# Experimental Analysis of Pressure Die Casting Process with different Die angle and Fillet radius

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*Abstract* — Present analysis is on pressure die casting process, It was carried out on considering A356 (molten aluminium) material with steel die. The study was conducted in casting industry, wall shear stresses has been analyzed shear stress detecting device and sensors. A simplified and idealized experimentation is done by using symmetry assumption and a non-simplified investigation of process have been used in the analyses. The major study was done on pressure die casting by using different fillet radius and chamfer angle.

In our analysis, experimentation have been developed the model is considered as existing part in continuous production. The analysis results show that 30 degree of chamfer angle and 6mm of fillet radius gives absolute convergence on pressure and temperature, Validation and optimization is done to determine the effect of pressure die casting process during working condition. The temperature and pressure with wall fluxes is analysed in pressure die casting for enhancement of machinability to reduce internal stresses generated due to imbalance of temperature and pressure. Wall shear stresses were also analysed at the die and molten metal interface zone for enhancement of workability for product and to reduce surface defects on manufactured product.

Hence chamfer angle of 30 degree on die and fillet radius of 6mm shows minimum wall shear stress with high temperature and pressure distribution on squeeze die casting process.

Keywords— *Pressure, Temperature, wall shear stresses, fillet radius, chamfer angle, squeeze die casting process.*

## I. INTRODUCTION

Pressure die casting is brief, dependable and cost-powerful manufacturing processes for manufacturing of excessive quantity steel components which can be internet-formed have tight tolerances. Basically, the stress die casting system consists of injecting beneath high strain a molten metallic alloy into a steel mold (or tool). This gets solidified swiftly (from milliseconds to 3 seconds) to shape a net formed element. Its miles then automatically extracted. Die casting is a metallic casting procedure that is characterized by forcing molten steel underneath high strain right into a mould cavity. The mould cavity is created the usage of two hardened tool metal dies that have been machined into form and work further to an injection mildew throughout the system. Maximum die castings are made from non-ferrous metals, particularly zinc, copper, aluminium, magnesium, lead, pewter, and tin-based totally alloys. Relying at the kind of metal being forged, a hot- or cold-chamber device is used.

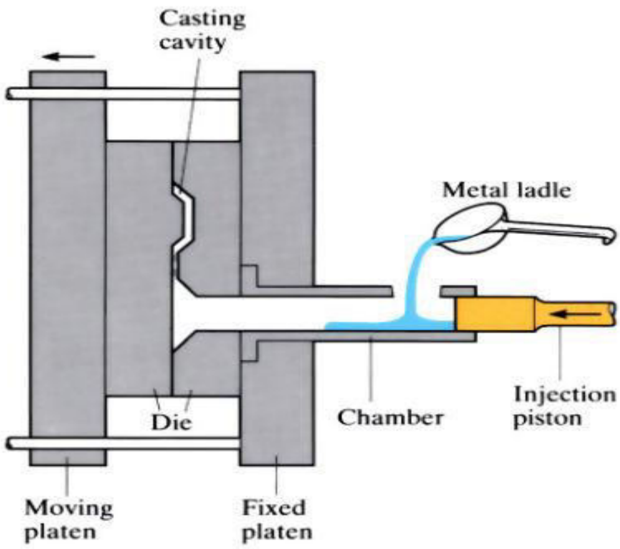


**Figure** 1-1 Squeeze casting machine

The casting gadget and the metallic dies represent massive capital fees and this has a tendency to restrict the technique to high-extent production. Manufacture of parts the use of die casting is extraordinarily simple, involving best four important steps, which keeps the incremental price consistent with item low. Its miles especially desirable for a big amount of small- to medium-sized castings, that is why die casting produces extra castings than some other casting manner.

## II DIE CASTING

Die casting is a manufacturing procedure that could produce geometrically complex steel components through using reusable molds, referred to as dies. The die casting procedure involves the use of a furnace, steel, die casting system, and die. The metal, typically a non-ferrous alloy together with aluminum or zinc, is melted inside the furnace and then injected into the dies within the die casting machine. There are main forms of die casting machines - warm chamber machines (used for alloys with low melting temperatures, together with zinc) and cold chamber machines (used for alloys with high melting temperatures, such as aluminum). The variations between these machines could be special inside the sections on device and tooling. However, in each machines, after the molten metallic is injected into the dies, it rapidly cools and solidifies into the very last part, referred to as the casting. The steps in this system are defined in extra element within the next segment.

## III PROCESS CYCLE OF DIE CASTING

**Clamping** - The first step is the instruction and clamping of the two halves of the die. Each die half of is first wiped clean from the previous injection after which lubricated to facilitate the ejection of the subsequent element. The lubrication time increases with component length, in addition to the variety of cavities and facet-cores. Also, lubrication won't be required after every cycle, but after 2 or 3 cycles, depending upon the cloth. After lubrication, the 2 die halves, that are connected within the die casting device, are closed and securely clamped together. Sufficient pressure should be applied to the die to hold it securely closed while the metallic is injected. The time required to shut and clamp the die depends upon the machine - larger machines (people with more clamping forces) would require greater time. This time may be estimated from the dry cycle time of the machine.

**Injection** - The molten metal that is maintained at a hard and fast temperature inside the furnace, is next transferred into a chamber in which it can be injected into the die. The approach of shifting the molten steel is dependent upon the type of die casting system, whether a warm chamber or cold chamber device is being used. The difference on this system could be specific inside the next phase. Once transferred, the molten metallic is injected at excessive pressures into the die. Typical injection strain tiers from 1,000 to twenty,000 psi. This strain holds the molten metallic inside the dies at some point of solidification. The quantity of metallic this is injected into the die is known as the shot. The injection time is the time required for the molten steel to fill all of the channels and cavities in the die. This time is very short, generally much less than zero.1 seconds, with the intention to save you early solidification of anyone a part of the metallic. The right injection time may be determined by way of the thermodynamic homes of the cloth, in addition to the wall thickness of the casting. A extra wall thickness will require an extended injection time. In the case wherein a chilly chamber die casting gadget is being used, the injection time ought to also consist of the time to manually ladle the molten metallic into the shot chamber.

**Cooling -** The molten metallic that is injected into the die will start to cool and solidify once it enters the die cavity. When the entire hollow space is filled and the molten metal solidifies, the very last shape of the casting is formed. The die can't be opened until the cooling time has elapsed and the casting is solidified. The cooling time may be expected from several thermodynamic residences of the metal, the maximum wall thickness of the casting, and the complexity of the die. A extra wall thickness will require an extended cooling time. The geometric complexity of the die also calls for a longer cooling time due to the fact the extra resistance to the float of warmth.

**Ejection** - After the predetermined cooling time has surpassed, the die halves may be opened and an ejection mechanism can push the casting out of the die hollow space. The time to open the die may be expected from the dry cycle time of the device and the ejection time is decided via the size of the casting's envelope and have to consist of time for the casting to fall freed from the die. The ejection mechanism have to follow some pressure to eject the part due to the fact in the course of cooling the component shrinks and adheres to the die. Once the casting is ejected, the die may be clamped shut for the subsequent injection.

**Trimming** - During cooling, the fabric inside the channels of the die will solidify connected to the casting. This excess cloth, alongside any flash that has took place, die casting method.

### ❖ OBJECTIVE OF THE WORK

The main objective of the current work is

- The main objective of our proposed work is validation of the pressure die casting models by optimizing the experimental outcome.
- To predict temperature and pressure for different die chamfer angle and fillet radius.
- To perform experiment for analyzing wall shear stresses at constant pressure of 70 MPa.
- To define temperature and pressure distribution, wall shear stresses for the different chamfer angle and fillet radius at constant pressure input.
- Predict temperature distribution along the pressure die casting process.

### ❖ PROBLEM FORMULATION –

The survey of different previous works we predict the pressure and temperature is higher as compared to present study is shown in our base paper. The purposes of this study reduce the temperature and increase the workability and machinability at various chamfer angle and fillet radius in pressure die casting.

## VI EXPERIMENTAL COMPONENT PARAMETERS

**Preparing the Mold**

Step one of pressure die casting is guidance of mold. Throughout this first step, the manufacturing employer applies a lubricant to the interior partitions of the mildew. That is frequently vital because the lubricant regulates the mildew's temperature while also creating a movie between the molten metal and therefore the mold, thereby allowing less difficult elimination of the casting.

**Injection**

After making ready the die mold, the manufacturing organization injects it with molten metal. The moulds have to be completed closed and sealed throughout this step. Otherwise, it won't be prepared to "be given" the especially pressurized molten steel. Counting on the precise software, the molten metallic could also be injected into the mold at a stress of among 1,500 to 25,000 pounds in line with sq.In (PSI). The mold maintains this strain till the molten steel has cooled and solidified.

Figure – Cavity pouring of Material A356

**Cavity Ejection**

Subsequent, the manufacturing agency ejects the newly made hollow space from the mildew. The mould itself typically features ejector pins that, while engaged, launch the hollow space. Of direction, the cavity should be strong for it to eject. If the uncooked steel remains liquid, the manufacturing organization ought to look forward to it to cool before it could eject the cavity from the mold.

**Shakeout**

The fourth and final step of high-pressure die casting is shakeout. During this step, the manufacturing company separates any scrap metal from the newly created cavity. It's not uncommon for high-pressure die casting to produce excess scrap metal. In other words, not all of the molten metal is used to create the casting. Some remains stuck inside the mold. As a result, the scrap metal must be removed before the mold can be reused. To recap, high-pressure die casting generally consists of four steps: preparing the mold, injecting the mold with molten metal, ejecting the newly created cavity from the mold, and separating scrap metal from the cavity.

**Table - Properties of molten material**

| Material Properties | A356 |
|---|---|
| **Thermal Conductivity** | 159 |
| **Specific heat** | 1154 |

## VII RESULT AND DISCUSSION

The effects of pressure and temperature on squeeze casting process is proceeded for present analysis the Reynolds stresses and wall fluxes were also determined for enhancement of workability and machinability of a product produced by pressure die casting process. The results have been compared with experimental value of same parameter and also compare with present base paper model with different chamfer angle and fillet radius of die for operating under similar operating conditions to discuss the enhancement in heat transfer and pressure as well as wall fluxes and Reynolds stresses on account of pressure die casting

Table 5.1 Validation results of pressure determine with numerical simulation

| Validation | | | |
|---|---|---|---|
| 70 MPa | 46MPa | 23MPa | Time |
| 27.6 | 13.8 | 1.6 | 0 |
| 29.3 | 15.9 | 3.8 | 5 |
| 32.5 | 18.2 | 6.1 | 10 |
| 35.2 | 21.4 | 8.2 | 15 |
| 37.4 | 24.7 | 10.5 | 20 |
| 41.3 | 26.9 | 12.8 | 25 |

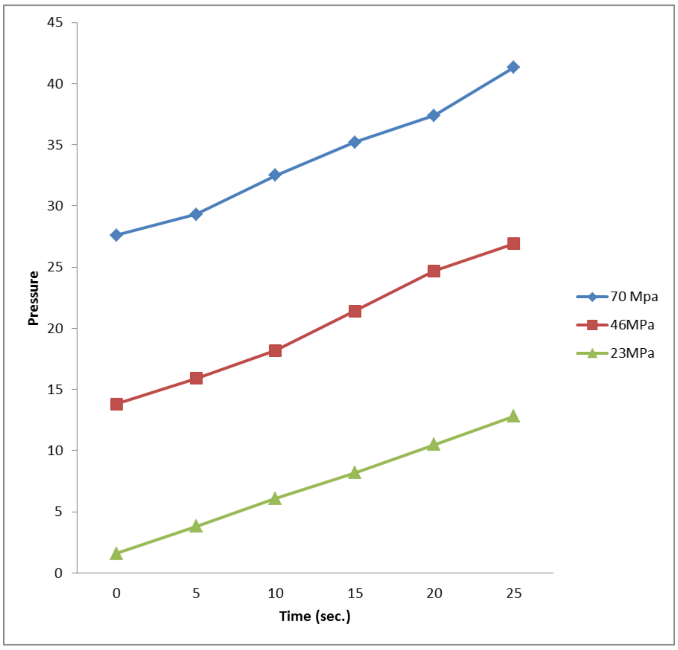


Figure 5.1 Comparison of pressure with different values of plunger pressure w.r.t. time

The values of pressure with different plunger pressure signifies, the convergence of present analysis with base paper values, thus experimental data with different conditions seems to be approximately average with present numerical simulation., 70 MPa and 46 MPa exhibits higher pressure during die casting process as shown above in the graphical representation, these values are w.r.t. time

Table 5.2 Comparison of temperature distribution on squeeze die casting process on different plunger pressure

| | Validation | | |
|---|---|---|---|
| Time (Sec.) | 70 MPa | 46 Mpa | 23 Mpa |
| 0 | 280 | 250 | 225 |
| 5 | 385 | 325 | 260 |
| 10 | 425 | 370 | 300 |
| 15 | 445 | 390 | 325 |
| 20 | 455 | 400 | 340 |
| 25 | 500 | 430 | 370 |
| 30 | 525 | 450 | 385 |
| 35 | 530 | 475 | 400 |

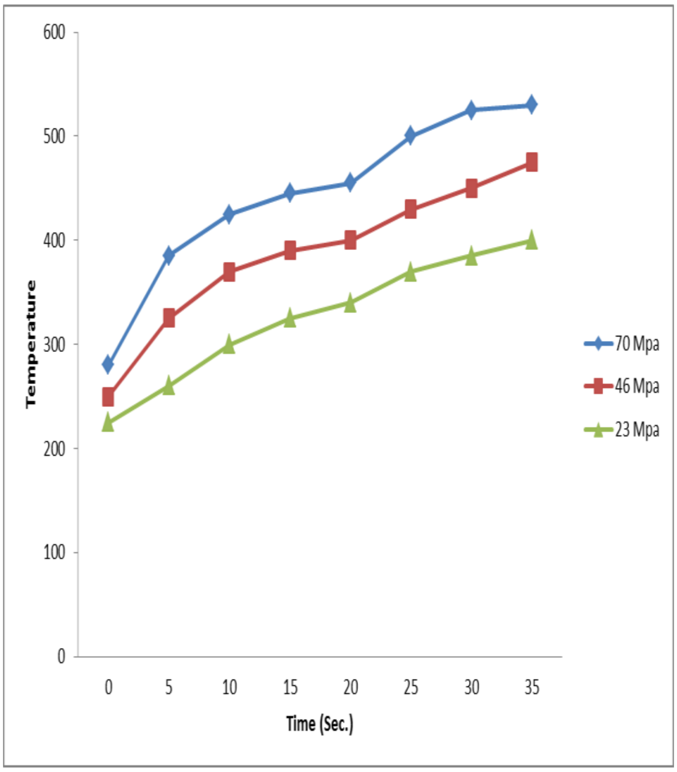


Figure 5.2 Comparison of temperature with different values of plunger pressure w.r.t. time

**5.2 Contour plots of pressure die casting with different plunger pressure**

Figure - squeeze die casting process with material A356.

Figure - Temperature monitoring of squeeze die casting process with material A356

Figure - Poured molten material A356 in molten chamber.

### 5.3 Optimization on squeeze die casting model with different chamfer angle

Table 5.3 shows the values of pressure with different chamfer angle

| Pressure (70MPa) | | |
|---|---|---|
| 30 ° | 45 ° | 60 ° |
| 26.3 | 28.1 | 30.2 |
| 28.2 | 30.3 | 32.9 |
| 31.1 | 33.6 | 35.8 |
| 33.9 | 36.8 | 39.1 |
| 35.7 | 39.4 | 41.7 |
| 39.1 | 40.7 | 43.6 |

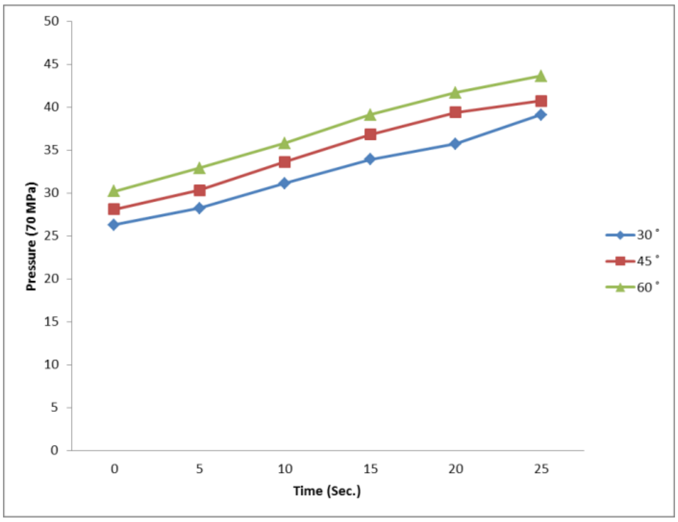


Figure 5.4 Comparison of different pressure values w.r.t. time and chamfer angle

Table 5.4 shows the values of temperature with different chamfer angle

| Temperature (70 Mpa) | | |
|---|---|---|
| 30 ° | 45 ° | 60 ° |
| 270 | 285 | 298 |
| 365 | 390 | 405 |
| 412 | 430 | 445 |
| 437 | 450 | 475 |
| 450 | 465 | 485 |
| 485 | 510 | 530 |
| 500 | 535 | 550 |
| 515 | 550 | 575 |

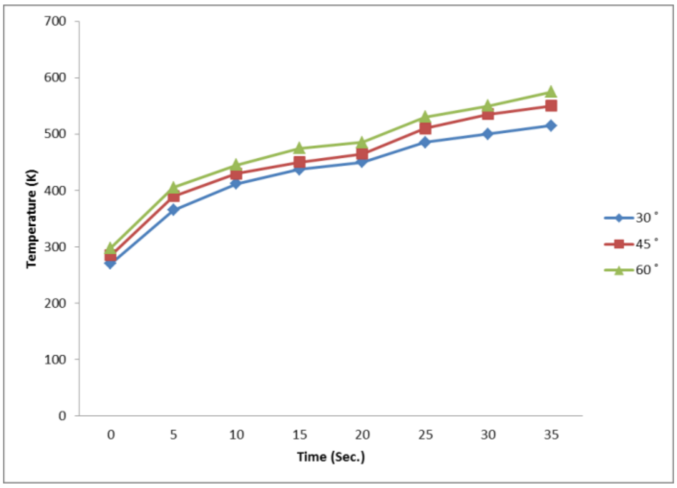


Figure 5.5 Comparison of different temperature values w.r.t. time and chamfer angle

### 5.5 Optimization on squeeze die casting model with different fillet radius

Table 5.7 shows the values of pressure with different fillet radius.

| Pressure (70MPa) | | | |
|---|---|---|---|
| Time (Sec) | 2 mm | 6mm | 8mm |
| 0 | 27.9 | 26.1 | 29.3 |
| 5 | 29.5 | 27.9 | 32.8 |
| 10 | 32.7 | 29.8 | 34.6 |
| 15 | 34.9 | 31.5 | 38.2 |
| 20 | 37.8 | 33.8 | 39.9 |
| 25 | 39.6 | 36.9 | 42.1 |

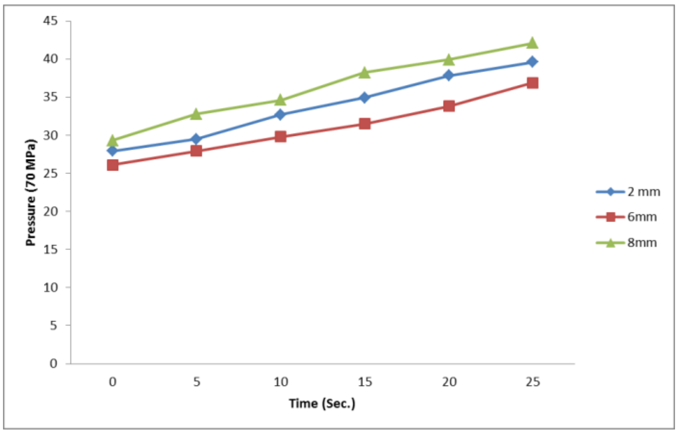


Figure 5.11 Comparison of different pressure values w.r.t. time and fillet radius

Table 5.8 shows the values of temperature with different fillet radius

| Temperature K (70Mpa) | | | |
|---|---|---|---|
| **Time (Sec)** | **2 mm** | **6mm** | **8mm** |
| 0 | 287 | 272 | 297 |
| 5 | 389 | 364 | 410 |
| 10 | 435 | 415 | 450 |
| 15 | 460 | 440 | 485 |
| 20 | 472 | 455 | 497 |
| 25 | 515 | 480 | 535 |
| 30 | 545 | 498 | 560 |
| 35 | 556 | 510 | 582 |

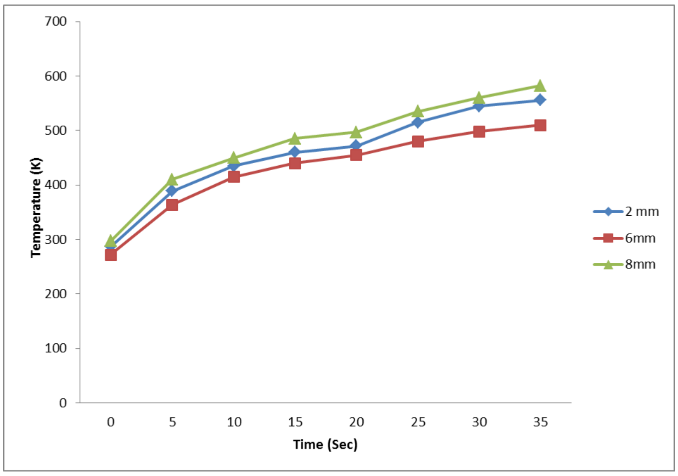


Figure 5.12 Comparison of different temperature values w.r.t. time and fillet radius

## VIII CONCLUSION

- Average deviation of result obtained from experimentation in pressure die casting process, for base model the pressure and temperature distribution lies within the range, pressure is deviate 3.76% for optimization model and temperature distribution is deviate 3.91% as compared to experimental work of the base paper.
- Average deviation of results obtained for different chamfer angle from experiment in temperature is deviated by 17.01 % i.e., temperature decreases for $30^0$ chamfer angle geometry at a pressure of 70MPa for analysis.
- Average deviation of result obtained for different fillet radius of squeeze die casting process from experimental investigation in pressure is deviated by 20.15% i.e., pressure decreases for 6mm fillet radius geometry w.r.t. time at each time steps for analysis.
- Decreases for 30 degree chamfer angle and fillet radius 6mm for different time steps on squeeze die casting process, the average variation is analyze by 6.7% and for wall shear stresses w.r.t. it is decreased by 18.63%, 24.12%, and 19.35%, 16. 97% respectively.
- This experimental analysis clearly indicates that 6mm of fillet radius and 30 degree of chamfer angle on plunger pressure of 70MPa decreases the and wall shear stresses due to this effect workability and machinability of a manufactured product increases, hence it also signifies the actual convergence of pressure and temperature management provides actual time of pressure die casting to produce a product with less manufacturing defect, Thus 30 degree of chamfer angle and 6mm of fillet radius would be used for dies design in squeeze die casting process.

6.2 SCOPE FOR FUTURE WORK

- For the future works in this area the following outlines are -
- Simulation could be done for the die casting in different angles as well as with different pressure.
- Simulation could be done for the different molten material also including die material for pressure die casting process.
- Simulation could be done for the different die temperature.
- Simulation could also be done by varying different fillet radius.

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