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"Defect analysis and remedies in the High Pressure Diecasting Process with ADC-12 Alloy". – A Technical review.

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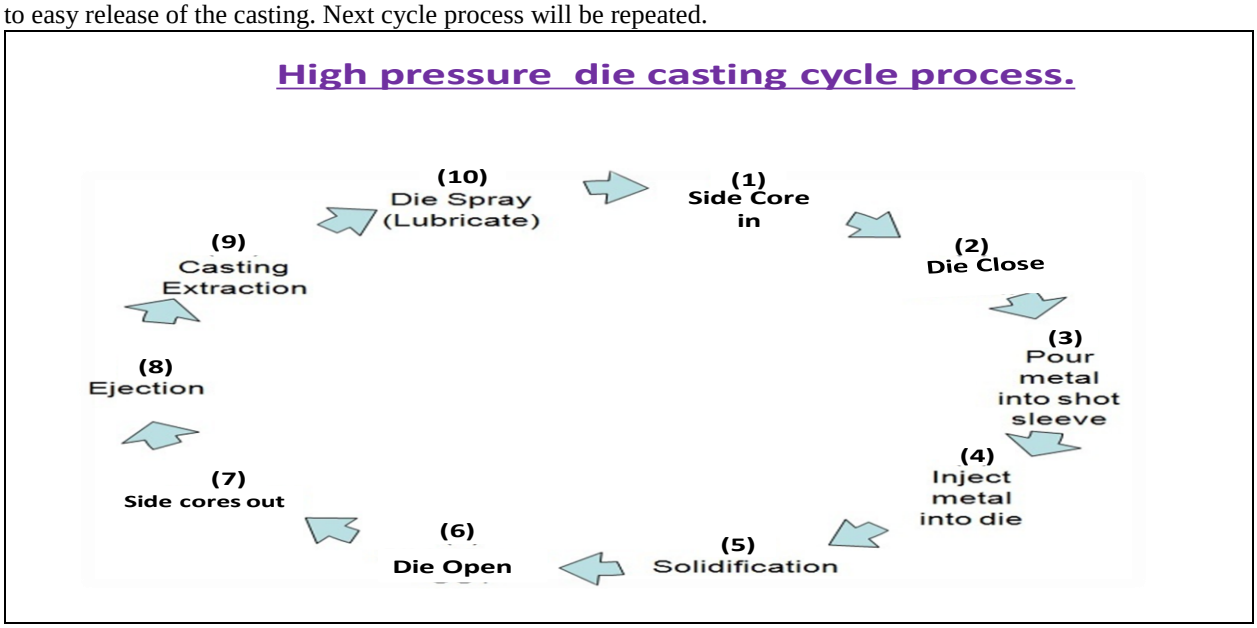
Abstract: In the present automotive supply chain the suppliers are facing the more diecasting defects. Most ofthe automotive manufacturers are changing the products from heavy weight components to lower weight likealuminum. The High pressure diecasting (HPDC) process is the most vital engineering process in which thecomponents are produced with low weight and high productivity. During this process the components foundwith more abnormalities as casting defects in both internal and external .This paper is presenting to avoid suchtype of defects in the HPDC process.

Key words: HPDC Process, internal defects, external defects

I. Introduction:

The HPDC process consists of one horizontal diecasting machine with one mould and the holding furnace. The metal is transferred to the shot sleeve chamber through the autoladle.Metal is poured into the shot sleeve by auto ladle and injection process is carried by the separate injection system with the high velocity (2m/sec – 4.5 m/sec) and high pressure (600kg/cm^2 to 800600kg/cm^2).The mould is filled and allow to solidify with some time (Min-4sec to Max15 Sec) depending up on the wall thickness of the casting. Casting is ejected by the ejection system and to be collected by the operator or special extractor mechanism. Specialchemical (water is mixed with coolant in 1:200 ratio) water is sprayed on die halves to cool the mould and to form micro film upon the mould to easy release of the casting. Next cycle process will be repeated.



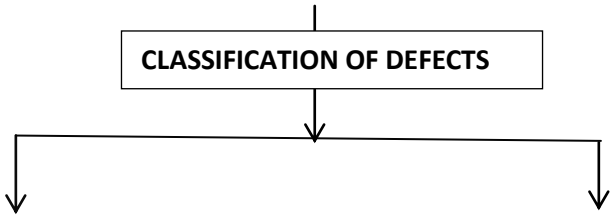
II. Diecasting defects:

In High Pressure Die casting process we found more defects in the process. These defects are pertaining to both surface defects and the internal defects. The surface defects and internal defects are subjected to be change depend up on the casting geometry, surface area of the component and selection of the machine. The ADC-12 [1] alloy is used most of the automobile industry.

All defects are not depending upon the multiple Parameters .The main root cause of the defect is only one or two.Optimisation of the all parameters will leads to create another defects. The Parameters are defined basically in two forms one is Constant and other one is Variable parameters .The Constant parameters are belongs to tool/Die and the Machine. To reduce the defects means we have to focus on variable parameters. The variable parameters are changing due to mechanical losses, the electrical losses and some frictional losses. The defect is one of the abnormalities in the process which can be rectified. The increment in internal rejections will be impact on company's profitability indirectly.

The causes for the defects will categorize in two ways. One is assignable causes (probable causes) and other one is the variable causes. Probable causes are rectified by the experience team and the assignable causes are requiredthe management support like in the tool modification, Machine part replacement or purchase the new equipment to rectifythe particular problem.

In this paper we are highlighting the major defects which are occurring in the high pressure diecasting process and its remedies. This paper has been presenting by an experienced research scholar. If the surface defects are more than 5 % it can be resolved by the correction in the tool/die and machine parameters and if the defects are under 5% needs another improvement in the above Both. In addition to the above it is required to examine some other parameters also like man, methods, materials and process. The HPDC defects can be classified as



Surface defects or visual defects	internal defects/After machining defects
I. Cold shut	1.Blow hole
II. Crack	2.Inclusion
III. Drag3.Shrinkage porosity	
IV. Damage	
V. Chip off	
VI. Gate blow hole	
VII. Peel off	
VIII. Blisters	
IX. Soldering	

2.1Surface defects:

2.1.1 Cold shut: The cold shot is categorized as surface defect because of it can be found out by visual. This type surface defect is predominant causing the more rejections in the High pressure die casting process. The main causes and remedies are under:

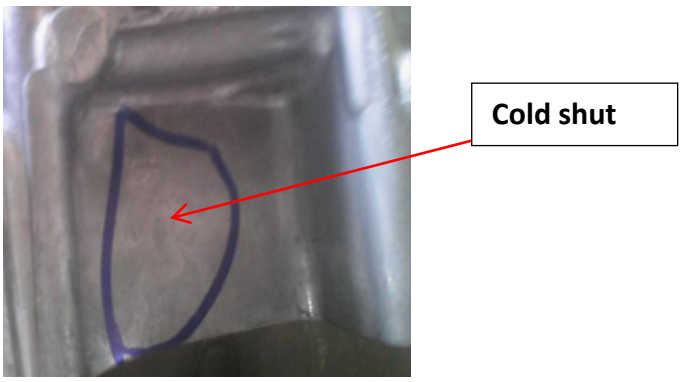


Fig: 1

Parameter	Root causes	Remedies
Die	1. Water leak into the die cavity 2. Overflow blocked. 3. Vent locked 4. Flash from the die.	1.Correct the water leakages 2.open the over flows 3.Open the vents 4.1.Blue match the die inserts and maintain the insert position to be more than 0.5mm than housing 4.2. Avoid higher range of machine parameters.
Process	1. Lower metal temperature (<620^{0}C) 2. More die coat spray > 10 sec 3. Due to plunger tip dragging the First and second phase velocities are not acting properly 4. Flash from plunger tip. 5. Fast shot too delayed.(<2.0 m/sec)	1.Maintain metal temperature between 660^{0}C - 680 ^{0}C 2. Maintain die coat spray according to die temperature to be maintain (180^{0}C -220^{0}C) after spray. 3.Verify the tip lubrication and maintain constant volume (2ml/shot) 4. Check the tip alignment with the machine and control the tip wear out/ Change the plunger tip 5. Fast shot speed to be maintain 3.5m/sec – 4.5 m/sec
Machine	1. Biscuit thickness should be (20mm-30mm) 2. ACC pressure shot not effective (shows Lower value as designed by manufacturer)	1. Verify the ladle is carrying the designed quantity of metal is transferring in each cycle. 2.1. Set the Accumulator value and observe in each cycle. 2.2. Maintain Hydraulic oil [2] temperature less than 55^{0}C
Material	1. Low Si content (<8%) 2. Diecoat dilution High (< 1:100) 3. Fe content is less (<0.8%)	1.Verify the Silicon content it should be 9.0% - 12.0% 2. Diecoat dilution should be 1:200 as designed by the supplier. 3.Fe content should be 0.8% to 1.3%
Man	1. Intensification pressure is low 2. Cycle time more. 3. Less air spray (water content remains inside cavity)	1.Training to be provide to the operator on machine parameters on intensification pressure [3] application to be maintain up to 250 kg/cm 2.Optimize the cycle time 3.Apply more air into the die cavity

Table: 1

2.1.2 Crack:

The crack [4] is found where the thin walled casting is producing in HPDC process. Some castings wall thickness configuration is changing from thin section to thick section then there will be chance of crack defect. Simultaneously If wall thickness less than 2 mm with more casting area there will be occurrence of crack defect.

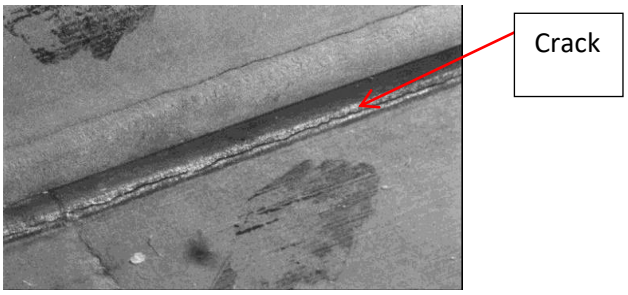


Fig:2

Parameter	Root causes	Remedies
Machine	1. Ejection Force is too high 2. Shorten hold (dwell) time to get the casting out of the die sooner (Max.1 sec) 3. Improper machine platen alignment. 4. Die opening speed more. 5. Less die coat spray.	1.Maintain medium ejection force 2.Ejection forward time should be 1sec after machine open 3.Align the machine platen top to bottom less than 0.3mm 4.Redue the die opening speed 5. Die coat spray should be sufficient as per the casting profile.

Die	1.Insuffient Draft angle 2.Check that bumper rods are all exactly the same length. 3. Check that the bumper plate is not bent or loose. 4. Slow down the ejection action (if possible) so as to be able to observe carefully. 5. Watch for uneven ejection, i.e., the ejector plate twists during ejection. 6.Check for good radius at the crack location 7. The runner and biscuit area is too hot. 8.Heat up adjacent space cool spots 9.Ejector plate Bend 10.Die internal stresses are more[5]	1. Draft angle should 7be 1-2Degree 2. Bumper rods should be exactly the same length 3.Check the tool back plate tight ness 4.Ejection forward speed should be slow in motion 5. Up and down ejection should be avoided. 6. 1R or 2R depending on casting profile 7.Provide cooling to the runner and spreader 8.Provide spot cooling at the crack area 9.Provide without bend ejection plate in the die 10.Sent for stress relieving after completion for
Process	1. Less die coat dilution. 2.Soldering in die 3. Higher metal temperature. 4.Less die coat spray 5.Biscuit catch up in plunger tip 6.More gate velocity[6]	1. Diecoat dilution should be 1:200 as designed by the supplier 2.Provide extra spray line at the location 3. Maintain metal temperature between 660^0C -680 ^{0}C 4. Provide spray time as designed 5.Cool the plunger tip 6.Maintain gate velocity as 50 m/sec- 60m/sec
Material	Low Fe content	Fe content should be 0.8% to 1.3

Table:2

2.1.3 Unfillling: It is also called as nonfilling and it comes under the surface defect. This defect is usually found in the HPDC process.Unfilling contribution in HPDC process is nearly 2-3% of the total rejection.

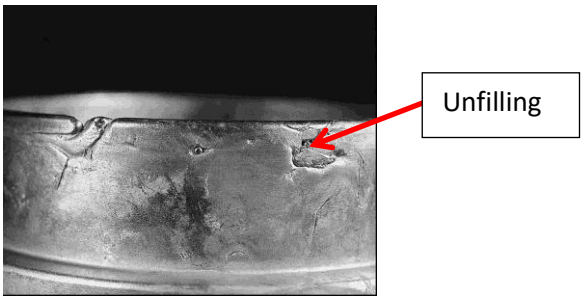


Fig: 3

Parameter	Root causes	Remedies
Machine	1.Specific Injection Pressure[7] is too Low (<600 kg/cm^2) 2. Casting Velocity V2 is Too Slow. (< 2.0 m/sec) 3.Check ACC pressure Build Up (Pressure should reach before die closing 4.Auto ladle carrying the un even volume if metal	1.Depending upon the customer requirement Specific Injection Pressure to be maintain 600 kg/cm^2-850 kg/cm^2 2. Fast shot speed to me maintain 3.5m/sec – 4.5 m/sec 3.1. Set the Accumulator pressure value and observe it in each cycle. 3.2.Maitain Hydraulic oil temperature less than 55^0C
Die	1. Insuffient Over flows (or) Insufficient Over flow volume. 2.Less metal feeding 3.Metal flows in zigzag path	1.Over flow volume to be increased by 20% and Provide extra overflows at that area 2. Increase the gate thickness and metal feed. 3.Runner design to make in such a way that flow always parallel to vertical axis

		of the component
Process	1.Low metal temperatures 2.Insufficient die temperatures 3.Less biscuit thickness	1. Maintain metal temperature between 660^0C -680 ^{0}C 2. Die temperature [10]to be maintain (180^0C -230^0C) after spray 3. Biscuit thickness to be maintained between 20mm-30mm always.

Table: 3

2.1.4 Blister:

Blister [8] is the surface defect in which the casting surface is uneven and having convex surface. It is formed due to the more mould having more temperature .It is having less than 1% in the HPDC process.

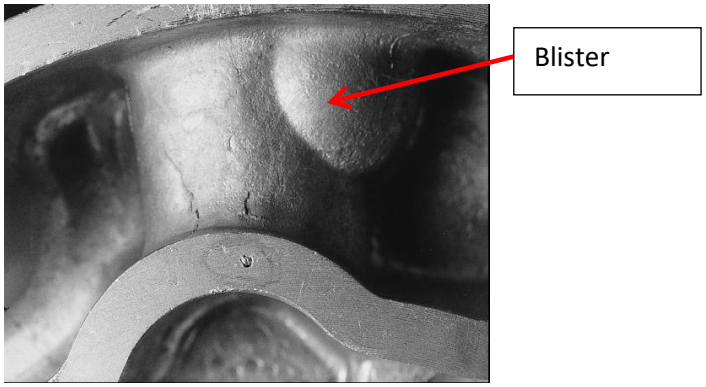


Fig:4

Parameter	**Root causes**	**Remedies**
Machine	1. Casting Velocity V2 is Too Slow. 2.Filling Rate is Too Slow	1. Fast shot speed to be maintain 3.5m/sec – 4.5 m/sec 2. Filling rate [9] should be less than 40 milliseconds according to casting geometry.
Die	1. Die is Too Hot. 2. Insuffient Die Venting.	1. Die temperature [10] to be maintain (180^0C -220^0C) after spray 2.Die venting to be increase
PROCESS	1.Less Die Lubricant	1. Provide extra spray line at the location

Table: 4

Soldering 2.1.5:

The soldering is the property of the die to catch the metal if the diecoat microfilm has been removed.This happened when the die got more heat .Due this problem it is difficult to get dimentional accuracy .It happening where the draft is less and misalignment between the fixed and moving halves of the die.

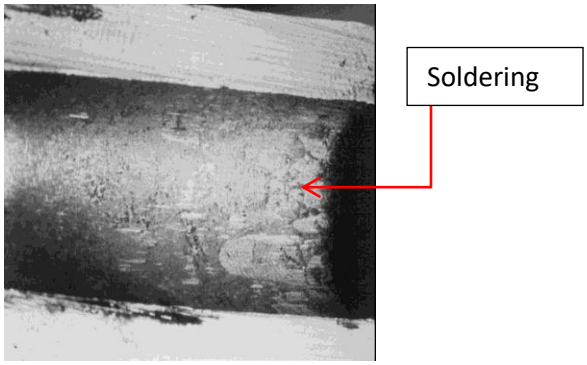


Fig:5

Parameter	Root causes	Remedies
Machine	1.Slow shot Speed in lower side 2.Fast shot Start Point 3.Add cooling lines specifically at the point of soldering, control 4.water flow as needed 5. spray in the solder Area verfication 6.Low heat transfer steel inserts	1. Slow shot Speed to be maintain between 0.18m/sec -0.2 m/sec 2. To be provide as per the claculation 3.Spot cooling to be added at the location of soldering 4.Increase the water flow if cooling is available 5.Provide extra spray line at the location 6. Use high heat transfer steel inserts
Process	1.Insufficent spray 2.High metal temparature 3.Less draft 4.Misalighment between fixed platen to moving platen 5. Gap between Tie bar to machine platen is more	1. Provide extra spray line at the location 2. Maintain metal temperature between 660^{0}C -680 ^{0}C 3.Draft to be increase 4.Alignment to be 0-0 between two platens 5.To be maintain 0.05mm - 0.45mm
Man	1.spray lines disturbance	1.Check the spraylines condition every two hours once.

Table: 5

2.2 Internal defects :

2.2.1Shrinkage Porosity: Porosity is attributed mainly by gas entrapment. Most alloys have a higher density in their solid state as compared to their density in the liquid state. As a result, shrinkage porosity forms during solidification [12]. Due to the turbulent manner the metal enters and fills the die cavity, gas often becomes entrapped in the metal, resulting in porosity. The shrinkage porosity is having interconnectivity between two holes. It will appear when the when the part/casting going to an machining operation.

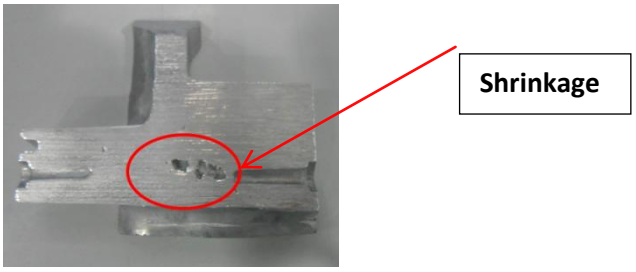


Fig:6

Parameter	Root causes	Remedies
Machine	1. Specific Injection Pressure is too Low. 2.Casting Velocity V2 is Too Fast 3.The amount of metal pressure applied at the end of the plunger stroke or final intensified metal pressure too low 4.Low metal temperature 5. Insufficient water cooling at location To extract the heat. 6.First phase velocity is too low 7. First phase length variation.	1. Depending upon the customer requirement Specific Injection Pressure to be maintain 600 kg/cm^2-850 kg/cm^2 2.Fast shot speed to be maintain 3.5m/sec – 4.5 m/sec 3.Intesification pressure to be maintain more than 250 kg/cm^2 4.Maintain metal temperature between 660^{0}C -680 ^{0}C 5. Provide spot cooling at the crack area 6.Slow shot Speed to be maintain between 0.18m/sec -0.2 m/sec 7. To be provide as per the design and fine tune until get the result.
Die	1. Insuffient Die Venting. 2.Die Is Too Cold 3.Less feed of metal 4. Improper metal feed due to Casting configuration	1.Suffient venting to be provide as per the design 2. Die temperature to be maintain (180^{0}C - 220^{0}C) after spray 3.Increase the gate thickness by 30% 4. Runner location to be change parallel to defect location.

Process	1.Less Die Lubricant 2.Water in the shot sleeve	1.Increase the spray time by 2 sec from the existing one 2.Provide air in the shot sleeve [13]

Table: 6

2.2.2 Blow hole: Porosity is the formation of voids inside the castings either through the entrapment of gas or improper pressure configuration in HPDC machines. Porosity is one of the most difficult defects to eliminate in die casting. If the porosity diameter is more than the 0.4mm it is called as blow hole [14]. The industry sometimes has to settle to move porosity to a different location in a casting rather than to remove it completely. The porosity is not eliminated completely from the castings and it is not always possible to do with the current level of Diecasting process .Gas porosity [15] is forming at the time of solidification where the internal gases present in the mould. In addition, attempts to eliminate porosity defects in castings can affect other process settings and results in other casting defects.

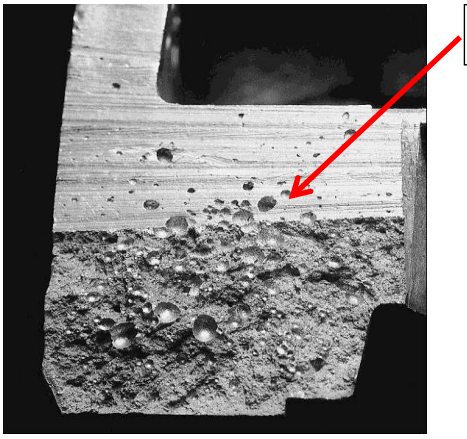


Fig:7

Parameter	Root causes	Remedies
Machine	1. Specific Injection Pressure is too Low. 2.Casting Velocity V2 is Too Fast 3.Filling Rate is Too Slow 4.Pour Rate (delay Time Before Shot) 5.Slow Shot speed high 6.Change Over Point	1. Depending upon the customer requirement Specific Injection Pressure to be maintain 600 kg/cm^2-850 kg/cm^2 2.Fast shot speed to be maintain 3.5m/sec – 4.5 m/sec 3.Filling rate to be increase as pe the design 4. Shot delay time should nor more than 1.0sec. 5. Slow shot Speed to be maintain between 0.18m/sec -0.2 m/sec 6. Change over point from slow shot to fast shot to be as per the design calculations.
Die	1. Insuffient Die Venting. 2.Die Is Too Cold 3.Insuffient over flow Volume 4. Die Flashings. 5.Runner area mismatch 6.Vents are not in best location	1. Suffient venting to be provid as per the design 2. Die temperature to be maintain (180^0C - 230^0C) after spray 3.Over flow volume to be increased by 20% and Provide extra overflows at that area 4.Avoid flashing with proper Blue matching 5.Runner are always to be in the convergent mode from start point to end point, 6.Vents to be provide where the internal to be escape out easily

Process	1.More gases in the metal 8.Filling ration is less	**1.** Make degassing process with degassing machine[16] **2.** Filling ration is between 50%-70%

Table: 7

III. Conclusion:

In present days the diecasters are facing the major diecasting defects like nonfilling and cold shuts and internal defects. These defects are in the range of 3% to 5%.The main reasons for those defects are contributing both tool and the machine and the process. But the contribution of internal defects like blow holes and

shrinkages are affecting the product quality. These shrinkage defects are not visible and these defects are visible when the component subjected to machining at that area.

The above analysis is very useful for the diecasters to reduce the scrap rates. The defects and root causes will be identified by experienced diecaster and analysis can be made according to the defect. If the defects in the high pressure diecasting process are reduced then the margin of the company will leads to higher level. These defects are one of the hidden losses which can be identified easily by the experienced diecasters. Some of the OEM customers like HONDA, MARUTHI, HERO, FORD and TVS are required 100 PPM in HPDC process machined component. This will increase the line efficiency and more productivity improvement. Finally the end customer also will happy with the product.

The HPDC line efficiency will be calculated based upon the quality rating. In the HPDC the OEE (Overall Equipment Effectiveness) plays a vital role in the diecasting industry. The OEE is calculated as multiplication of, A (Availability), P (Performance) and Q (Quality rating) i.e. A X P X Q.If the quality rating is decrease the OEE will be reduced. If the OEE is more than 85% the company known as world class manufacturing company.

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