Case Studies: Application of Basic Fundamentals to Solve Foundry Rejection Problems and successful Turnaround Stories

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Abstract: At times, instead of applying complicated techniques, basic fundamentals help solve involved foundry problems. Different case studies taken up in the present paper aptly describe how principles of flow-off, Time-Temperature-Transformation diagram, usage of the knowledge of the tendency of gases to go up, , conversion of turbulent flow to lamellar flow before the metal being allowed to enter the mould cavity, need of minimum metal thickness during the entire foundry process and above all, involvement of the entire related work force could become instrumental in solving problems, which were looking difficult to solve at the outset. Usage of T-T-T diagram was made to change hardness at a particular spot of an adaptor plate to ease out punching after final assembly of the inverter. As per norms, the adaptor plate of the final inverter was to be punched at a particular location for identification. Workmen suddenly started complaining of high hardness and inadequate punch-depth in spite of heavy hammer-blow. After studying the entire process, it was revealed that in the symmetrical casting, ingate location was changed inadvertently by the foundry and this change had brought about the hardness problem at the particular location. Shifting of runner and thus allowing the metal entry from a particular location of the mould rectified the punching difficulty. Addition of adequate flow-offs reduced rejections due to cold shut and slag from a level of 50% to below 2%. A basic mistake in molding was resulting in more than 40% castings being rejected due to cold shut, as the process was adding to this low metal thickness. Correction in drawing and further process control solved the seemingly difficult high rejection problem. A heavy steel casting with ultrasonic requirement was made successfully only by exchanging cope and drag. In the casting weighing 2 tons, the central cylindrical self-core portion was kept in drag considering safety compared to vertically hung core, which otherwise would have resulted in core fall due to gravity. But, as gases tend to rise up, the solid portion above

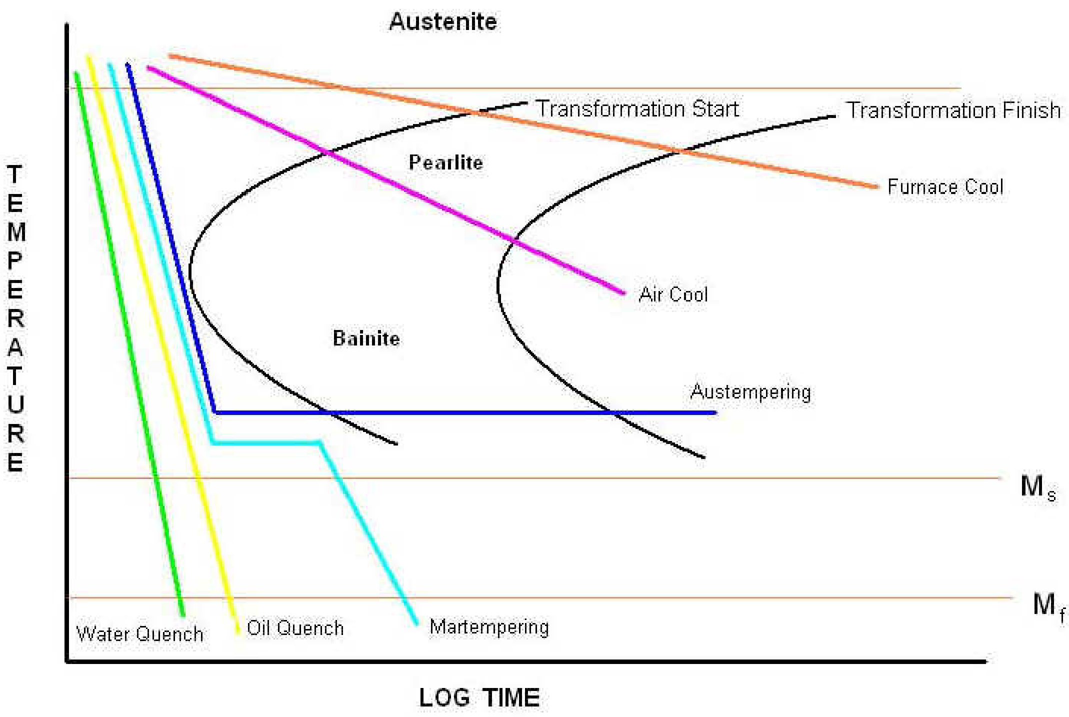
the self core would always show gas defects in the ultrasonic testing. When cope and drag were interchanged ensuring that the hung core in cope would not fall while closing and later during pouring, the castings were accepted for ultrasonic test. In case of crank case castings, where heavy slag defects were revealed at a particular location after machining, it was noted that one of the ingates in drag was just below the sprue. This made the slag enter the mould cavity before the flow from the sprue could be made lamellar. A shift of the ingate by 35 mm solved the problem. All the case studies depict that a rational approach with open mind, proper understanding of materials, fluid flow and basic metallurgical principles make the solution very much obvious. In addition to above technical solutions, workmen and the staff on shop-floor play a pivotal role. Arousal of interest and involvement of the people on shop-floor make the entire exercise effective.

Introduction: In the present text, some case studies are undertaken, which show as to how simple and common place remedies are capable of otherwise seemingly complicated issues.

1. **<u>Loom End shield</u>**: This is part of a product of a well known company making generators. The rejection due to cold shut was over 40%. A foundry based in Rajkot was pouring the casting in hundreds, but no one was able to diagnose the seemingly obvious reason.

The foundry applied various gating designs. Higher pouring temperatures were also tried. But all in vain. While the problem was posed for getting a solution, a rejected casting was brought and cut at the defective portion. As was expected, the wall thickness was low, to the tune of 2.8 mm. The drawing showed 4 mm thickness at the spot. The drawing section was advised to consider making the section to 5 mm. The pattern inspection and the molding procedures were improved to ensure that the mould does not sag and the effective metal thickness continues to be 5 mm. This brought down the rejection to a respectable level.
Some may think as to how such an obvious diagnosis took such a long time. But the fact is that many units do not come to the obvious remedy and spend valuable time and money on futile experiments. This necessitates proper understanding of basic foundry principles by the concerned.

2. **Punching difficulty in adaptor plate**: This problem relates to the punching problem difficulty of a casting. After complete assembly of the alternator, a specific portion of the casting of ‘adaptor plate’ was to be punched for identification. Workers often complained regarding hardness of   c 
the castings. This was also a major safety problem, as hitting hard by a hammer might result in injury.
The problem was studied and it was ascertained that the poured metal was conforming to specifications. So, changing chemistry of the metal was not feasible.
As can be seen from the above sketches, the metal was to traverse a long distance to fill the mould cavity. The casting is symmetrical. Gating given was such that the punched portion of the casting was at the farthest point from the ingate. This was resulting in quick cooling of the metal at the farthest location.
The cooling rate of metal was making all the difference. As can be seen from the TTT curve given below that the metal was to travel half the periphery of the relatively thin casting before it touched the portion required to be punched. The resulting matrix would always be harder than the one with average cooling rate.
An obvious remedy was to change gating such that metal would enter the cavity near the portion to be punched. As there would be continuous flow of hot metal near the portion, the portion would remain hot and cooling would be relatively slower leading to a softer metal.
Thus, gating was modified so as to allow metal entry near the portion to be punched. This remedy solved the problem.
It can thus be seen as to how a mere shift of the gating system resulted in the problem solution.



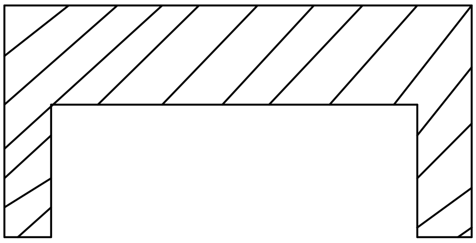
3. <u>A 2 ton steel casting requiring ultrasonic testing had been given lay out as follows:</u>

Initially, the cylindrical core was kept in the drag and metal would be on the upper side of the core. As metal would be poured in the mould cavity, core gases would be given out and they, having a tendency to go up, would accumulate at the top of the core. Even in presence of vents given in the cylindrical core at the bottom, some gases would have a tendency to go up and these gases would be locked up in the metal.

The obvious remedy was to invert the system. When hot metal was introduced below the core, and the top core print would touch the mould, the gases evolved from the core could easily leave the core from top without disrupting any metal wall. The only precaution to be taken was that the hung core was tightened safely, so that it would not fall due to gravity.

Self core could also be designed with discretion reducing the cost.

The casting sketch:

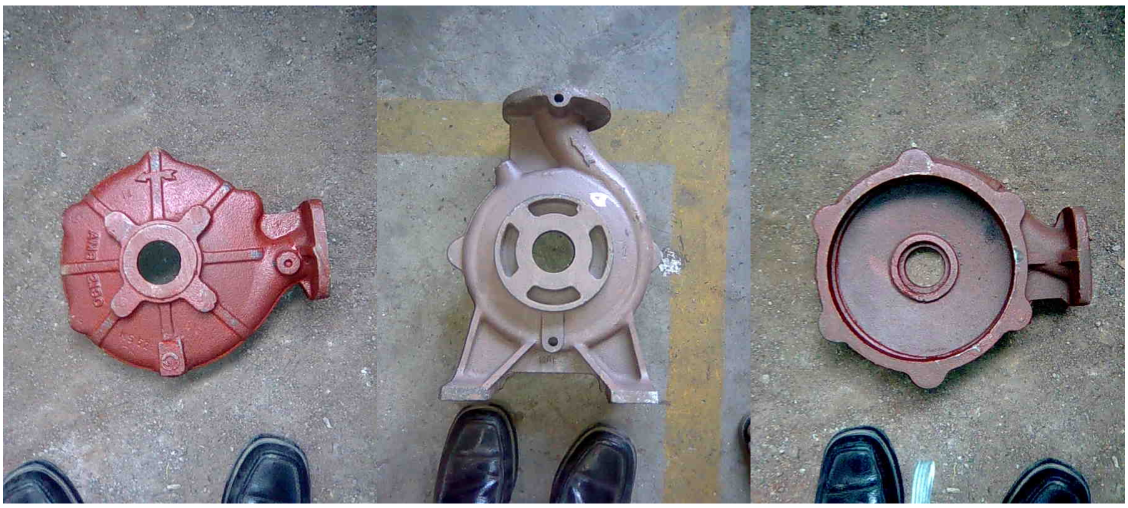


(Core)

4. **Pump casing castings with and without feet:** They are shown below. In order to reduce additional expenses on patterns, separate pattern is made only for the feet. As per requirements of the customer, this additional attachment is done to the regular volute pattern for getting castings with feet.
   Some representative problems are mentioned below regarding production of the volute castings.

   A. Volute main cores were made with low-gas core mixture. No core-venting was provided giving the reasoning that blow hole would not occur, as the sand mixture was with low gas material.

      Many castings were being rejected on foundry floor as well as after machining due to blow hole. Different means were tried to reduce the blow hole, but in vain.
      Finally, introduction of vent in the volute core at center eliminated the problem. One should bear it in mind that howsoever small the gas-evolution is, gases are generated, when the core is surrounded by hot metal. These gases should be drawn away from the mould by proper core-venting.



B. In the pattern without feet, a conventional gating was given to the body of the casting. When feet were added to the pattern, they would continue with the earlier gating. In the casting poured (with feet), rejection due to cold shut was on a high side. Higher temperature of the poured metal did not solve the problem.

When the runner bar was extended and an additional ingate was given to a foot, the problem was solved. It should be borne in mind that the heavy feet required substantial metal and the pouring time would be on increase. When ingates were introduced even at the feet, metal flow rate improved and the cold shut problem was solved.

When casting weight increases (due to feet in this case), pouring time will increase, if the earlier gating is continued. Gating system should be modified so as to ensure that the poring time does not increase inadvertently. Additional ingates at the feet and flange solved the problem.

C. Heavy unwarranted leakages were found the in the castings. Pressure testing is performed, when the castings are completely machined. Thus, all efforts of machining were wasted, when leakage was declared after the full machining operation.

On closer pattern examination, it was revealed that a portion of the pattern at the center print had been modified by m-seal to place the core easily. This made the core shift in a particular direction thus making low wall at a particular location. When poured, the low wall became instrumental in giving rise to small cold shut lines, which escaped the usual casting inspection. While being pressure tested, the cold shut lines would give way and the castings were rejected due to leakage.

Immediate supervisor and the molders never had imagined that an unauthorized modification on print (which they thought would not affect as no metal was coming there) would result in leakage problem as mentioned above.

This example aptly explains the need of regular worker training.

5. **<u>A casting rejection over 25% due to slag inclusion and cold shut:</u>** A particular foundry in Haryana had been producing different types of castings of a particular family. But, over 50% boxes leaked while pouring. The molders would stop pouring due to leakages from the parting line. After the leakage subsided, they would resume pouring to fill the mould. But, due to this discontinuance, slag in the gating system would enter the mould cavity and further, many castings used to develop cold shut.
   After closing the moulds, weights would be put on moulds before starting pouring. There were no proper mould venting. As pouring started, air in the mould cavity would be replaced by hot metal. In absence of effective vents, when hot metal entered the cavity at high speed, the already present air in the mould cavity would be instrumental in lifting the upper mould. This would result in mould leakages as mentioned above.
   Obvious remedy was to arrange permanent vents on the match plated patterns. After individual mould was made, it would be made to stand on the flask wall and vents would be opened by vent bars manually to allow effective air evacuation while the pouring started.

As can be seen from the above sketch that vents are provided at specific spots on the pattern. Due to machine molding and squeezing, heights of the flow-offs were limited to a level about one inch below the box height.

In order that the mould air is effectively driven out of the mould cavity while starting pouring, vent diameter and number should be sufficient to allow the air exit equal to the volume in-flow of the hot metal. With this in mind, each cope box was made to stand on wall after the mould was made and piercing with a vent bar made the vent throughout.

The results were extremely encouraging. The rejections fell down to below 10% level from the earlier levels of over 25%.

It is found that the above problems are faced in numerous castings. But, proper diagnosis is seldom done. Defects continue and high rejection is considered as part of the game.

Judicious applications of flow-offs help reduce the problem.

6. **Rejection due to slag inclusion**: A casting of cylinder block had high rejection due to slag. Customer end rejection due to slag revealed after machining was also alarming. When gating system was analyzed, it revealed that a part of the gating was in core. Cope had the runner and the ingates were located in drag. One ingate was directly below the sprue. Thus, slag from the sprue went directly to the mould cavity. The ingate was shifted, so that the distance of the ingate closest to the sprue was at least 35 mm. This remedy solved the slag inclusion problem.

Conclusion: As is evident from the above case studies that any rejection problem should be studied in totality. Workmen on shop-floor should be made to involve themselves in solutions. Know-how and know-why should be discussed with open mind. Conducive atmosphere should be created in foundry, so that workers involve their hearts in addition to their hands. One should encourage actual technical solutions. If need be, help of an outside consultant should always be resorted to. After a technical solution is reached at, it should be viewed as 'win-win'. Considering limitations of the technical staff of a particular medium-sized foundry, the management should not be critical with its own staff, as to why they could not arrive at the solution by themselves. Expert opinion should always be sought in time. Involvement of every one is the key to problem-solving.