OPTIMIZATION OF DIE CASTING PROCESS FOR ZAMAK ALLOY AND A380 ALUMINUM ALLOY BY USING TAGUCHI METHOD

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Abstract:- In the present paper, optimization of process parameters of an aluminum die casting operation is discussed. The quality problem encountered during the manufacturing of a die casted component was porosity and the potential factors causing it are identified through cause effect analysis. An analysis of variance (ANOVA) is conducted to find the factors with significant effects on porosity. The pressure of the plunger used in the die casting machine and temperature of the liquid aluminum are identified as significant factors after the analysis. And also study was developed in order to maximize the quality of small parts injected in Zamak alloy for automotive components. Using simulation, the runners' location was improved as well as gas relief.

Index Terms : **- Zamak Alloy, A380 Aluminum Alloy, Taguchi Method, Simulation**

1. INTRODUCTION:-

Die casting is a process where a permanent mould is used, and melted metal is injected by pressure, allowing smaller cycles and continuum parts production [1]. Die casting are amongst the highest volume, mass produced items manufactured by the metal work. Die casting is one of the fastest and most cost effective methods for producing a wide range of components. [4] However to achieve maximum benefits from this process, it is critical that designers collaborate with the die caster at any early stage of the product design and development. High pressure die casting (HPDC) process has been widely used to manufacture a large variety of products with high dimensional accuracy and productivities. [1] It has a much faster production in comparison with other methods and is an economical and efficient method for producing components requiring low surface roughness and high dimensional accuracy. All major alloys can be processed with this technology.

1.1 Gravity die casting

Gravity Die Casting is a permanent mould casting process, where the molten metal is poured from a vessel or ladle into the mould. The mould cavity fills with no force other than gravity, filling can be controlled by tilting the die [4, 6].

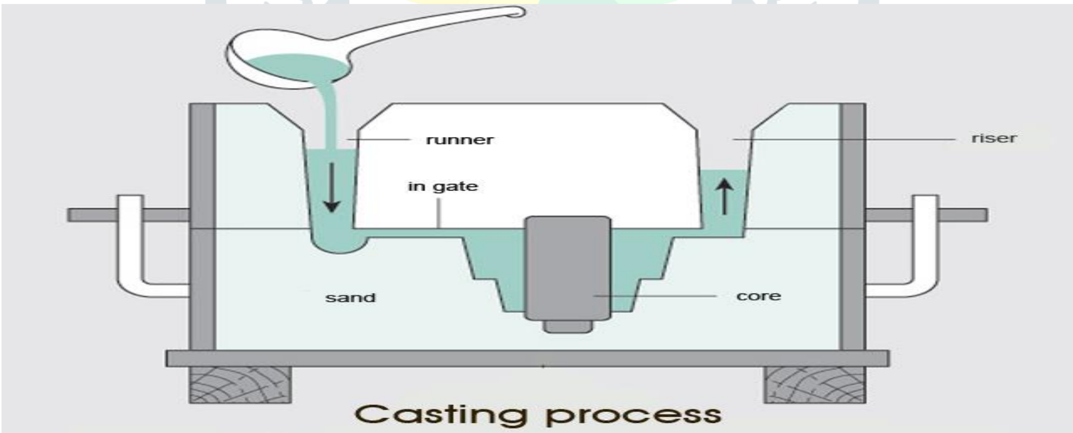

Fig1.1 Casting Process

1.1.1Hot chamber die casting process

Hot chamber die casting at beginning of the cycle the piston of the machine is retracted which allows the molten metal to fill the pneumatic or hydraulic powered piston then force this metal out of the gooseneck into the die. Hot chamber machines are used primarily for zinc, copper, magnesium, lead and other low melting point alloys that do not readily attack and erode metal pots, cylinder and plunger. A complete die casting cycle can vary from one second from small component weighing less than one ounce to three minutes for a casting of several pounds. This makes die casting process the faster the technique for producing precise nonferrous metal parts [4, 6].

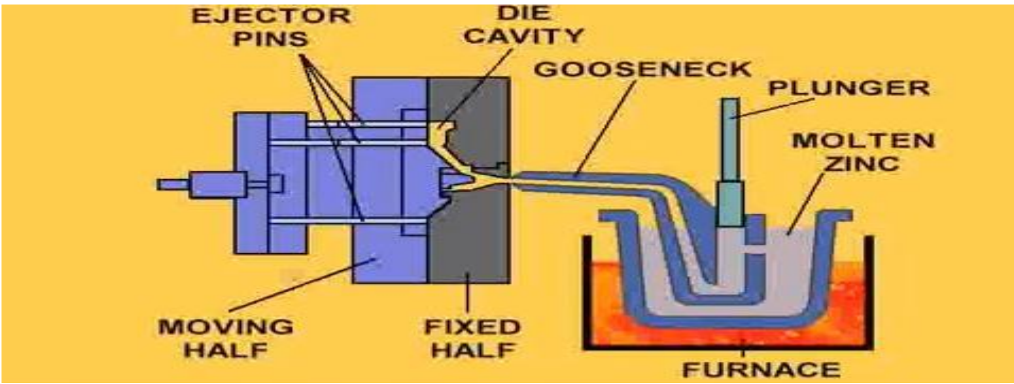

Fig 1.2 hot chamber die casting

1.1.2. Cold chamber die casting process

The cold chamber die casting process is used with higher melting point alloys, such as aluminum and magnesium. Since the cold chamber is located outside of the furnace, as compare to chamber, it required a means of moving the molten metal from holding furnace to the cold chamber. Casting cycle times can range from 10s for a small machine to 2 min for large machine .The die is closed and the molten metal is ladled into the cold chamber shot sleeve. The plunger pushes the molten metal into the die cavity where it is held under pressure until it solidifies. The die opens and the plunger advances, to ensure the casting remains in the ejector die [4, 6].

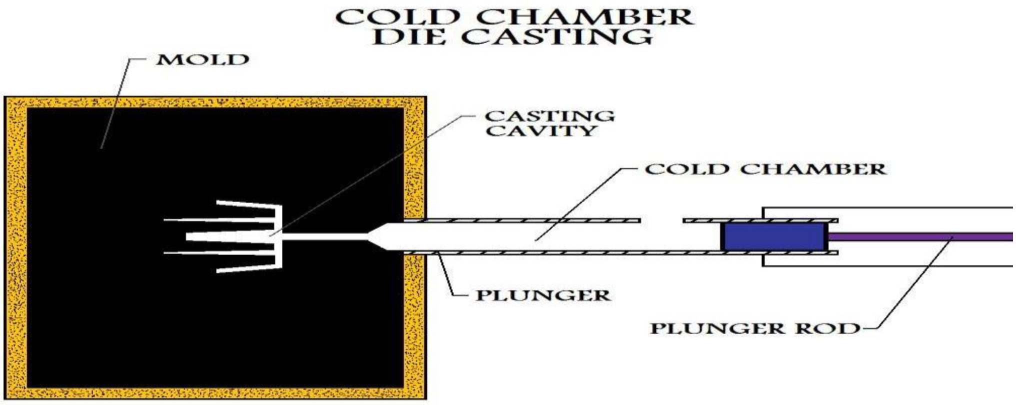

Fig 1.3 Cold Chambers Die Casting

1.2 Die Casting Materials:-

Heating a metal to a desirable melting temperature, therefore, the metal should be able to maintain its desirable characteristics within that temperature range; otherwise, the whole process will be futile. Exerting pressure, the metal must be able to maintain the same properties when subjected to these high pressures [4]

1.2.1 Zinc Die Casting

Zinc is one of the most popular metals that are used to make a number of products.

1. ZA alloys

These alloys are mainly used to cast components that require superior strength. This strength is due to the fact that they contain higher amount of aluminum.

2. Zamak alloys

These alloys contain about 4% aluminum. Like the ZA alloys, they are known to have provided good castability and strength. For decades, these alloys have been used in major metal casting applications. Like other die casting technologies, this process involves forcing the molten zinc under high pressure into a mold cavity. The zinc cast parts are used in a wide range of applications that impact our daily lives.

Advantage

- Process flexibility
- precisions and tolerance
- strength and ductility
- excellent thermal properties

1.1.2 Aluminum Die Casting

It is used for a wide range of engineering applications and it can be manipulated to any shape depending on the requirements at hand. Apparently, die casting aluminum has proved to be environmentally and sustainable. This is from the fact that about 95% of the metal can be recycled. This is basically due to the intrinsic physical and chemical properties of aluminum. This is the main reason why it is has been adopted globally [3].

- Alloy 383- it possesses the following key properties: dimension stability, ease of casting and good mechanical properties. It has superior corrosion resistance too.

- Alloy B390-it is known for its superior wear resistance and high hardness. They are mainly used to die cast the internal combustion engine pistons.
- A360-it is mainly used to cast aluminum parts where pressure tightness and fluidity is a priority. It maintains corrosion resistance and strength even at elevated temperature.

- Alloy A380- it has good thermal and mechanical properties. Its performance properties are similar to most alloys listed above.

Properties
- Corrosion resistance
- Lightweight Superior
- Thermal and electrical
- Properties high operating
- Temperature Strength and hardness
- Environmentally friendly

1.3 Simulation:-

A simulation is an approximate imitation of the operation of a process or system; the act of simulating first requires a model is developed. This model is a well-defined description of the simulated subject, and represents its key characteristics, such as its behaviour, functions and abstract or physical properties. The model represents the system itself, whereas the simulation represents its operation over time. Simulation is used in many contexts, such as simulation of technology for performance optimization, safety engineering, testing, training, education, and video games. Often, computer experiments are used to study simulation models. Simulation is also used with scientific modelling of natural systems or human systems to gain insight into their functioning.

1.3.1 Computer simulation:-

A computer simulation is an attempt to model a real-life or hypothetical situation on a computer so that it can be studied to see how the system works. By changing variables in the simulation, predictions may be made about the behaviour of the system. It is a tool to virtually investigate the behaviour of the system under study. Computer simulation has become a useful part of modeling many natural systems in physics, chemistry and biology and human systems in economics and social science (e.g., computational sociology) as well as in engineering to gain insight into the operation of those systems. A good example of the usefulness of using computers to simulate can be found in the field of network traffic simulation. In such simulations, the model behaviour will change each simulation according to the set of initial parameters assumed for the environment. Several software packages exist for running computer-based simulation modeling (e.g. Monte Carlo simulation, stochastic modeling and multimethod modeling) that make all the modeling almost effortless. Modern usage of the term "computer simulation" may encompass virtually any computer-based representation.

2. Literature review

Helder pinto & F.J.G. Sliva 11(2017):-

Study about Zamak alloy and using this how to improve die casting process. This study is focused in die casting applied to automobile industry where many casted parts are used in their components. In order to produce free defects parts, it is important to ensure that the processes and the values used are correctly set to achieve such performance. The process parameters varied were the injection pressure, hydraulic pressure, pot temperature and cooling time. In this high pressure high casting process following parameters are consider 1) Molten metal temperature (Zamak) 2) Mould temperature 3) Injection speed 4) Injection time 5) Solidification time. The study allows understand how important is the runner's location as well as the vents avoiding problems resulting from the wrong cooling process, no escape of the gases or bad choice of the parameters used in the process.

K.Ch. Apparao & Anil Kumar Birru 27(2017):-

In this paper we Identifying and optimizing various significant process parameters of high pressure die casting by using QFD-Taguchi based hybrid approach in order to yield the optimum casting density of the A380 alloy. This paper we using taguchi method and Identification of critical process parameters, selection of appropriate orthogonal array, analysis of means and analysis of variance are employed to study the performance characteristic of the die casting process. In this paper most critical parameters consider 1) Injection pressure 2) Molten metal temperature3) Plunger velocity4) Die temperature. This paper we three level parameter change and check which level is perfect for this aluminum die casting process. Quality technique, injection pressure, molten metal temperature, plunger velocity (1st and 2nd stage) and die temperature are identified as most significant process parameters which are affecting the casting density in order to yield customized products. Result Injection pressure is the most significant factor among the selecting factor. Molten metal temperature, Plunger velocity (1st and 2nd stages), die temperature and injection pressure were identified as influential parameters affecting the casting density of A380 alloy castings.

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In this paper study about optimization of process parameters of aluminum die casting operations. The quality problem encountered during the manufacturing of a die casted component was porosity and the potential factors causing it are identified through cause effect analysis. Objective of this paper is the pressure of plunger used in the die casting machine and Temperature of the liquid aluminum are identified as significant factor the analysis. In this paper following parameters are consider 1) Molten metal temperature 2) Plunger velocity 3) Hydraulic pressure 4) Metal filling Result The result is hundred experiment observations were collected and used for 70% training 15% validation and 15% testing. In order to achieve a required density of casting the corresponding setting of hydraulic pressure and metal temperature can be predicted from the neural network.

3. Methodology

3.1 Experiment details:-

The experiment have been conducted on high pressure die casting and This work was developed with the main goal of the study and improves the mould design of small parts used in command cables for car doors, seats, and so on. The simulation was used as the main tool to realize the main factors influencing the creation of pores into these small parts. The systematization of the study intended to create guidelines strong enough to take them into attention when designing a mould for this purpose

3.2 Zamak alloys:-

Alloy base material of zinc these alloys contain about aluminum, copper. Like the Zinc alloys, they are known to have Provide good castability and strength. For decades, these alloys have been used in major metal casting applications. Like other die casting technologies, this process involves forcing the molten zinc under high pressure into a mold cavity. The zinc cast parts are used in a wide range of applications that impact our daily lives. In order to produce free defects parts, the casting parts studied in this work, the different sizes of each part and the different shapes between them become difficult to set the filling attack in a way to avoid air entrapment and consequently porosities. In this study, finite elements simulation were initially performed, simulating the cast way as it is done in the real process and using the parameters[1].

Table no 3.1 Specification of Zamak Alloys [4]

Sr no	Material	Percentage (%)
1	Zinc	90
2	Aluminum	4
3	Copper	5
4	Magnesium	0.5
5	lead	0.3
6	cadmium	0.2

all parameter control is most necessary in high pressure die casting same parameter are the most important are the following ones: (a) Temperature of the melted metal (b) Resistance temperatures (c) Bomb pressure (directly implicit with the injection pressure)(d) Extraction pressure(e) Machine pressure(f) Injection time(g) Extraction time (h) Cooling time(i) Mould temperature &Cooling fluid temperature.

Table no 3.2 Die casting process parameter range [1]

Parameter	Values
Temperature (Zamak alloy)	440ºC
Mould temperature	100ºC
Injection speed	5.093 m/s
Injection time	0.30 s
Solidification Time	0.35 s

In this Zamak alloy we cannot change parameter because if we change the parameter than the problem are created if we all parameter are same but Zamak temperature change than the metal flow rate change and problem are created. Same we change all parameter than in simulation software check. In order to produce free defects parts, it is important to ensure that the processes and the values used are correctly set to achieve such performance. Nowadays, it is very usual to resort finite elements simulations, willing to reduce the time spent in setting those parameters in the machines. In this study, finite elements simulation were initially performed, simulating the cast way as it is done in the real process and using the parameters presented.

Temperatures will keep a progressive cooling, permitting a homogeneous cooling, and temperatures, ensuring that all these parameters act at the right time. In this way, a structure without any defects and consequently without loss of mechanical properties can be assured. In order to avoid die casting defects we need to have a previous knowledge of the parameters for each casting part the right material temperature and pressure. Today Finite Element Methods (FEM) or Scientific Fluid Dynamics (CFD) is the main technique to be used by casting industry. As a requirement for quality process, even so, the fact that finite element methods are the first attempt for establishing the parameters, it is necessary the need to have knowledge of the process, and its link with the different sizes of the parts and functionalities, so that the data could be computed as inputs [1]. This work was developed with the main goal of the study and improves the mould design of small parts used in command cables for car doors, seats, and so on. The simulation was used as the main tool to realize the main factors influencing the creation of pores into these small parts [1].

3.3 Terminals geometry

This study a special part was used as shown in fig it looks like an extended H shape and its dimensions are 30 mm length, 13, 7 mm in the widest area, presenting as well a surface area of 856, 97 mm2 and a volume of 902, 39 mm^3, being its mass weights 5, 96 g. It was chosen due to problems with its cast, like micro-porosities and rejects, and also because of the hard geometry that it presents, becoming hard the filling process, increasing the chance of defects appearance if the appropriate parameters are not set. It works with all its body in traction, which becomes the entire part functional, making casting defects a huge problem [1].

Fig 3.1 shapes of terminals used in casting H Special shapes [1]

3.3.5Simulation software used for finding die casting defect and problem

The finite elements software used was provided by Finite Solutions, Inc., which comprises two programs, the SOLID Cast and the FLOW Cast, we also had the external help of FLOW3D. The first one simulates multiple metals pour types and mould processes, using graphic technology from 3D modeling and X-ray images to AVI video files, while the second is a flow simulation, which simulates how molten metal will flow through the entire entities which comprise the gating system and metal mould casting cavities. The ideal results, as if a real process was being made are set by defining boundaries between the cast and the border and giving this boundaries characteristics equal or as close as possible to the reality. [1, 4]

Table no 3.3 Border conditions [1]

Properties	Values
Material	Steel H-13
Density x Specific Heat	3,56184e+06 [Kg/m/s2 /K]
Thermal Conductivity	28,6 [W/m.K]
Thermal Penetration Depth	0.01133 [m]
Mesh	
Total mesh cells	121440
Mesh Cell Size	0.0004 [m]

3.3.6 Description using simulation method process

We give two parts for manufacturing and first part manufacturing all parameter are taken constant. And second Part Change some parameter and checked, first parts are good but second parts are defective.

In this simulations were made in two parts, in the first one, it was used the exact parameters that are being used in the injection machines and exactly the same layout used into the mould, with their runners and without gas escapes. The fluid velocity vectors were analyzed to realize the fill process and air entrainment, temperatures and cavitation's potential, to observe where the critical points could be located.

Another parameter traced was the surface defect concentration, in order to understand how extent was the possibility to occur defects on the surface. The second part was assigned to the improvement of the process, after studying the first results and changes were made to the mould and filling characteristics. Some simulations were performed and analyzed in order to set the right until parameters achieving the best results.

The analyses at this stage were the same as the one before: the fluid velocity parameters vectors, air entrainment, temperatures and cavitation were all reviewed and compared with the initial, in order to conclude if the changes made allow to achieve the desired results and pass to the final step, which created the real mould and get parts to be analyzed and compared with the first ones. [1, 4]

3.3.7 Application for Zamak alloy

(1) Spherical
(2) Cylinders
(3) L shapes
(4) S shape or cranks
(5) Modified cylinders
(6) Special shapes.

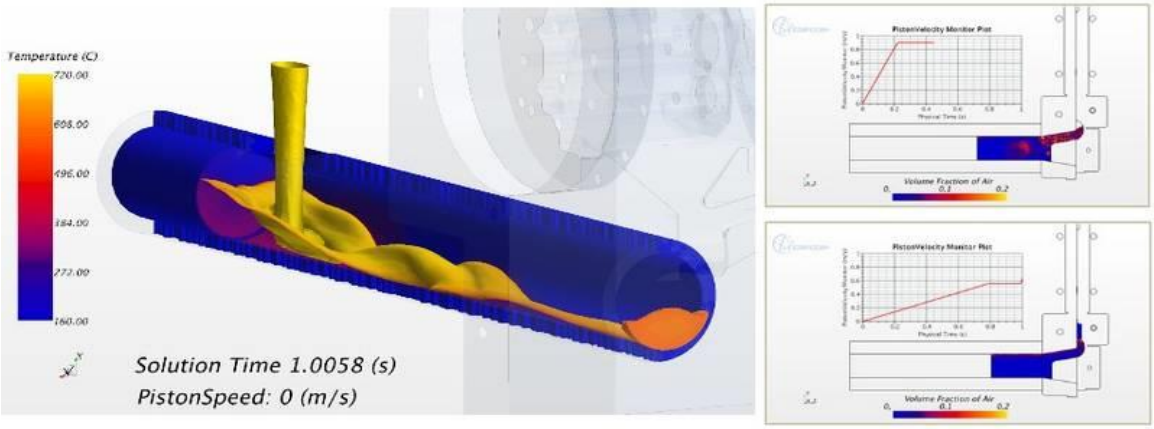

Fig 3.2 simulation method used for die casting process

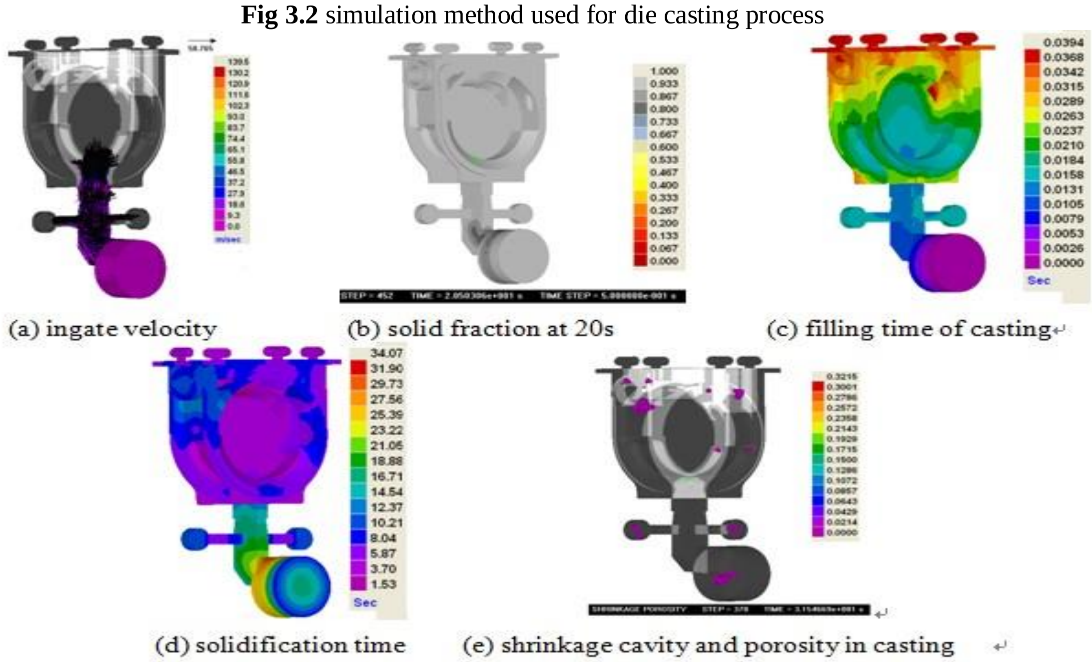

Fig3.3 Simulation method used for molding filling and solidification

3.4 Taguchi method using for A380 aluminum alloy

3.4.1 A380 aluminum alloy

It has good thermal and mechanical properties. Its performance properties are similar to most alloys listed above. Mixture of A380 alloy. Optimizing various significant process parameters of high pressure die casting by using QFD-Taguchi based hybrid approach in order to yield the optimum casting density of the A380 alloy. Identification of critical process parameters, selection of appropriate orthogonal array, analysis of means and analysis of variance are employed to study the performance characteristic of the die casting process [2, 3].

3.4.2 Taguchi method

To improve the quality of manufactured goods, and more recently also applied to engineering, die casting process have welcomed the goals and improvements brought about by Taguchi methods. States that the effect of uncontrollable factors (humidity, noise, vibrations etc.) Can be nullified by the proper selection of the level combination of controllable factors or process parameters. The aim of the Taguchi method is to establish the parameter settings which render the product quality robust to unavoidable variations in external noise, a few researchers made an attempt on various manufacturing processes by using Taguchi method. [2, 5]

Table no 3.4 Specification of A380 aluminum alloy

Parameter	Value
Aluminum	**87.7%**
Silicon	**8%**
Copper	**3%**
Iron	**1.3%**

3.4.3 Proposed optimal procedure

The integrated approach combines the QFD with Taguchi method in order to determine the die casting process parameters with optimal response characteristics, as depicted in [2]

3.4.4Parameter design

The most significant process parameters and their respective levels and appropriate orthogonal array (OA) for design of experiment here selected to determine optimum casting density of the A380 alloy. Selection of process parameters identify the casting process parameters which may affect the die casting density, was constructed based on the exploratory significant parameters that affect processes, which were indistinguishable to the present investigation. The process parameters can be listed in four categories as follows: 1) Parameters related to die casting machine: Plunger velocity during 1st and 2nd stage, fast shot set point, cavity filling time, multiple pressures during 3rd stage 2) Parameters related to shot sleeve: Dimensions and filling time of shot sleeve 3) Type of die lubricant 4) Parameters related to die: Temperature of the die, size and shape of the gate, venting system of die design, cooling system of die design 5) Parameters related to cast metal: Temperature of the casting metal, condition and composition of the cast metal[2,5].

Table 3.5 Range of process parameter [2]

Parameter destination	Process parameter	Parameter range	Level 1	Level 2	Level 3
A	Molten metal temperature	650-750	650	700	750
B	Plunger velocity 1^{ST} stage (m/s)	0.020-0.34	0.02	0.18	0.34
C	Plunger velocity 2^{nd} stage (m/s)	1.2-3.8	1.2	2.5	3.8
D	Die temperature	180-260	180	220	260
E	Injection pressure	12-24	12	18	24

3.4.5 Selection of orthogonal array

It was revealed that non-linear behavior of the process parameters of a die casting can be determined only if more than two levels per each parameter are used. Therefore, each parameter was analyzed in three levels. The process parameters along with their values at selected levels are also given in Table. The molten metal temperature imposed in conjunction with the piston velocity in first and second stages, affects the density of the die casting process. Thus, it was also decided to study the interaction effects of these parameters on the density of the die casting process [2, 5].

Table no 3.6 ORTOHOGONAL ARRAYS [2]

Ex no	A	B	A*B	A*B2	C	A*C	A*C2	B*C	D	E	B*C2
1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	2	2	2	2	2	2	2
3	1	1	1	1	3	3	3	3	3	3	3
4	1	2	2	2	1	1	1	2	2	2	3
5	1	2	2	2	2	2	2	3	3	3	1
6	1	2	2	2	3	3	3	1	1	1	2
7	1	3	3	3	1	1	1	3	3	3	2
8	1	3	3	3	2	2	2	1	1	1	3
9	1	3	3	3	3	3	3	2	2	2	1
10	2	1	2	3	1	2	3	1	2	3	1
11	2	1	2	3	2	3	1	2	3	1	2
12	2	1	2	3	3	1	2	3	1	2	3
13	2	2	3	1	1	2	3	2	3	1	3
14	2	2	3	1	2	3	1	3	1	2	1
15	2	2	3	1	3	1	2	1	2	3	2
16	2	3	1	2	1	2	3	3	1	2	2
17	2	3	1	2	2	3	1	1	2	3	3
18	2	3	1	2	3	1	2	2	3	1	1
19	3	1	3	2	1	3	2	1	3	2	1
20	3	1	3	2	2	1	3	2	1	3	2
21	3	1	3	2	3	2	1	3	2	1	3
22	3	2	1	3	1	3	2	2	1	3	3
23	3	2	1	3	2	1	3	3	2	1	1
24	3	2	1	3	3	2	1	1	3	2	2
25	3	3	2	1	1	3	2	2	2	1	2
26	3	3	2	1	2	1	3	1	3	2	3
27	3	3	2	1	3	2	1	2	1	3	1

These interactions were the molten metal temperature imposed in conjunction with piston velocity (first stage) (A×B), molten metal temperature with piston velocity (second stage) (A×C) and the piston velocity first and second stage (B×C) As per Taguchi's method, the total DOF (degree of freedom) of selected OA must be greater than or equal to the total DOF required for the experiment. The total DOF for five factors, each factor at three levels and three interactions, is 22 Therefore, a three-level OA with 27 experimental runs (DOF=27−1=26) has been selected for the present research. The assignment of the casting process parameters (A to E) and parameter interactions (A×B, A×B2, A×C, A×C2, B×C and B×C2) in columns [2,5].

The experiments have been conducted on high pressure die casting machine of technocrats model The test sample was a square plate of A380 alloy (Al, 8% Si, 3% Cu, 1.3% Fe) with dimensions 100 mm × 100 mm × 20 mm. Thick test casting has been selected to facilitate the experimental procedure[2].

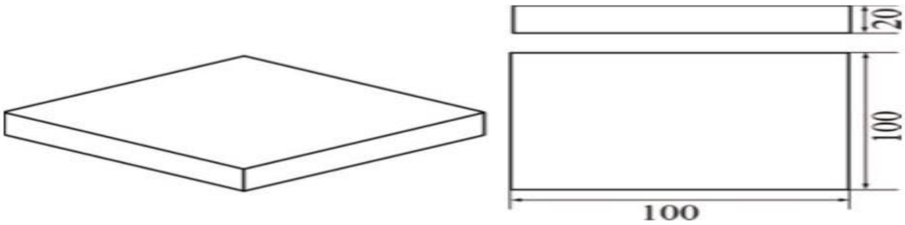

Fig 3.8 Schematic representation of die casting pattern used in experimental procedure (unit: mm)

As per Taguchi design, 27 experiments were conducted at each test condition. For each test condition, three test castings were made using a randomization technique. The pictorial view of the casting part. The casting density was measured using the immersion technique. Castings were weighed first in air and then immersed completely in degassed distilled water. All weightings were conducted on Metter Balance with accuracy at 0.0001 g. Application of this technique leads to the following expression for the density of the casting [2].

$$\rho = \frac{m}{(m - m_1)} \rho_w$$

Eq no 1 Calculate density using this formula [2].

Where m is the mass of the casting part in air, m1 is the mass of the same casting part in degassed distilled water and ρw is the density of the degassed distilled water. The density of degassed distilled water at 20 °C is 998 kg/m3. Using aforesaid method, the densities of the experimental casted parts were measured and furnished [2].

Table 3.7 Casting density value and S/N ratios against trial number table given

Casting density/(g·cm−3)					
Exp no	Repetition 1	Repetition 2	Repetition 3	Average	S/N ratio
1	2.777	2.775	2.78	2.777	8.8726
2	2.781	2.778	2.783	2.781	8.8830
3	2.783	2.783	2.788	2.785	8.8955
4	2.785	2.78	2.786	2.784	8.8923
5	2.787	2.785	2.79	2.787	8.9038
6	2.776	2.773	2.779	2.776	8.8684
7	2.789	2.787	2.792	2.789	8.9100
8	2.772	2.778	2.781	2.777	8.8715
9	2.788	2.775	2.785	2.783	8.8892
10	2.787	2.784	2.785	2.787	8.9038
11	2.78	2.778	2.791	2.780	8.8809
12	2.78	2.776	2.782	2.780	8.8798
13	2.782	2.789	2.783	2.782	8.8871
14	2.782	2.778	2.785	2.782	8.8861
15	2.783	2.782	2.785	2.785	8.8965
16	2.787	2.781	2.79	2.784	8.8934
17	2.788	2.784	2.784	2.788	8.9058
18	2.781	2.775	2.792	2.781	8.8840
19	2.785	2.784	2.787	2.786	8.8986
20	2.786	2.783	2.788	2.786	8.8996
21	2.788	2.778	2.789	2.780	8.8798
22	2.781	2.785	2.782	2.789	8.9079
23	2.783	2.789	2.793	2.781	8.8851
24	2.785	2.782	2.791	2.785	8.8975
25	2.786	2.781	2.786	2.784	8.8934
26	2.786	2.785	2.788	2.786	8.9007
27	2.787	2.783	2.788	2.786	8.8996

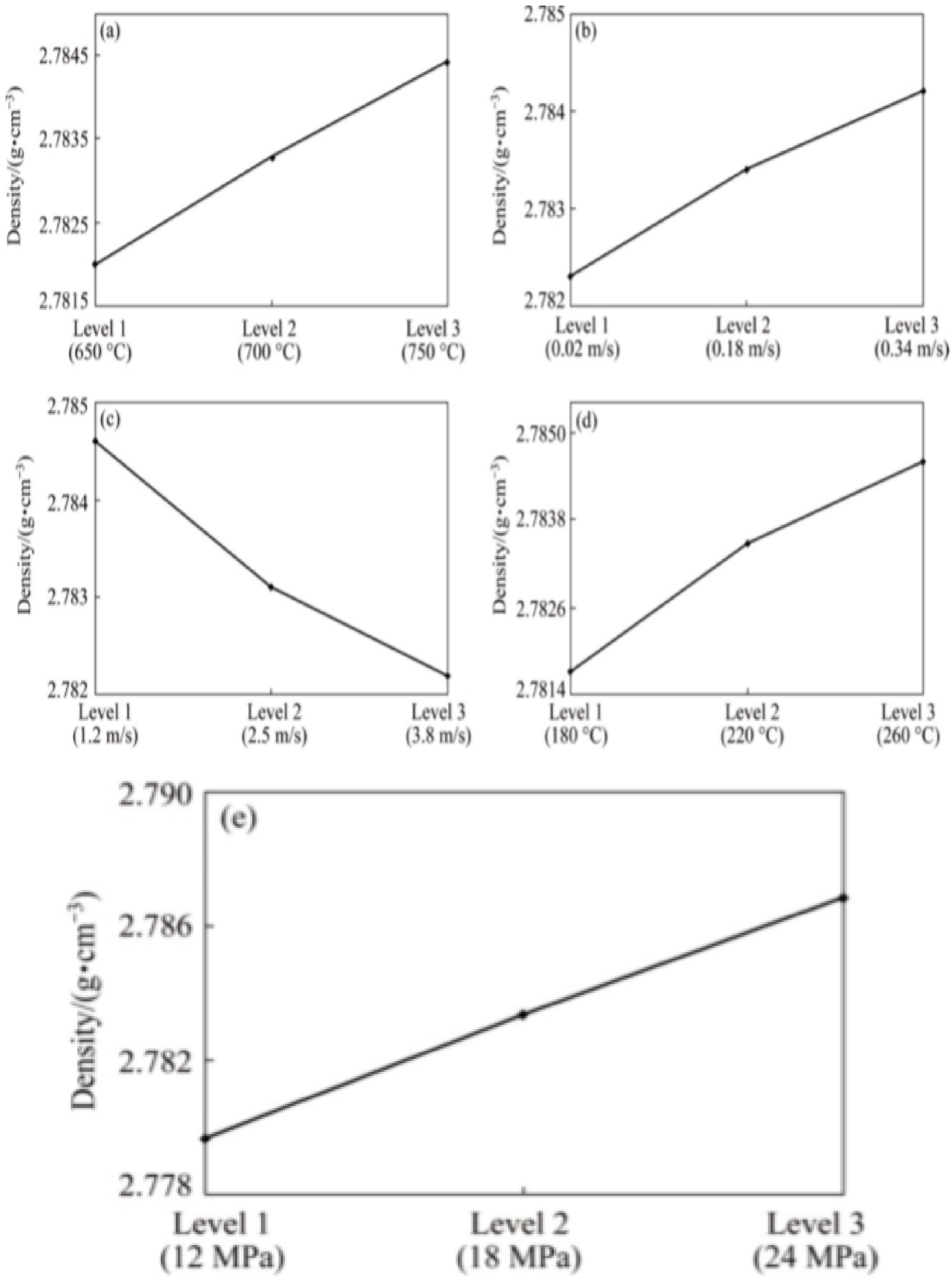

Fig 3.9 Average values of casting density of each parameter at levels 1−3: (a) Molten metal temperature; (b) Plunger velocity (1st stage); (c) Plunger velocity (2nd stage); (d) Die temperature; (e) Injection pressure [2]

Experimental data are traditionally used to analyze the mean response. The Taguchi method stresses the importance of studying the variation of the response using the Signal-to-Noise (S/N) ratio [2]. The reason for this is to minimize the variation in the quality characteristics due to uncontrollable parameters. Hence, the density is a "Higher the better" type of quality characteristic. So the S/N ratio was used for that type of response, and is given by Eq. S/N ratio [2, 5].

$$\eta = -10\lg\left(\frac{1}{n}\sum_{i=1}^{n} 1/y_i^2\right)$$

Eq no 2 S/N ratio formula

Where η is the S/N ratio

yi is the response value for a test condition repeated in n times.

Table no 3.8 Average values of casting density (g/cm3) at varies levels with main effects [2]

Factor	Level 1	Level 2	Level 3	L2−L1	L3−L2
A	2.782	2.7833	2.7844	0.0013	0.0017
B	2.7823	2.7834	2.7842	0.0011	0.0008
C	2.7846	2.7831	2.7822	-0.0015	-0.0009
D	2.7817	2.7835	2.7846	0.0018	0.0011
E	2.7797	2.7833	2.7868	0.0036	0.0035

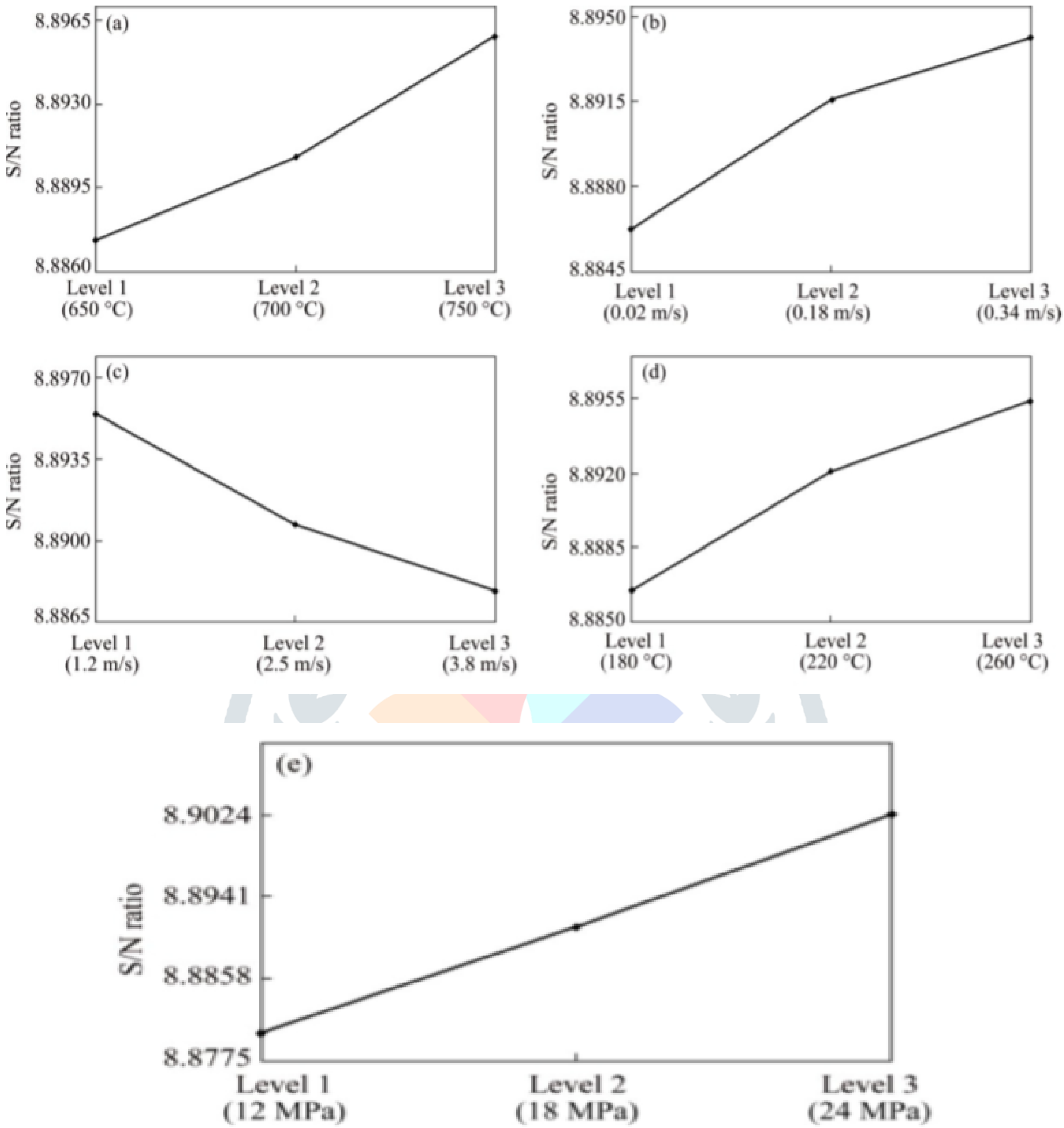

Fig 3.9 Average values of casting density of each parameter at levels 1−3: (a) Molten metal temperature; (b) Plunger velocity (1st stage); (c) Plunger velocity (2nd stage); (d) Die temperature (e) Injection pressure

Experimental data are traditionally used to analyze the mean response. The Taguchi method stresses the importance of studying the variation of the response using the Signal-to-Noise (S/N) ratio [2]. The reason for this is to minimize the variation in the quality characteristics due to uncontrollable parameters. Hence, the density is a "Higher the better" type of quality characteristic. So the S/N ratio was used for that type of response, and is given by Eq. S/N ratio [2, 5]

Table no 3.8 Average values of casting density (g/cm3) at varies levels with main effects.

Factor	Level 1	Level 2	Level 3	L2−L1	L3−L2
A	2.782	2.7833	2.7844	0.0013	0.0017
B	2.7823	2.7834	2.7842	0.0011	0.0008
C	2.7846	2.7831	2.7822	-0.0015	-0.0009
D	2.7817	2.7835	2.7846	0.0018	0.0011
E	2.7797	2.7833	2.7868	0.0036	0.0035

3.4.6 Estimation of density mean

From the analysis of S/N ratio and the mean response characteristic, optimum levels of the control factors are determined as: A3, B3, C1, D3 and E3. Hence, utilizing the estimation model of Taguchi based on the average values of optimum levels of factors and equivalent "β-factors" the estimated mean of the quality characteristic (experimental casting density) is achieved by the following **equation no 3 μ=Mβ(M)+(A3−M)*β(A)+(B3−M)*β(B)+(C1−M)*β(C)+ (D3−M)*β(D)+(E3−M)β(E)**

where M is the overall average of trials. β(A), β(B), β(C), β(D), β(E) are the β-factors of factors A−E, respectively, and defined by Eq. [2]

$$\beta(P) = 1 - \frac{1}{F_P}$$

Eq no 4 where FP is the F-ratio of factor P.

A3, B3, C1, D3 and E3 are the near optimal levels of the control parameters. The β (M) is the overall β-factor.

Table no3.9 Average value of S/N ratio at varies levels (1-3) with main effect

Factor	Level 1	Level 2	Level 3	L2-L1	L3-L2
A	8.8873	8.8908	8.8958	0.0035	0.0050
B	8.8863	8.8916	8.8942	0.0053	0.0025
C	8.8954	8.8907	8.8978	-0.0047	-0.0029
D	8.8865	8.8921	8.8953	0.0056	0.0032
E	8.8803	8.8912	8.9025	0.0109	0.0113

Table no 3.10 ANOVA of die casting density

Factor	SS	DOF	V	F-ratio	P/%
A	$3.2805*10^{-5}$	2	$1.6401*10^{-5}$	131.532	9.301
B	$1.6382*10^{-5}$	2	$8.1913*10^{-6}$	65.692	4.610
C	$2.6975*10^{-5}$	2	$1.3487*10^{-5}$	108.166	7.636
D	$3.6037*10^{-5}$	2	$1.8018*10^{-5}$	144.502	11.023
E	0.0002271	2	$1.1357*10^{-4}$	910.822	61.483
A*B	$2.0987*10^{-7}$	4	$5.2469*10^{-8}$	-	-
$A*B^2$	$5.5555*10^{-7}$	8	$6.9444*10^{-8}$	-	-
A*C	$1.8518*10^{-7}$	4	$4.6296*10^{-8}$	-	-
$A*C^2$	$2.0987*10^{-7}$	8	$2.6234*10^{-8}$	-	-
B*C	$3.5802*10^{-7}$	4	$8.9506*10^{-8}$	-	-
$B*C^2$	$4.0740*10^{-7}$	8	$5.0925*10^{-8}$	-	-
Error	$8.7285*10^{-6}$	70	$1.2469*10^{-7}$	-	5.947
Total	0.00035	80	$4.3750*10^{-6}$	-	100

SS-sum of squares, DOF-degree of freedom, V- variance, P-percentage contribution

Table no3.11 S/N ANOVA of die casting density

Factor	SS	DOF	V	F-Ratio	P/%
A	$3.2465*10^{-4}$	2	$1.6232*10^{-4}$	505.640	9.599
B	$1.6324*10^{-4}$	2	$8.1618*10^{-5}$	254.242	4.817
C	$2.6758*10^{-4}$	2	$1.3379*10^{-4}$	416.756	7.909
D	$3.5576*10^{-4}$	2	$1.7788*10^{-4}$	554.099	10.521
E	$2.2168*10^{-3}$	2	$1.1084*10^{-3}$	3452.726	65.660
A*B	$2.2559*10^{-6}$	4	$5.6398*10^{-7}$	1.757	0.029
$A*B^2$	$9.5397*10^{-6}$	8	$1.1924*10^{-6}$	3.715	0.207
A*C	$2.4568*10^{-6}$	4	$6.1419*10^{-7}$	1.913	0.035
$A*C^2$	$2.2711*10^{-6}$	8	$2.8388*10^{-7}$	0.884	-0.009
B*C	$7.9007*10^{-6}$	4	$1.9751*10^{-6}$	6.153	0.196
$B*C^2$	$3.1904*10^{-7}$	8	$3.9880*10^{-8}$	0.124	-0.067
Error	$2.472*10^{-5}$	70	$3.2102*10^{-7}$	-	-
Total	0.00337527	80	$4.2190*10^{-5}$	-	-

SS-sum of squares, DOF-degree of freedom, V- variance, P-percentage contribution

3.4.7Confidence interval (CI) around estimated mean of density

Confidence interval (CI) has been calculated for 95% consistency level and some conformational experiments have been conducted at optimum level of the process parameters for validation of the adequacy of the Taguchi method. The mean percentage defect (μ) calculated by for the selected trial condition is 2.79057 g/cm3. To verify predictions, the confidence levels, i.e., the maximum and minimum values have been calculated, between which the values of conformational experiments should fall. The interval was obtained by the set of

Eq no 6

$$CI = \pm\sqrt{\frac{F(1,\ \alpha,\ n_e)V_e}{N_e}}$$

Where F (1, α, ne) is the F value from the F table for α=risk, confidence = 1− risk (DOF of mean = 1), ne is the DOF of error, Ve is the pooled error variance and Ne is the effective sample size: **Eq no 7 [2]**

$$N_e = \frac{N}{1 + \sum P(u_p \beta(P))}$$

where N is the total number of trials, up the DOF of factor P and β (P) the β-factor of factor P. An interval confidence level of 95% for the casting density, the F (1, 5%, 70) =3.98, Ve=3.21026×10−7 and the effective size of sample is Ne=2.4725. Thus, the confidence level of interval is computed as CI=0.000718. So, the 95% CI of the predicted optimum is 2.78985 g/cm3<μ<2.79128 g/cm3. [2]

In this paper we change the parameter in three level and the A380 alloy density and we this alloy study parameters when changed from the lower to higher level parameter E is more prominent than remaining four parameters (molten metal temperature, plunger velocity at 1st and 2nd stages and die temperature). revealed that the casting density is maximum at the 3rd level of the parameters A, B, D and E and also at the 1st level of the parameter C[2,3,5].

Average values of casting density of each parameter at levels 1−3: (a) Molten metal temperature; (b) Plunger velocity (1st stage); (c) Plunger velocity (2nd stage); (d) Die temperature; (e) Injection pressure [2, 4].

4. Results and Discussion

In my case study I am study about Simulation method for Zamak alloy and taguchi method for A380 alloy. In simulation method we looking at the simulations results, we conclude that the expectations to obtain improved parts are a reality. The restrictions imposed by old equipment are a problem hard to overcome because they set limits to important parameters such as pressures, speeds and temperatures. The changes in the mould layout and parameters like feeding, venting and even in filling pressures by the change of spurs, enable the possibility of improvement without the weight of having to change equipment. Thus, it will be possible to achieve conformal parts without spending large sums of money in machine improvements. The change of runners from two to one gives a more laminar flow, avoiding turbulences in the front section of the part. The creation of gases 4escapes provides exits so the gases do not get entrapped and the spurs improvement change the pressures in order to lower that parameter, becoming the filling steady. The global goal was achieved because to obtain health parts in pressure die casting, it is important to have a laminar flow with gases and porosities as less as possible.

In taguchi method we three level are used and in this three level last parameter shows that the parameter E is more prominent than remaining four parameters (molten metal temperature, plunger velocity at 1st and 2nd stages and die temperature. In simulation method using Zamak alloy I am study about how to increasing mass production using Zamak alloy and in taguchi method I am study about which level important for the given alloy 3 levels is most suitable in A380 alloy.

5. Conclusions

In my case study I am study about Zamak alloy and taguchi method in Zamak alloy This study allows realize what really affects the high-pressure die casting process of small parts in Zamak alloy. The study allows understand most important of the runners' location as well as the vents, avoiding problems resulting from the wrong cooling process, no escape of the gases or bad choice of the parameters used in the process. And in taguchi method I am study QFD approach in the die casting process for identifying significant critical process parameters in order to yield the customized products. Hence, molten metal temperature, Plunger velocity (1st and 2nd stages), die temperature and injection pressure were identified as influential parameters affecting the casting density of A380 alloy castings. And injection pressure is the most significant factor among the selected parameters.

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