 5 | 349 | 96,455 |

Rs: Indian Rupe

**Table 1 Details of Rejected Castings in June 2010**

| SI. No. | Defect Name | Defect Location | Causes | Remedial Measure (RM) |
|---|---|---|---|---|
| 1 | **Sand Drop** | Long member | Chill and mould interface not cleaned properly | Before closing the mould, ensure the cleaning of mould, chill and mould interface. |
| | | Square pad area: Top & Bottom 40 mm area Around Breaker Core | Sleeve inside loose sand not cleaned up | Close the sleeve top hole by covering paper before mould closing and remove at the time of pouring. |
| | | | Loose sand around the breaker core is due to improper sand ramming | Replace No-Bake core with Shell core |
| | | Cross member | Core crushing while core setting. | Loose piece design modified |
| | | | Core end broken and fallen inside mould | Two pads provided at the bottom face |
| 2 | **Blow Hole** | Around chill interface area | Failure to connect Flow Offs | Flow off provided on the casting face |
| 3 | **Mismatch** | Around the Bore | Lack of locators in pattern and improper setting of cores | Provide six locators three are metallic and three are self locator |
| 4 | **Oversize** | | Improper clamping of moulds, mould lift and mould bulging | Centre clamping with C-clamps |

**Table 2 Major Sand Drop Location, Causes & Remedial Measure**

| SI. No. | Defects | Defect Location | Rejection* Before RM (Quantity) | Rejection** After RM (Quantity) | Reduction in Rejection (percent) |
|---|---|---|---|---|---|
| 1. | Sand Drop | Long member | 52 | 18 | 65.4 |
| | | Square pad area | 41 | 10 | 75.6 |
| | | Cross member | 26 | 4 | 84.6 |
| 2. | Blow Holes | Around chill area | 36 | 12 | 67.0 |
| 3. | Mismatch | Around bore | 43 | 7 | 83.7 |
| 4. | Oversize | - | 48 | 11 | 77.0 |

RM: Remedial Measure, ***** During March – June 2010, ****** During March – June2011

**Table 3 Rejection Control after Remedial Measure**

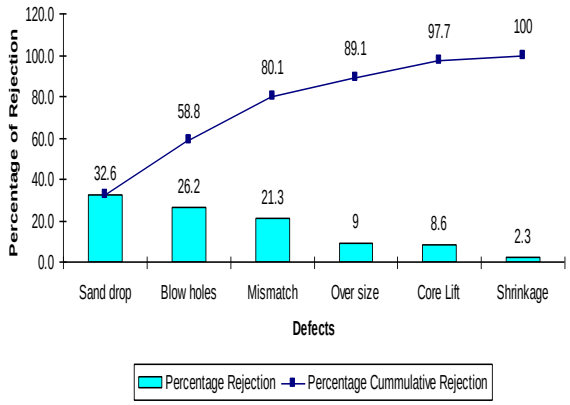


***Figure 1 Pareto Diagram of Defects in TSB Casting***

***Figure 2 Photograph of TSB Casting***