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HOW TO SOLVE SHRINKAGE POROSITY IN THE ALUMINUM GRAVITY DIE CASTINGS?

(A shop floor experience & case studies).

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Abstract:-Part 1:Many Aluminum castings are being produced all over the world, using gravity die casting process. Shrinkage porosity is one of the major problems faced. In part 1 theoretical aspects of shrinkage are illustrated. How to identify, analyze & find root causes for Macro & Micro shrinkages & develop solutions? are explained. In part 2:Case study 1: In a critical casting" Body", shrinkage occurred inside bore & solved by reducing wall thickness & re designing core. Case study 2: Micro shrinkage was occurred in a critical casting, "Valve body". By re designing the "casting shape a little" & providing copper chilling it was solved.

Key words: Micro & Macro shrinkage, feeding, chilling.

Introduction:- Shrinkage occurs in an Alum casting due to the "uneven shape of the casting. But it can not be changed by the casting maker. Only minor changes can be obtained from customer. If the casting has thick sections, shrinkage may occur. They are produced by *"Non homogeneous* variations of volume of metal ,occurring between the beginning & end of solidification. Shrinkages are two types: 1) Macro 2) Micro shrinkages, which are two different manifestations of same effect, with different sizes. To solve shrinkage, casting maker can *manipulate* only 1)the processing of metal ,but can *not* change the alloy.2) pouring conditions 3) design of the die.4) die coating & cooling methods.

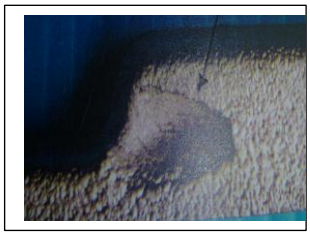


Fig 1. Macro shrinkage

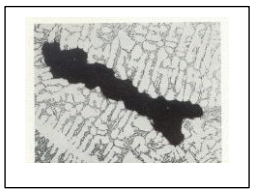


Fig 2. Micro shrinkage

Theoretical aspects of the causes:- (1)Macro shrinkage cavities are caused by massive volume reduction due to lack of feeding & when the alloy is of 'Short freezing range". It can be external or internal. The volume of the solid crystals is less than that of the liquid from which they grew. The solid mass occupy lesser volume than the liquid. Hence the difference in volume is made up of cavities of various forms.(2) Micro shrinkage occur between the dendrites, where the crystallization of the last liquid to solidify. They are noticed in the internal sections. The shape is always *'odd'*.

The factors that influence shrinkage cavities are :- **(**A)Factors depending on the casting alloy spec: (*A*.1)*Solidification range, (A.2) % Shrinkage during solidification*,*(A.3)Gravity* (*A.4)Evolution of gases* (B)Factors depending on the conditions of pouring:-(B.1)*Pouring temperature*.(*B*.2)*Rate of pouring (B.3)Feeding systems (Risers)*(C) Factors depending on the die (*C.1)Initial temperature of the die (C 2) Conductivity of the die* (By providing copper chills & cooling many surprising improvements can be achieved) (D) Factors depending on the casting (*D1)Heavy section thickness (D.2) Complexity of it's Shape* .(E) Factors depending on the shell sand cores (*E1)Type of metal entry in to the die(Eg: Over heating the ingate area) (E* 2) Resin content. (F)Factors depending on the molten Metal Quality:- (*F1*)Inclusion may encourages the nucleation of shrinkage .(*F2*) Calcium content (if calcium is > 0.0008%) micro shrinkage cavities may occur. (F3)Modification of molten alum:- If Sodium based flux are used , micro shrinkage may occur.

Part 2:- Case Study.1 *(1)Housing casting:- Micro Shrinkages* occurred in the areas as shown in the Fig3&4.Air leaked in the pressure test

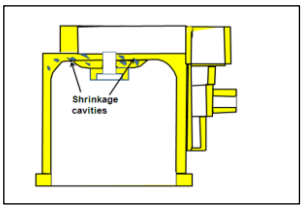


Fig.3 Shrinkage areas

Fig.4.Body casting

Causes:-In the die, over heating of the big bottom core; 150 dia ;due to the direct hitting of molten metal(>400C) (Ref fig.5) & lack of feeding to this heavy Section thickness area. It became a hot spot. Unable to provide feeder due to die design problems.

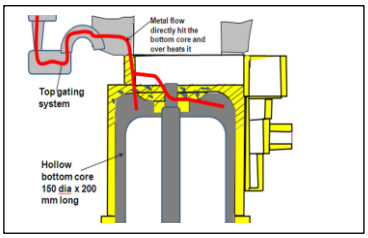


Fig.5Direct hitting of metal on the big bottom core

Corrective actions taken.(1) In the hot spot area ,wall thickness was reduced & made uniform ,7mm through out instead of 12 mm, with customer acceptance. (2) Cooling was provided below the over heating area.

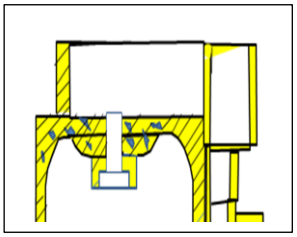


Fig.6.Wall thickness:12mm

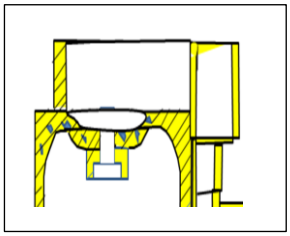


Fig.7 Wall thickness reduced to 7 mm after

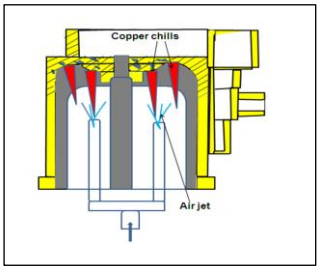
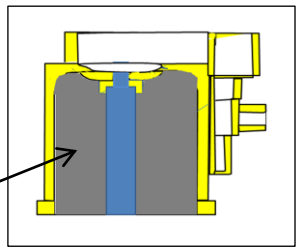


Fig 8. Copper chills with air jet cooling was provided, inside the 'Hollow core'.

Result:-The shrinkage was *eliminated*. But *air started leaking* through the *copper chills.* Also the shop became very ***noisy*** due to the discharge of compressed air &expensive. This was ***Not accept able to the management.*** Find another way**.** Core was studied & noticed that '*air* in 'hollow inner area of the core 'made it a poor conductor of heat. It was decided to try a solid core (ref Fig.9*)* expecting *sufficient conduc - tivity* for dissipating all the heat from the hot spots. The result was " no shrinkage" .

Fig.9. Solid metal bottom core,150 mm dia, conducts heat better & faster.



Case study 2: In the casting shown below micro shrinkage was occurring on valve seat.]

Fig 10 Full shot of the casting, Valve Body

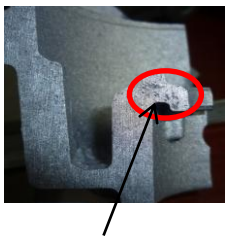


Fig.11Micro Shrinkage on Valve seat

Corrective actions taken (1) Machining allowance was reduced on the valve seat from 4.5 mm to 1.5 mm. (2) copper chills were provided & water cooling was done on the chills. Ref Fig 12. **Result**: *No shrinkages.*

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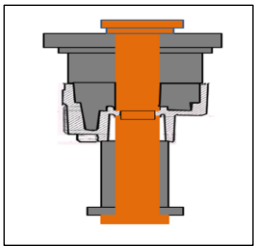

Fig12. Big copper chills were provided through the top & bottom cores

Conclusions (1) Try to provide risers (2) Explore for reducing wall thickness in the areas.(3) Provide copper chills with air or water cooling (4) Reduce machining allowance..

Product designers should consider foundry process capability& avoid frequent section changes

References:-

[1] T.P.Fisher Technology of Gravity Die casting- .