

Influence of Heat Treatment on Internal Stresses and Non-Homogeneity for A360 Aluminium Alloy Housing Component

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Abstract - There are many factors that affects the dimensions of the manufactured products, there can be defect in the product's manufacturing processes, material composition leading to change in physical and chemical properties, handling methods, etc. The purpose of this study is to investigate the main causes of variation in the dimensions of the A360 Aluminium alloy components and to provide a solution for it. Six Sigma DMAIC approach is adopted as methodology. Internal stresses and non homogeneity due to entrapped gases were the root causes found. At elevated temperatures the component tries to attain homogeneity and relieve those internal stresses due to which variation in dimension and geometry in the component is been observed. In this paper, how adding of Heat Treatment in manufacturing process affects and is beneficial for the component is validated. Use of Process Capability index to indicate for the long run of the process without any errors.

Key Words: Heat Treatment, Internal Stresses, Non-Homogeneity, A360 Alloy, Defects .

1. INTRODUCTION

Material Properties of Aluminium Alloy A360
A360 is an aluminium alloy with excellent pressure tightness and fluidity. It has high silicon content and offers high corrosion resistance as well as high strength, even at elevated temperatures. It has more ductility than other Aluminium Alloy

TABLE 1

Mechanical Properties	
Material	Aluminium
Alloy	A360
Tensile Strength (MPa)	317
Yield Strength (MPa)	170
Shear Strength (MPa)	180
Hardness (HB)	75

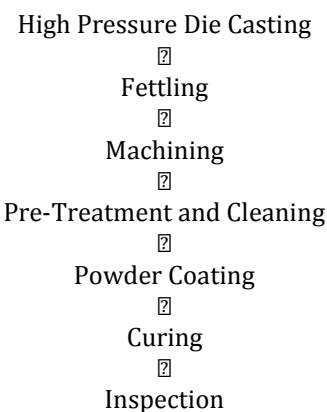
TABLE 2

Physical Properties		
Process		Cold Chamber Die Casting
Density (g/cm ³)		2.63
Melting Point (Average ± 500C)		577
Thermal Conductivity (W/mK)	113	
Coefficient of Thermal Expansion (µm/mK)		21
Electrical Conductivity (%IACS)	29	

TABLE 3

Material Composition	
Silicon	9-10%
Iron	1.3%
Copper	0.6%
Mg	0.35%
Mn	0.4-0.6%
Nickel	0.5%
Zinc	0.5%
Tin	0.15%
Others	0.25%
Aluminum	Balance (85-87%)

1.2 Manufacturing Process Flow of the Component



● **High Pressure Die Casting**

Die casting is a metal casting process that is characterized by forcing molten metal under high pressure into a mold cavity. The mold cavity is created using two hardened tool steel dies which have been machined into shape and work similarly to an injection mold during the process.

Most die castings are made from non-ferrous metals, specifically zinc, copper, aluminium, magnesium, lead, and tin-based alloys. The casting equipment and the metal dies represent large capital costs and this tends to limit the process to high-volume production. Manufacture of parts using die casting is relatively simple, involving only four main steps which keeps the incremental cost per item low. It is especially suited for a large quantity of small- to medium-sized castings, which is why die casting produces more castings than any other casting process. Die castings are characterized by a very good surface finish (by casting standards) and dimensional consistency.

The high-pressure injection leads to a quick fill of the die, which is required so the entire cavity fills before any part of the casting solidifies. In this way, discontinuities are avoided. This creates the problem of air entrapment. This problem is minimized by including vents along the parting lines.

● **Fettling**

The complete process of cleaning of casting is called Fettling process. The cleaning is done manually for small cast products. It involves the removal of cores, gates, sprues, runners, risers and chipping of any unnecessary projections on the surface of the castings. After fettling castings goes through glass beading process which is a metal cleaning process that creates a clean, bright and uniform matte texture. The glass beads are applied to a surface using low air pressure. This process removes impurities present on the metal surface.

● **Machining**

The process of removing metal from the workpiece is called Machining process. Conventional method is used for machining with the help of **Brother 10** special purpose machine. Operations performed on the castings are drilling, boring, tapping, finishing.

● **Pre-Treatment and Cleaning**

Pre-Treatment is a surface preparation process prior to powder coating. It includes removal of dirt, oil, grease, surface impurities and the oxidation products present on the surface by means of chemicals. The components are dipped in different chemical baths of different concentrations. Coating is done immediately after Pre-Treatment process because the cleaned surface is in the highly reactive state and it can get corroded quickly. After Pre-Treatment masking is done to prevent painting on unwanted areas.

Sr.No.	Bath	Temp	pH
1.	Hot water Rins	60-70°C	6-8
2.	Degreasing Surtech 133	60-70°C	9-10
3.	Water Rins1	R.Temp	6-9
4.	Water Rins2	R.Temp	6-8
5.	Activation	R.Temp	1-2
6.	Water Rins1	R.Temp	4-5
7.	Water Rins	R.Temp	6-8
8.	Passivation Surtech 650	R.Temp	2.5-4
9.	DI Rins1	R.Temp	6-7
10.	DI rins 2	R.Temp	6-7
Total Process Time		23 min 33 sec	

● **Powder Coating and Curing Process**

After masking painting is done on the product using spray gun. Powder coating is a type of coating that is applied as a free-flowing, dry powder. The main difference between a conventional liquid paint and a powder coating is that the powder coating does not require a solvent to keep the binder and filler parts in a liquid suspension form. The coating is typically applied electrostatically and is then cured under heat to allow it to flow and form a "skin". The powder may be a thermoplastic or a thermoset polymer. It is usually used to create a hard finish that is tougher than conventional paint. Curing is the process in which components are passed through curing oven. The Curing oven is maintained at 200°C to 215°C. Curing Process

2. Problem Statement

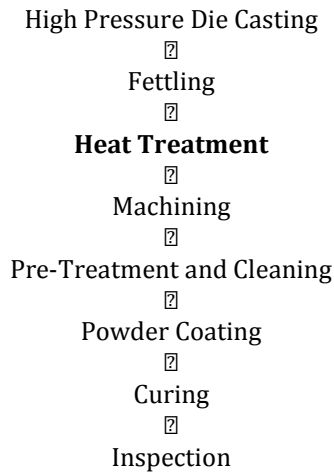
Variation in Critical to Quality dimensions and distortion of threads in components were observed which led to failure of pressure leak test and Go NO-Gauge during inspection on large scale. The dimension varied were observed to be exceeding the specification limit by 25-30 microns. As the component is been used in explosive areas, it is important to maintain the CTQ dimensions and threaded sections

3. Solution

After studying all the process parameter we found that internal stresses and non-homogeneity being the root cause of the problem. As the component is high pressure die casted followed by low solidification time of 3 seconds which led to generation of internal stresses and due these stresses variation were observed at elevated temperature. After studying the manufacturing process, referring various research paper and reference books, it was found that Heat Treatment is been used for attaining homogeneity and for relieving of internal stresses. Heat Treatment is a Special Process, the results of which cannot be predicted and hence trial and error method is been optioned. We decided to perform Heat Treatment on the components before machining so that whatever the variation in the CTQ

dimensions will occur due to stress relieving will get compensated in the machining process itself.

3.1 Modified Process Flow Chart



4. EXPERIMENT

For this we made 3 batches of 30 components each which were heated for different temperatures and time duration. We measured the CTQ dimensions after each process.



Fig 1- Convection Heating Oven for Components

BATCH No.	HEAT TREATMENT	
	Time	Temperature
Batch 1	4 hours	200°C
Batch 2	6 hours	200°C
Batch 3	6 hours	260°C

Table 4 – Temperature and time duration for Heat Treatment

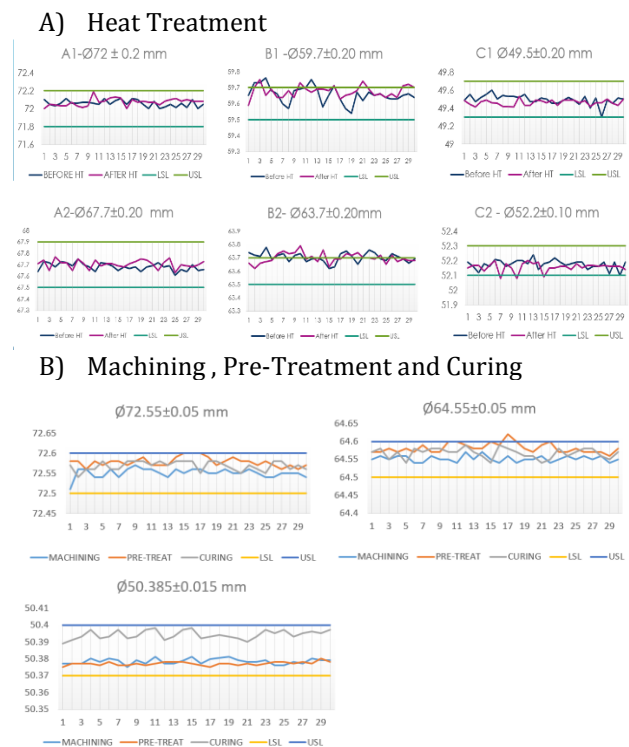
Quality Control Instruments used

1. Vernier Caliper for internal diameter
2. Air Plug Gauge
3. Go and no go Gauge for Threads

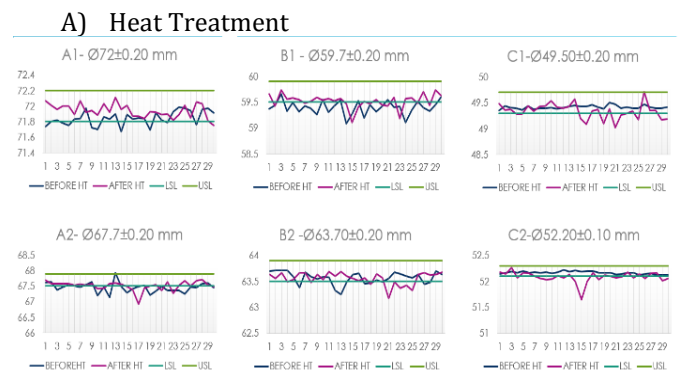
4.1 Dimensional Analysis

As the batches of components are heat treated for different time and temperature. To check whether the heat treatment has affected the components, it is investigated with the help of dimensional analysis of those Critical to Quality dimensions carried out with quality control instruments. The graph plotted are for Heat Treatment, Machining, Pre-Treatment and Curing Process, Final Inspection is for acceptance and Rejection of components.

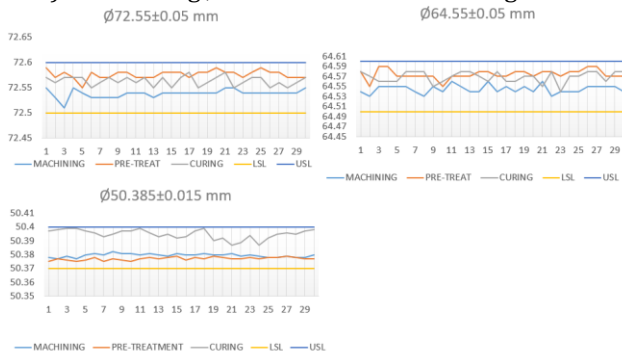
4.1.1 Batch 1 Dimensional Analysis



4.1.2 Batch 2 Dimensional Analysis

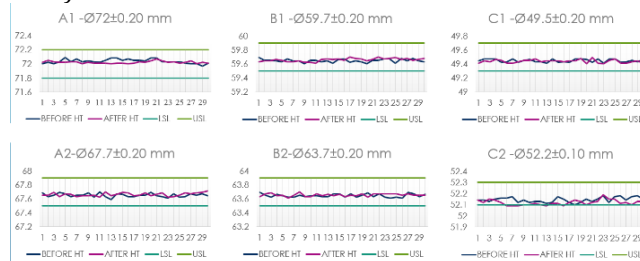


B) Machining, Pre-Treatment and Curing

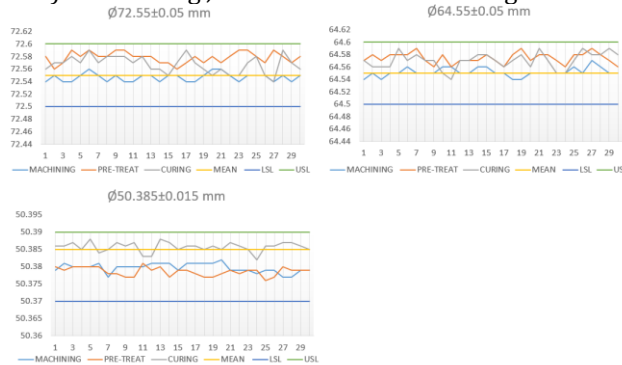


4.1.3 Batch 3 Dimensional Analysis

A) Heat Treatment



B) Machining, Pre-Treatment and Curing



5. RESULT

Batch 3 gave the best result, with lower variation in dimensions, maintaining circularity and geometry of threads.

Sr. No	Dimension (mm)	Final Dimension Range (mm)
1	Ø72.55±0.05	72.55 – 72.59
2	Ø64.55±0.05	64.55 – 64.59
3	Ø50.385±0.015	50.385 – 50.389

6. CONCLUSION

Batch 3 which was heat treated for 6 hours at 260°C gave the best result, with dimensional variation under specified tolerance limit. NO failure in Gauge inspection and pressure leak test were observed. 100% of the components passed the gauge test.

REFERENCES

- [1] Dr. Srihari G. Acharya “Design for productivity using GD&T”, New Jersey’s Science & Technology University
- [2] Mr. Bhavesh Mistry and Dr. P.M. George “Study and Scope of DFMA and GD&T in Manufacturing Process-Case study on dual plate check valve”, 7th international conference on advanced computing and communication technologies - ICACCT 2013, At panipat, Haryana, Volume: 4.
- [3] Mr. Hemant Urdhwarshe “The Six Sigma approach”, Symphony productivity journal, March 2000 and Reproduced in Quality World March 2006.
- [4] Mr. Franco Bonollo, Mr Nicola Gramegna and Mr. Giulio Timelli “High Pressure Die Casting –Contradictions and Challenges”, The journal of the Minerals, Metals & Materials Society ISSN 1047-4838 Volume 67 No.5
- [5] Dr. Laxaminarayan and Dr.A. Chennakesavareddy “Influence of Heat Treatment on mechanical behavior of Aluminium 7075/silicon carbide composites manufactured by casting process”, International Conference on Advanced Materials and manufacturing Technologies (AMMT) December 18-20, 2014
- [6] M.S. Rahman, M.Z.H. Khan and M.F.I.A. Imam “Influence of Heat Treatment on Fatigue and fracture behavior of Aluminium Alloys”, Journal of Engineering Science and Technology Vol.10 No. 6 (2015) 730-742
- [7] Mr. Yerriswamy Wooluru and Dr. P. Nagesh “The process capability analysis – A tool for process performance measures and matrices”, International Journal of Quality Research 8(3) 399-416

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