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Design and Development of a Permanent Mould for the Production of Motor-Cycle Piston in SEDI-Enugu.

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Abstract

This paper demonstrates the possibility of designing and developing a four-cavity low pressure die casting mould in SEDI-Enugu. This research and development included the design of the die blocks and the core box for core production. Furthermore, the die blocks were cast, machined and later heat treated to obtain the desired properties of a mould material. After which the components were assembled and mounted on the Low pressure die casting machine. Emphasis was made on the coating of the mould and crucible pot internal surfaces with a solution of zinc oxide and sodium silicate. This is done prevent iron entrapment in mass of the molten metal as well as to minimize the sticking of castings on the mould during casting operation.

Introduction

There is hardly any street corner in Nigeria where one cannot find tricycles and motorcycle used as a means of transportation. For this reason, the research and development of a four-cavity low pressure die casting mould for piston production became imperative for the technological and economic development of the transportation sector in Nigeria. Since there is high unemployment rate in the country, so many people depend on this means of transportation both businesses for their daily survival and easy movement of goods and services.

Nigeria`s GDP would have been greatly enhanced if the volume of importation of pistons is reduced drastically through local production. In addition, employment opportunities would have been created, and vices would have be curbed in Nigeria.

This need prompted us to design and develop the four-cavity die casting mould for motorcycle and tricycle piston production in Nigeria.

Design Considerations

Mould design is one of the most important steps in the process because the shape and attributes of the mold will directly affect the final product. Mould design affects the shape, configuration, quality, and uniformity of a product created through the die casting process.

1. Draft

Draft is the degree to which a mould core can be tapered. A precise draft is needed to smoothly eject the casting from the die, but since draft is not constant and varies according to the angle of the wall, features such as the type of molten alloy used, shape of the wall, and depth of the mould can affect the process.

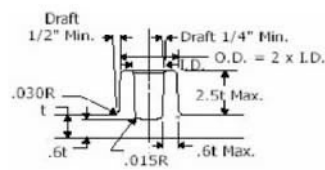


Figure 1: Draft angles sample [1].

2. Fillets

A fillet is a concave junction used to smoothen an angled surface. Sharp corners can hinder the casting process, so many moulds have fillets to create rounded edges.

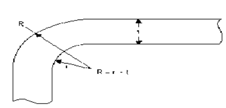


Figure 2: Radii design sample

3. Parting Line

The parting line connects different sections of the mould together. If the parting line becomes deformed from work strain, material may seep through the gap between the mould pieces, leading to non-uniform moulding and excessive seaming.

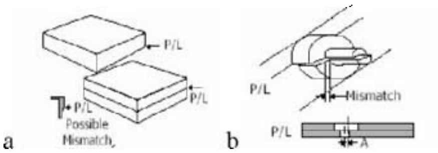


Figure 3: (a) Parting line and (b) Mismatch[1].

4. Bosses

Bosses are die cast knobs that serve as mounting points or stand-offs in mould design. Manufacturers often add a hole to the interior structure of the boss to ensure uniform wall thickness in a molded product.

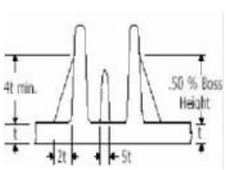
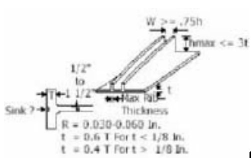


Figure 4: Boss design sample

5. Ribs: Die cast ribs can be used to improve material strength in products lacking the wall thickness



required for certain applications.

Figure 5: Ribs design sample

6. Holes and Windows

Holes or windows in a die cast mould directly affects the ease of ejecting a completed moulding and enables the creation of substantial drafts.

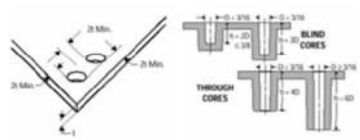


Figure 6: Hole design sample

7. Sprues, runners and gates should be so provided that they facilitate the removal of the casting. Sprue holes are always tapered. A sprue pin is usually fixed at the inner end of the sprue to deflect metal into the runner. Runners or runners are cut at the die parting. Gates join the runner with the die cavity [3].

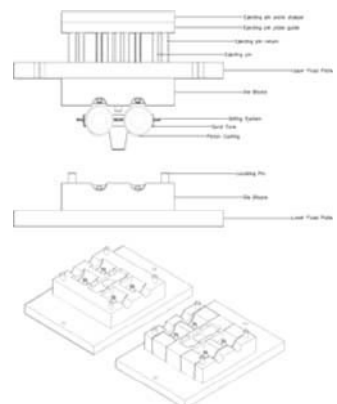


Figure 7: Four-cavity Motor cycle piston die mould designed with Solid Works package

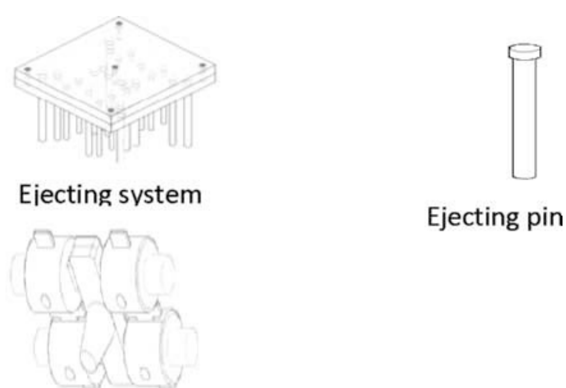


Figure 10:

Die Blocks Production

Development of die blocks involves a lot of manufacturing operations and they are as follows:

- Gravity Casting of Cast iron blanks.
- Fettling of the Cast.
- Annealing the Blank.
- Milling Operation.
- Turning Operation.
- Boring Operation.
- Drilling Operation
- Threading Operation.
- Surface Grinding.
- Heat Treatment Operation.

Temperature In Metal Cutting

Although the vast majority of machining operations are conducted with the work piece at ambient temperature, because of the large plastic strain and very high strain rate there is a significant temperature rise. This has an important bearing on the choice of tool materials, their useful life and on the type of lubricant system required. As a result of the rubbing action a secondary deformation zone develops in the chip adjacent to the chip-tool interface and this also contributes to heat generation.

Much data on temperature generation in metal cutting may be correlated with a dimensionless number $R_t = \kappa/\upsilon d$, where κ is the thermal diffusivity = $k/\rho c$, υ is the cutting speed and d is the depth of cut. R_t is called the thermal number. If all of the heat generated goes into the chip, the adiabatic temperature is given by

$$T_{ad} = \frac{u}{\rho c}$$

Where u = the specific cutting energy, ρ = the density of the work piece material, c = specific heat of work piece[5].

Cutting Fluids

We have seen that machining processes involve high local temperatures and high friction at the chip-tool interface. Thus most practical machining operations use a cutting fluid designed to ameliorate these effects. The primary functions of a cutting fluid are: to decrease friction and wear, reduce temperature generation in the cutting area, wash away the chips from the cutting area, protect the newly machined surface against corrosion.

Non-traditional Machining Processes

Table 1: Non-traditional machining processes.

Source of energy	Name of processes
Thermal energy processes	Electrical discharge machining, EDM Laser-beam machining, LBM Plasma-arc machining, PAM
Electrical processes	Electrochemical machining, ECM Electrochemical grinding, ECG
Chemical processes	Chemical machining, CHM
Mechanical processes	Ultrasonic machining, USM

[7].

Heat Treating of Die Blocks

Heat treatment of die blocks involves the following steps:

1. Heating of the die blocks slowly to austenitizing temperature.
2. The dies blocks are soaked at this temperature for an extended period to achieve uniform austenitic structure.
3. After soaking, the dies are quenched in a medium to temperatures below the transformation temperature to achieve martensitic structure.
4. Tempering is the next stage of heat treatment. Here, martensite formed as a result of quenching is tempered to a tougher structure. The stages in heat treating a tool steel die is illustrated below in Figure 27.

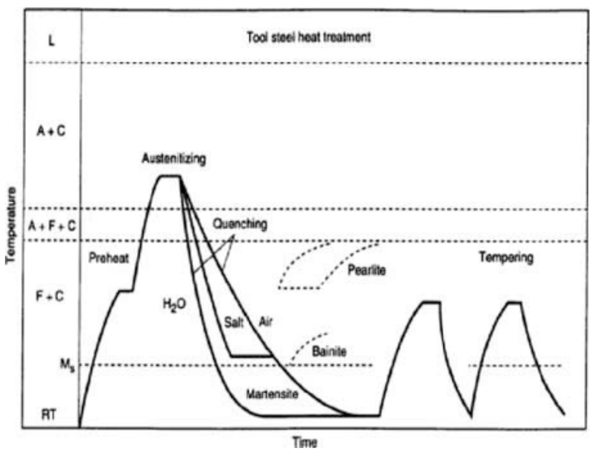


Figure 27: Heat treatment cycle of hot working steels (Krauss 1995).

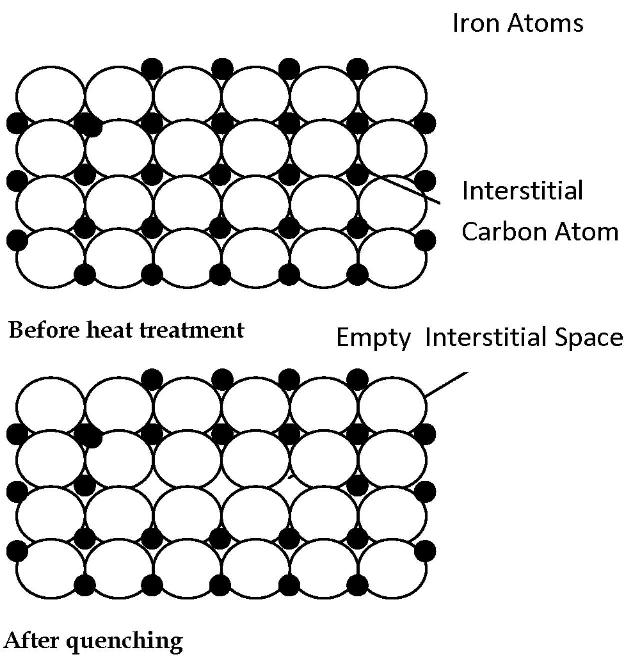


Figure 28: Harden Iron-Carbon Atomic Structure [10].

Quenching during heat treatment involves simultaneous occurrence of different physical events such as heat transfer, phase transformation and stress-strain evolution, but heat transfer is the driving physical event as it triggers other processes [11]. When the hot metal is submerged into the liquid pool, heat transfer is controlled by different cooling stages known as vapour blanket stage, boiling stage, nucleate boiling stage and convective or liquid cooling stage [1-3]. The important factors, which influence the metallurgical transformation during quenching, are shown in Figure 30 [13]. Among these factors, only a few can be changed in the heat treatment shop. The selection of optimum quenchant and quenching conditions both from the technological and economical point of view is an important consideration [13]. Brine solution, oil, polymer etc. are used as conventional quenching media. Brine solution is restricted to quenching simple shapes and steels of comparatively low hardenability because of the occurrence of intolerable distortion, and quench cracks [14].

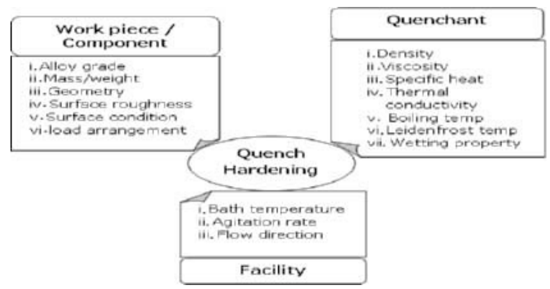


Figure 30: Factors influencing the metallurgical transformation during quench hardening.

Table 2: Approximate Soaking Periods for Hardening, Annealing, and Normalizing Steel [9].

Thickness of Metal (mm).	Time of Heating to Required Temperature (hr).	Soaking Time (hr)
25.4	0.75	0.5
25.4 - 50.8	1.25	0.5
50.8 - 76.2	1.75	0.75
76.2 - 101.6	2.25	1
101.6 - 127	2.75	1
127 - 203.2	3.5	1.5

Table 3: Heat treating of die blocks (shock resisting material)[15].

Rate of Hea ting	Prehe at Temp eratur e	Hard ening Temp eratur e	Tim e of Que nchi ng	Med ium at Que nchi ng	Temp ering Temp eratur e	Soaking Time
Ver	650°	845°	5 –	Oil	250°	60min(t

y Slowly (5°C /min)	C	C – 950° C	30 min		C	emperin g) 45min(hardening)

Figure 19: Drilling, Milling, Ejection system assembly and Assembled die blocks

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