UNIQUE WAYS OF REJECTION CONTROL – SOME CASE STUDIES WITH IMPROVEMENT THEMES

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ABSTRACT

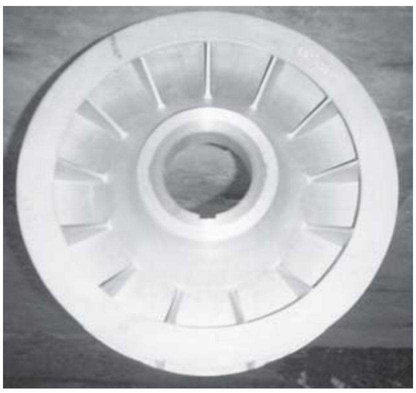
The word 'Technology' should be viewed in a very wide scenario here. Off -beat ideas to reduce rejection and usage of new material or processes, also come in purview of the improved technology. Some specific case studies are taken up, where a different angle to view the process and solve the problems helped. Some tend to consider wax rope being a venting process of the 1980's and they further consider that it should be scorned at in this 21st century. They give its impact on lowering of productivity and feel that the artistic placement of a wax rope on delicate contours of the core box ensuring that no part of the wax rope touches the core box will make the process man dependent. The usage of wax rope in the last decade was reduced to such an extent that now; hardly any wax rope manufacturer can be spotted out, if needed. It must be borne in mind that molders and core makers can be trained to insert wax rope while making core or mould, as the case may be. The process is not very complicated and anyone can learn it. The gains are too numerous and one should be willing to implement it if really required by the process. In a simple casting, slag inclusion may be analysed in different ways. How a simple flow-off could eliminate the slag defect can also be innovative. Various case studies depicted below show an innovative way of problem solving.

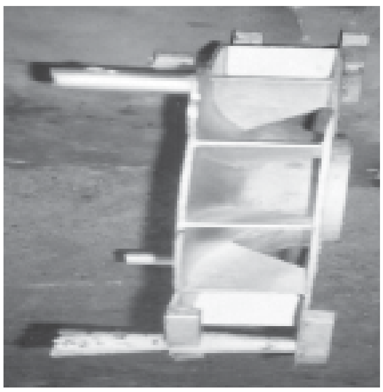
Keywords: Wax rope, Venting process, Radiography, Slag entrapment, Two ladle pouring, Shrinkage cavity, Hot spot, Pearlite, D.P testing.

THE ALUMINIUM FAN CASTING WITH RADIOGRAPHIC REQUIREMENT

The fan under study was made in three moulding boxes, thus avoiding the usage of core. The casting with 7 vanes invariably gave indications of gas holes, when viewed through x-rays. Reason of gas hole at the juncture of the vane and the upper shroud could not be visualised first, as there was no core used in the fan. On further investigation, however, it was understood that the green sand in between the upper and lower shrouds would give out gases including water vapour. If these gases did not have access outside the mould, the same would lift up and show the gas holes at the upper shroud as shown in the radiographs.

Wax ropes of 10 mm diameter were inserted while mould making, two each between each shroud, ensuring that the rope did not touch any part of the pattern. Other end of the ropes was taken outside the moulding





box, so that the gases evolved would be able to leave the mould through the cavity created. It was envisaged that once pouring would start, the wax rope would burn and the cavity thus created would ease out the mould gases outside the mould cavity.

As expected, the fan thus poured qualified in the radiography test. As per the analysis done later, no alternative method was able to yield the fan casting passing the radiography test and that the usage of the wax rope was the only effective way.

Metal was allowed to enter the mould through ingates given both in cope and drag. The lower shroud was filled mainly by the ingate in the lower shroud. Metal rose up through the vanes up to the upper shroud. Only then the upper ingates became operative and the mould cavity was thus filled with a lamellar flow. This avoided slag and sand entrapment.

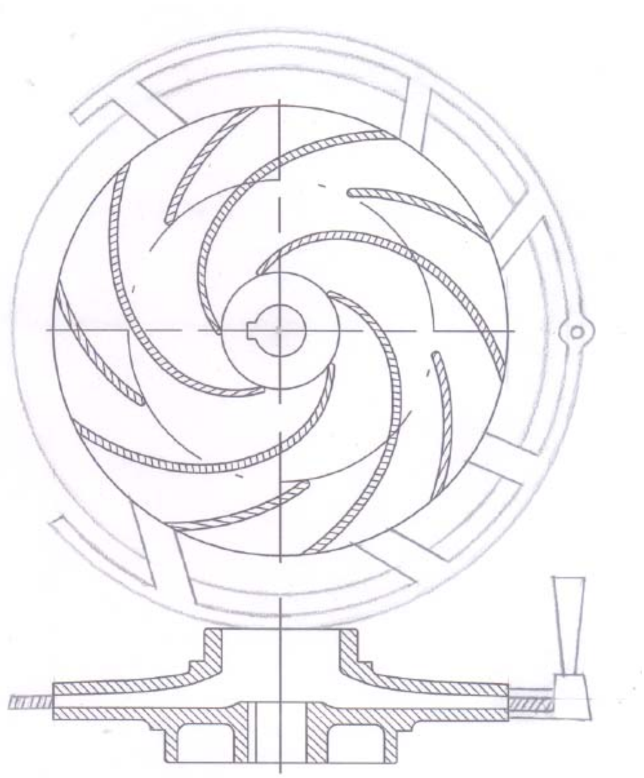
The green sand between the two shrouds eventually gave out water vapour and other gases, when pouring started. Earlier, these gases went up and the radiograph showed signs of gas inclusion at the interface of the vane and the upper shroud. Applying wax rope at each pocket allowed the evolved gases to go outside the mould through the cavity created at the wax rope location.

Thus, defect-free casting passing the radiographic test could be made by following the above process.

UNISTREAM IMPELLERS

In a big captive foundry setup in west India, there was a huge export requirement for bigger impellers. In smaller category of the same, ingates only in the cope or in the drag would result in consistently acceptable casting. Two down sprues were recommended for the bigger impellers. But the foundry setup did not allow pouring through two sprues. Two sprues would reduce productivity. Further, on conveyer, two ladle pouring was not feasible.

In the revised gating system of the bigger impellers, ingates were given both in cope and drag. This allowed metal entry into the mould cavity through the drag below the core. By the time, the cavity under the core is filled up and metal starts going up through the vanes, the ingates in the cope become operative and the remaining cavity is filled up by the metal through the ingates in the cope (above the core). Pouring time was reduced in this pattern of gating making the casting less prone to cold shut.



The above system with carefully calculated gating system avoids cold shut, core breakage and sand erosion as the metal enters the cavity in a lamellar flow.

CAST IRON END SHIELDS

An end shield casting had high rejection due to shrinkage cavity. Application of chills solved the problem to some extent. However, their application in these machine-moulded castings reduced productivity and rejection due to other chill related causes increased rejection. Application of a specific chill would make the moulding more involved. This would further reduce productivity and tend to increase rejection. Cost would further go up, as chills would have to be made and used on a daily basis.

Remedy was to improve the heat transfer to the shrinkage spot. On close study, it was revealed that all the castings with shrinkage had the defect in front of one ingate. Direct impingement of hot metal on the boss resulted in shrinkage .The thick portion of the casting happened to be at the same spot. The hot metal running towards the thick portion tended to make a hot spot. While solidification, surrounding thin part solidified earlier taking some of the liquid metal from the chunky portion. Thus shrinkage was generated here. Remedy was to arrange to send relatively cool metal to this thick spot. To do this, in the trial conducted thereafter, the said ingate was eliminated and its area was distributed in the remaining ingates. All the trial castings came without any defect. A further trial with subsequent 50 castings substantiated the same. Now, the entire casting cooling rate was same every where. Thus, elimination of the ingate in front of the shrinkage defect was the solution to the problem. The need to use chill was also removed and productivity was maintained.

(The figure is self explanatory. There was an ingate in front of 'A' and there was shrinkage due to the hot spot generated due to hot metal impingement near the boss. Elimination of this ingate solved the problem.)

AN END SHIELD CASTING WAS UNDER STUDY

The apparent problem was that of a crack (or shrinkage), which continued in over 80% castings. The rib, which was joining two round faces of the casting, used to develop crack as described above.

Observations Made

Many people studied the problem earlier. Some thought it to be shrinkage and advised a riser. At the same time, they suggested increasing the rib thickness by another 5 millimeter. Some thought of using zircon sand in the core around the rib, so that the shrinkage would be reduced by the chilling effect of the zircon sand. Some advised careful handling of the casting, so that crack initiation would be avoided in the transit.

As the castings were sizable in production, the above problem had become acute. To correctly analyse the defect, it was decided to visit the foundry, which was located at a far-away place in Belgaum. All procedural details were studied. Initial inspection of the pattern equipment was done. Detailed process right from moulding, core making, pouring, knock-out, shot-blasting to final inspection was scrutinised. To my surprise, a very simple nonconformity was leading to this so-called shrinkage defect. The core box was in two halves and the rib in the core had about 80% portion in one half. 20% of the rib was made due to the other portion of the core box. After removing the core from both the core boxes, the rib portion would be about 10 millimeter thick and be unnoticed. The core would be painted including the rib portion and be given to moulding line as usual. The core dresser would invariably omit the fin removal before painting the core. After ensuring that the defect diagnosis was correct, the reason of the apparent crack was explained to all the concerned and 5 cores were made taking care of the said fin removal. As the workmen were anxious to solve the problem for all these years, they were enthusiastic and cooperated very readily. Five castings were poured. As was anticipated, all the castings were O.K. Further a lot of 10 castings were also without defect. As the gravity of the defect was already known to all concerned, all decided to comply with the basic requirement.

A further production lot was made proving the above diagnosis to be absolutely correct.

Funnily enough, an 80% rejection had come down to nil.

Correct diagnosis followed by adequate treatment is all that is necessary.

Earlier, the bottleneck for dispatch of the valuable electric motors was the production of the above end shields. The above solution increased the sale worth millions.

PROBLEM OF FAST WEARING OUT OF THE CAST IRON INSERTS (BEARING HOUSING) IN G1R160 ALTERNATOR FRAME BACKGROUND

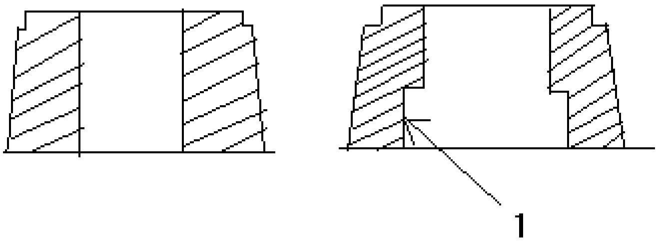
Cast iron insert casting was being poured where machining on the ID of the cast iron insert was to the tune of over 5.5-mm on radius.

After pouring the casting, the same was taken up for proof machining, where the machining allowance was reduced to 3.0 mm. Depending on the foundry defects, the insert was okayed for next operation i.e. for aluminum die-casting as insert. The insert was placed at the prelocated portion in the die. The mould would be closed and aluminium would be poured. The aluminum stator with the insert placed at the centre would be allowed to cool. After proper fettling and chromating, the casting would be machined and the insert would be brought to final machining dimension – ready for assembly at the plant.

Due to only one end of the shaft in the bearing and the other end not in the same casting, there may be slight mismatch and this would result in wearing out of the cast iron insert. Its hardness could not be increased very high as there would be problem of machinability. Thus much change in chemical analysis was ruled out.

1. Some basic metallurgical principles applied to solve the above problem are enumerated below:

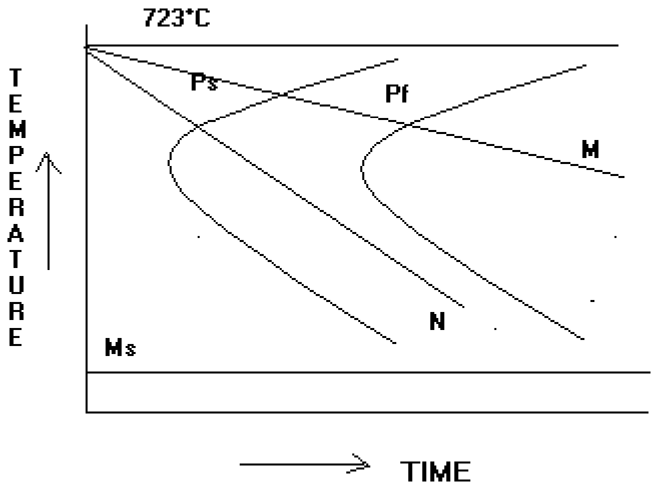
This was the as cast insert.



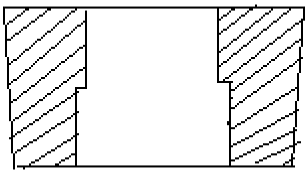
After machining, it was being converted to B.

Surface 1 was the bearing surface. Here machining allowance was over 5.5 mm on radius.

Metallurgically, from austenite, cooling curves (M) and (N) are drawn.



(M) identifies slower cooling curve whereas (N) signifies faster cooling. Faster cooling phase will have compact pearlite and finer graphite flakes as compared to (M), where pearlite platelets will be relatively coarse and graphite flake size will also be bigger. Structure resulting from (N) is desirable compared to that of (M), as in addition to higher strength, it also has improved toughness too. A structure conducive to greater wear resistance thus forms.



MODIFIED INSERT AS CAST

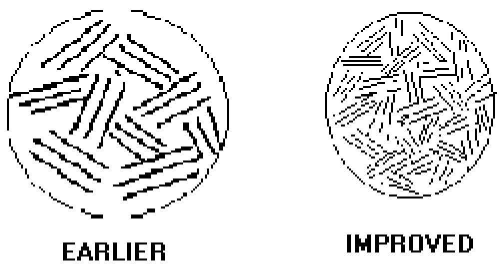
Once metal was poured into mould, nothing much could be done regarding the cooling rate. As we proceed along the cross-section inside the casting, wear resistance would gradually reduce due to above reason.

Machining allowance reduction was a very effective step towards solving the above problem of making the relatively harder phase on surface of the insert on the internal diameter. Similarly, while stating the problem initially, clear mention of the ‘bearing surface’ was made. Thus in the entire internal height, increasing wearing resistance of the bearing surface was what we were all concerned about.

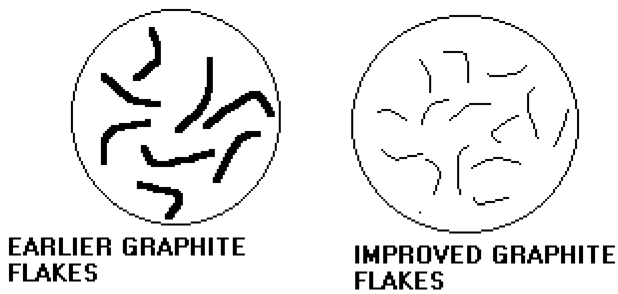
Therefore, Instead of having a straight internal surface, bifurcation was made in the bearing diameter which was increased in the casting, so that machining allowance here would be to the tune of 2.0 mm and thus the full advantage of the fine pearlite and graphite matrix would be obtained.

Once the machining allowance of the inserts was reduced, our major mission of imparting high wear resistance to the cast iron inserts was achieved.

ETCHED SURFACE



POLISHED SURFACE



Converting the metal of the above inserts to FG220 with 0.5% Cr will enhance harder phases and this would add to the life of the inserts without any addition to cost.

When the insert is put in the die and aluminium is poured, the insert gets heated. In order that even this additional temperature does not allow any adverse effect on structure, we recommend that the casting be cooled by water. This has already been seen in trials at initial stage that no harm is done. A continuous procedure (set-up) to this effect may be done at the vendor's premises.

As the outer taper of the C.I. insert is reverse, in order that this holds to the aluminium stator properly, machined groove to the insert may be thought of.

As a cost-effective measure, the 'O' ring as thought of in one of our earlier meetings may be discarded and only the modified insert without 'O' ring may be applied. Application of steel insert is not recommended because the same would wear out fast if the matrix is of ferrite or of coarse pearlite. Same explanation is for not recommending ductile iron insert for the above purpose.

SEVEN VANE IMPELLER

There was an order by M/s. Bhabha Atomic Research Centre for six impellers to be poured in alloy steel. The unique part of this order was that all these were required with dye penetrant testing all over the surface. In order that both the shrouds conformed to D.P. testing, the foundry personnel opted to add machining allowance to the tune of 6 mm on the shrouds. The reasoning was that any defect appearing on the shroud would be removed by machining and the casting would qualify the D.P. testing.

To everyone's dismay, however, the impellers poured and machined gave thick patches of the dye after the test showing that the impellers did not qualify the dye penetrant test. Distributed risers on the shroud worsened the quality and thus, the reputation of the foundry was at stake.

As a matter of fact, the open grained structure resulting from slow cooling of the steel 6 mm deep inside the casting surface was responsible for this D.P. test failure. As presented in an earlier case study, as one proceeds deep inside a casting, microstructure becomes coarse grained and it may show D.P. failure in some cases.

The defect was initially taken to be shrinkage. Introduction of chills at different places was thought of. Risering was considered at the juncture of each vane and shroud. Though this process succeeded marginally, there were some constraints.

After learning this phenomenon, the machining allowance of the shrouds was reduced to 3 mm and the impellers started complying with the requirements.

This occurred, because the cooling rate to a depth of 3 mm was faster than that at a depth of 6 mm. At 6mm depth, open grain structure mad the surface defective, when D.P. testing was done. The same surface was acceptable, when the machining allowance was reduced to 3 mm.

This is how, through a rather unique way, the problem was solved.

CONCLUSION

It shall be noted from the above case studies that correct diagnosis is very important to solve foundry defects. Once the diagnosis is correct, rather unique looking corrective measures can lead to good castings. Specifically, in the case of the end shield, everyone was thinking the cause to lie elsewhere. Introduction of risers or increasing the rib thickness proved to be no solution. Only, removing the sand fin of the core solved the problem. Economical solution is equally necessary. Instead of giving additional chill and thus reducing the productivity was no solution. After proper diagnosis, removal of the ingate in front of the thick boss solved the problem of shrinkage in the end shield. Overall foundry experience, basic theoretical knowledge and the will to associate it to solve problems, will to learn from others without having individual ego, all these qualities help one solve foundry problems,The same should always be borne in mind.

REFERENCES

1. Richard A. Flinn : 'Fundamentals of Metal Castings' Addison Wesley Publishing Company, Inc.
2. William F. Waller : 'Castings' The Macmillan Engineering Evaluations, Hampshire, U. K.
3. R. Wlodawer : 'Directional Solidification in Steel Castings', Sulzer Brothers Ltd. Switzerland