# DESIGN AND MANUFACTURE OF A ONE CAVITY MOULD FOR CASTING PISTON

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## ABSTRACT

In this paper, we design and manufacture a one cavity mould for the casting of a piston by sorting materials locally. The mould was also fabricated after the design calculations using basic machine tools like lathe, milling and drilling machines. Test conducted on the mould reveals sound casting with little or no defects

**KEYWORDS:** Permanent mould casting, Shrinkage allowance, Gates, Piston

Nigeria as a developing nation needs to be self reliant in all aspects of economic activities, which includes construction, manufacturing and other engineering endeavour (Nwachukwu, 1997). Manufacturing is undoubtedly one of the most important sectors of national economics as it creates wealth (Ibhadode, 2001).often times, one hears of plants not functional due to lack of spares parts which cannot be supplied by the original vendors of the plant because of its obsolescence. Casting provides a veracity and flexibility that have maintained casting position as a primary production method for machine elements. As Nearly sixty – five million tonnes of cast components worth more that \$100 billion are produced annually for automobile, industrial machinery, municipal fittings and many other sectors, by over 30000 foundries worldwide. Large numbers of companies are involved in designing, machining, testing and assembling cast components and in related activities such as tool making and material supply (Ravi, 2003)

Casting processes are divided according to the specific type of moulding method used in the casting

Follows: sand centrifugal, permanent die, plaster-mold and investment. As demand for quality castings in production quantities increased, the attractive possibilities of metal melds brought about the development of the permanent-meld process. Although not as flexible regarding design as sand casting, metal-mold casting made possible the continuous production of quantities of casting from single meld as compared to batch production of individual sand melds.

In permanent-mould castings, both metal melds and cores are used, the metal being poured into the meld cavity with the usual gravity head as in sand casting. Moulds are normally made of dense iron, large cores of cast iron and collapsible cores of alloy steel. All necessary spruses, runners gates and risers must be machined into the meld and the meld cavity itself is made with the usual metal shrinkage meld is usually composed of one, two or more parts, which may swing or slide for rapid operation. Whereas in sand casting the longest dimension is always placed in a horizontal position (Benjamin and Richard 1989). While in permanent-meld casting the longest dimension of a part is normally placed in a vertical position.

**The aim** of this paper is to design and manufacture one cavity permanent mould for casting an internal combustion engine piston

## THE OBJECTIVES INCLUDE:

1. To design one cavity permanent -mould

11 To manufacture the mold

**METHODOLOGY**: The mould material shall be obtained from steel shop. the design of the mould shall be based on the consideration of shape size, shrinkage allowances, casting material, production economies. The mould shall be manufactured by machining operations which shall include milling, boring, drilling, and turning.

## PISTON DATA

- 1. Crown external diameter 49mm
- 2. Crown internal diameter 46mm

3.	Crown thickness	3mm
4.	Skirt internal diameter	50
5.	Skirt thickness	45
6.	Piston height	56
7.	Pin hole diameter	10
8.	Pin hole length	8
9.	1 <sup>st</sup> land thickness	1.5
10.	2 <sup>nd</sup> land thickness	1.5
11.	1 <sup>st</sup> groove	1
12.	2 <sup>nd</sup> groove	1
13.	Piston material	Aluminium
14.	Material density	$2.7 \text{ x } 10^3 \text{ kg/m}^3$
15.	Piston mass	0.04kg
16. Corresponding piston volume		

## PATTERN ALLOWANCES

The following allowances are provided for

- i. Shrinkage allowances arising from solidification and contraction of the molten metal to be cast
- ii. Machine and draft allowance

Below show the pattern shrinkage, volumetric and machine finish allowances.

The works of Boothryod (1982) ,Ibhadode (2001) and Ravi (2003), have recommended the following pattern allowances (for aluminium base) for gravity die casting: from table, 1, 2 and 3 Linear shrinkage allowance 0.013mm

Linear shrinkage allowance 0.015mi

Machine finish allowance 1mm

## Mould cavity size

GATING SYSTEM

The functions of an ideal gating system are to

- Feel the meld cavity
- Introduce molten metal into the meld with as little turbulence as possible to prevent meld erosion and gas pick-up.
- Established the best possible temperature gradients in the casting
- Introduce proper skimming action on the metal as it flows through the spruce system.
- Regulate rate of entry of metal into the meld cavity.

In order for gates to function properly, one must control

- Rate of pouring.
- Size, number and location of gates leading to the cavity.
- Size and type of spruce and runner.
- Temperature (fluidity) of the metal
- Position of the mould during casting and freezing
- In the design of the gates two basic fluid flow equations are of interest
- Calculation of metal velocity and flow rates
- To understand the fundamentals of metal flow in gating systems.

The first of these laws is law of continuity which may be written

$$Q = A_1 V_1 = A_2 V_2$$

where 
$$Q = metal flow rate$$

 $A_1 = cross - sectional area of flow,$ 

## $V_{K_2}$ = velocity of metal flow at point 1 and 2

The second law or equation basic importance in flow calculations is Bernoulli equation. It states that the energy of a liquid at a given point can be separated into parts, *energy of velocity*  $\binom{v^2}{2a}$ ,

## energy of position (h)and energy of pressure $(\rho_1/\tau)$ .

In real gating systems, substantial energy losses occur at all channel entrances and exits, at bends,enlargements,contractions and even smooth channel due to frictional effects.bernoulli's equation can be modified to account for these losses by addition of appropriate terms to the equation. In this design, energy loss (per unit weight of metal is given)

$$h_f = \frac{\mathrm{f}L}{\mathrm{d}} \left( \frac{\mathrm{v}^2}{2\mathrm{g}} \right)$$

Energyy loss at bend

$$h\emptyset = k\left(\frac{v^2}{2g}\right)$$

These energy terms can be added to Bernoulli's equation in such a way as to describe the flow characteristics in any real system

## RESULT

The one cavity mould for casting piston was successfully design, manufactured and tested. The casting efficiency was satisfactorily and the cast was found to be sound with little or no defects.

Calculation         Dimension (Mm)         Construction         Mm         Mm/Mm           Gray casting iron         Up to 610 From 635-1220 From 635-1220         Open -         0.01042         0.00833           Steel Casting         Up to 610 From 635-1839         Open Core Construction         0.00894         0.00894           Steel Casting         Up to 610 From 635-1839         Open construction         0.02083         0.01563           Over 1830         -         0.01302         0.01302         0.01302           Up to 460 From 1245-1675         Cored Construction         0.01302         0.01422           Malleable cast iron         -         -         0.01302         0.01422           Aluminium         Up to 1220 Up to 1220 Construction         1.5         0.01432         0.01302           Aluminium         Up to 1220 Up to 610 Over 1220 Cored Cored Cored Cored Construction         0.0172         0.00651           22         0.00391         -         0.01302         0.01172           25         0.00260         -         0.01422         0.01172           Up to 1220 Cored Cored Cored Cored Cored Cored Cored Construction         0.01302         0.0172           Aluminium         Up to 120         Open Cored Cored Cored Construction         0.01302         0	Casting Allovs	Pattern	Type Of	Section Thickness	Contraction
Gray casting iron         Up to 610 From 635-1220 (Over 915         Open -         Image of the total states of the total states of total st	Custing Thiojs	Dimension (Mm)	Construction	Mm	Mm/Mm
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From 635-1839 Over 1830         construction         0.01563           Up to 460         Cored         0.01302           From 480-1220         Construction         0.01302           From 1245-1675         -         0.01042           Over         -         0.01432           Malleable cast         -         1.5         0.01432           iron         -         -         0.01302           Malleable cast         -         -         0.01432           iron         -         -         0.01432           Auminium         Up to 1220         Construction         6         0.01172           9.5         0.01042         12         0.0911         16           16         0.00781         19         0.00651         22           22         0.00391         25         0.00142         12           Over 1830         -         -         0.01302         0.01172           Over 1830         -         -         0.01302         0.01172           Over 1830         -         -         0.01302         0.01172           Over 1220         Cored         Cored         0.01302         0.01172           Over 1220 <td>Steel Casting</td> <td>Up to 610</td> <td>Open</td> <td></td> <td>0.02083</td>	Steel Casting	Up to 610	Open		0.02083
Over 1830 Up to 460 From 480-1220 From 1245-1675 Over         - Cored Construction         0.01302 0.02083 0.01302           Malleable cast iron         -         -         0.01432           Malleable cast iron         -         1.5         0.01302           Malleable cast iron         -         -         0.01042           Aluminium         Up to 1220 From 1245-1830 Over         0.01         0.01302           Aluminium         Up to 1220 From 1245-1830 Over 1830 Up to 610 Over 1220 635 to 1220         Open Construction         0.01302 0.01302           Magnesium         Up to 120         Open Construction         0.01302 0.001302           Magnesium         Up to 120         Open         0.01302 Over	_	From 635-1839	construction		0.01563
Up to 460 From 480-1220 Over         Cored Construction         0.02083 0.01563 0.01302           Malleable cast iron         1.5         0.01432           Malleable cast iron         1.5         0.01432           Malleable cast iron         1.5         0.01302           Malleable cast iron         1.5         0.01432           Malleable cast iron         1.5         0.01237           6         0.01172         9.5           9.5         0.01042           12         0.0911           16         0.00781           19         0.00651           22         0.00391           25         0.01042           0.01237         0.01042           19         0.00651           22         0.00391           25         0.01172           0.01172         0.01172           Over 1830         -           0.01042         -           0.01172         0.01172           0.01042         -           0.01042         0.01172           0.01042         -           0.01172         0.00142           0.01042         0.0052           Magnesium         Up to 120		Over 1830	-		0.01302
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Aluminium       Up to 1220 From 1245-1830 Over 1830 Up to 610 Over 1220 635 to 1220       Open Construction - Construction - Cored Construction - Onula 2       0.01302 0.01172 0.01172 0.01042 0.01302 0.01302 0.01172 0.01172 0.01172 0.01172 0.01172 0.01172 0.01172 0.01172 0.01172 0.01172 0.01172 0.01172 0.01172 0.01042 0.01042 0.01172 0.01042 0.01042 0.01042 0.01042 0.01042 0.01042 0.01042 0.01042 0.01042 0.01042 0.01042 0.01042 0.01042 0.01042 0.01042 0.01042 0.01042 0.01042 0.01042 0.01042 0.01042 0.01042 0.01042 0.01042 0.01042 0.01042 0.0052				16	0.00781
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Aluminium         Up to 1220 From 1245-1830 Over 1830         Open Construction         0.01302           Over 1830         -         0.01042         0.01302           Up to 610         -         0.01302         0.01302           Over 1220         Cored         0.01302         0.01172           635 to 1220         Cored         0.01172         0.01302           Magnesium         Up to 120         Open         0.05729				22	0.00391
Aluminium         Up to 1220 From 1245-1830         Open Construction         0.01302           Over 1830         -         0.01042           Up to 610         -         0.01302           Over 1220         Cored         0.01172           635 to 1220         Construction         0.01172           Magnesium         Up to 120         Open         0.05729				25	0.00260
Aluminium         Up to 1220         Open         0.01302           From 1245-1830         Construction         0.01172           Over 1830         -         0.01042           Up to 610         -         0.01302           Over 1220         Cored         0.01172           635 to 1220         Construction         0.01042           Magnesium         Up to 120         Open         0.05729	A1 · ·	II. ( 1000			0.01202
From 1245-1830       Construction       0.01172         Over 1830       -       0.01042         Up to 610       -       0.01302         Over 1220       Cored       0.01172         635 to 1220       Construction       0.01042         Magnesium       Up to 120       Open       0.05729	Aluminium	Up to 1220	Open		0.01302
Over 1830         -         0.01042           Up to 610         -         0.01302           Over 1220         Cored         0.01172           635 to 1220         Construction         0.01042           Magnesium         Up to 120         Open         0.05729		From 1245-1830	Construction		0.01172
Up to 610         -         0.01302           Over 1220         Cored         0.01172           635 to 1220         Construction         0.01042           -         0.0052           Magnesium         Up to 120         Open		Over 1830	-		0.01042
Over 1220         Cored         0.01172           635 to 1220         Construction         0.01042           Magnesium         Up to 120         Open         0.05729		Up to 610	-		0.01302
635 to 1220         Construction         0.01042           Magnesium         Up to 120         Open         0.05729		Over $1220$	Cored		0.011/2
-         0.0052           Magnesium         Up to 120         Open         0.05729		635 to 1220	Construction		0.01042
MagnesiumUp to 120Open0.05729			-		0.0052
	Magnesium	Up to 120	Open		0.05729
From 1245-1830   construction   0.01302		From 1245-1830	construction		0.01302

 TABLE 1 Pattern shrinkage allowances (Ibhadode,2001)

#### NOVATEUR PUBLICATIONS INTERNATIONAL JOURNAL OF INNOVATIONS IN ENGINEERING RESEARCH AND TECHNOLOGY [IJIERT] ISSN: 2394-3696 VOLUME 6, ISSUE 11, Nov.-2019

	Over 1830	cored	0.01302
	Up to 610	construction	0.01302 to
	Over 1220	-	0.01042
	635 to 1220	-	
Brass			0.01563
Bronze			0.0142-0.102083

## Table 2 pattern machine finish allowance (Ibhadode,2001).

Casting alloys	Pattern size(mm)	Bore (mm)	Finish(mm)
Cast iron	Up to 300	3	2.5
	330-610	5	3
	635-1070	6	5
	1090-1525	8	6
	1550-2030	9.5	8
	2060-3050	11	9.5
		Special instruction	Special instruction
Cast steel	Up to 300	5	3
	300-610	6	5
	635-1070	8	8
	1090-1525	9.5	9.5
	1550-2050	12	11
	Over 3050	16 Special instruction	12Special instruction
Mallachla incu	Un to 150	15	
Malleable from	Up to 150	1.5	
		2.5	
		2.5	
		4.3 5	
		J Special instruction	
		Special instruction	
Brass, bronze and	Up to 300	2.5	1.5
aluminium allov	300-610	5	3
castings	635-915	5	4
	Over 915	Special instruction	Special instruction

## Table 3 volumetric shrinkage (Hong Kong university, 2003).

Metal	Shrinkage Allowance(%)
Aluminium	7
Gray cast iron	1.8
Gray cast iron, high carbon	0
Low carbon cast steel	3.0
Bronze (Cu-Sn)	4.5
	5.5



Fig 1: Isometric view



Fig 2: Drawing showing different parts

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