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Comparative Study of Dimensional Variation and Surface Characteristics of Thin Walled Investment Casting of Different Geometrical Shape for Different Gating System in Hot Clay Mold

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Abstract: Defect free thin walled Investment casting process is a challenge even in modern days because it is a surface dominated system, i.e., surface-volume ratio is much more than regular cast products. Gating system is one of the important key to control the surface quality, uniformity of section of thin walled castings. Not only the position of gate, distance from gate, type of gate are control the casting quality but also the surface geometry of mold plays important role.

Keywords: Investment casting, Gating system, Surface quality, Uniformity of section.

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I. INTRODUCTION

Thin-walled investment casting is a surface dominated system. Surface-Volume ratio of thin walled investment cast products is much more, than other cast products. Due to many factors in Hot Clay Mold[1], like Capillary action, surface tension[2], gas pressure[3], higher friction head loss[4], the pattern of liquid metal flow differs from the traditional fluid flow[5] inside mold.

Surface of a thin walled investment cast product controlled by not only the kinetics of liquid metal flow[6] but also the gating system[7], gating position[8], size and shape of the mold cavity[9]. To understand the effect of gating system[10], few castings were done in different types of gating for different circular section products.

II. PROCEDURE OF THE EXPERIMENT

Three types of thin walled samples with circular cross-section were chosen for the experiment. The samples have different geometrical shapes,

I. Candle Stand- Cylindrical Shape
II. Cosmetics Case- Truncated Cone,
III. Cosmetic Cap- Hemispherical Dome.

Each sample was cast by different type of gating system with different mold position. Four gating system were selected for this experiment (Fig.-1), for Candle Stand same gating system was used.

The Gating Types are given below:

IV. Central Axial Top Gating System (TYPE-I) (fig.- 1a, 2a)
V. Peripheral Axial Top Gating System (TYPE-II) (fig.- 1b, 2b)
VI. Peripheral Radial Top Gating System (TYPE-III) (fig.- 1c, 2c)
VII. Peripheral Radial Bottom Gating System (TYPE-IV) (fig.- 1d, 2d)

To study the uniformity, thickness of the walls were measured point by point according to the planes and sections given in Fig. 3.a, 4 and 5.

2.1. Steps of Production:

At first clay cores (Indian clay+ Rice Husk+ Cow dung) were made using die (fig.3. b, c and d). Then thin uniform wax sheet and thread were used on the dried clay core to make desired shape and design (fig. 3. e, f and g). After that gating system was introduced. Then 3 to 4 coatings of clay on wax pattern were done.

The gates were attached at Plane-1, Section-1 point for all the peripheral gating system and were attached at central position of base for axial gating system.

Samples with gating system (sprue and cup) are given in fig.- 6, 7 and 8.

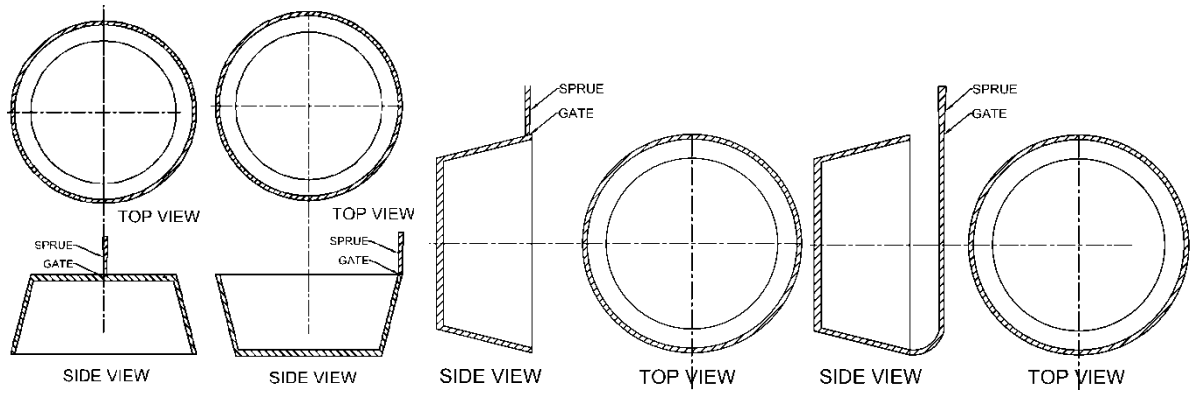


Figure 1: Schematic Diagram of **(a): Type-I**: Central Axial Top Gating system, **(b):Type-II**: Peripheral Axial Top Gating system, **(c):Type-III**: Peripheral Radial Top Gating system, **(d):Type-IV**: Peripheral Radial Bottom Gating system of Cosmetics Case

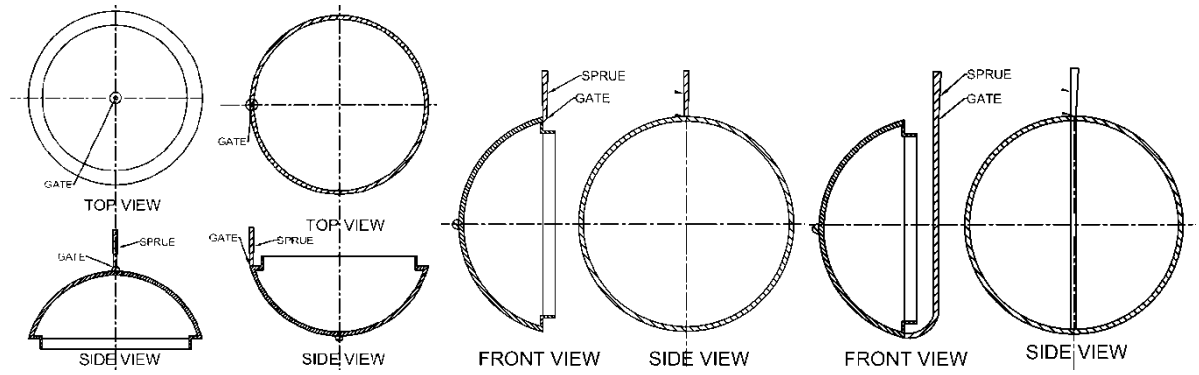


Figure 2: Schematic Diagram of **(a): Type-I**: Central Axial Top Gating system, **(b):Type-II**: Peripheral Axial Top Gating system, **(c):Type-III**: Peripheral Radial Top Gating system, **(d):Type-IV**: Peripheral Radial Bottom Gating system of Cosmetics Cap

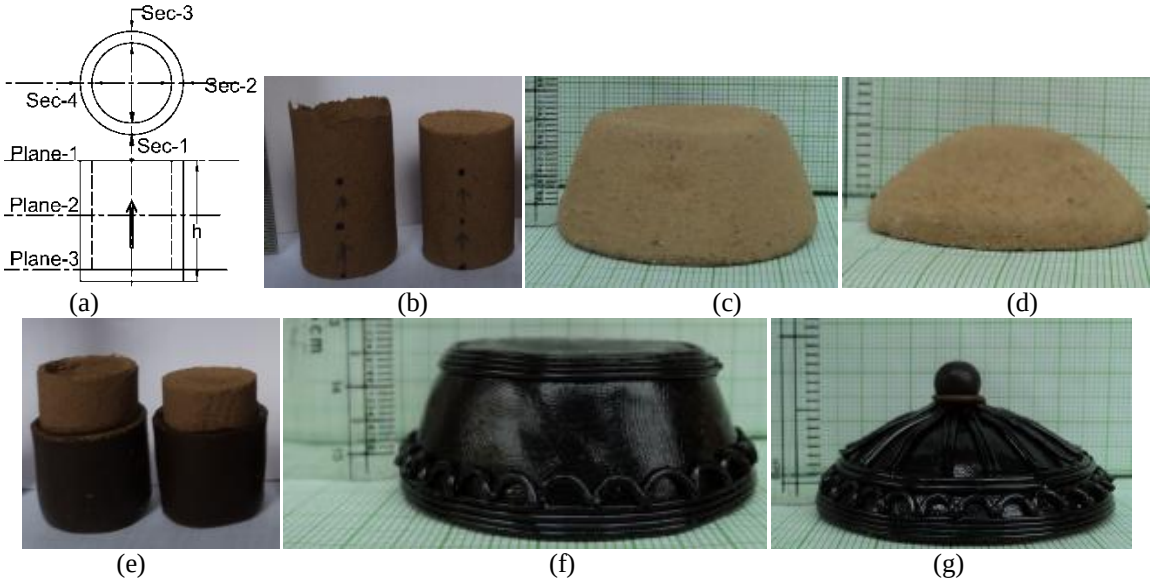


Figure 3: (a): Schematic Diagram of Candle Stand with Planes and sections, (b, c, d) Clay Core of Candle Stand, Cosmetics Case and its Cap, (e, f, g) Wax Pattern of Candle Stand, Cosmetics Case and its Cap.

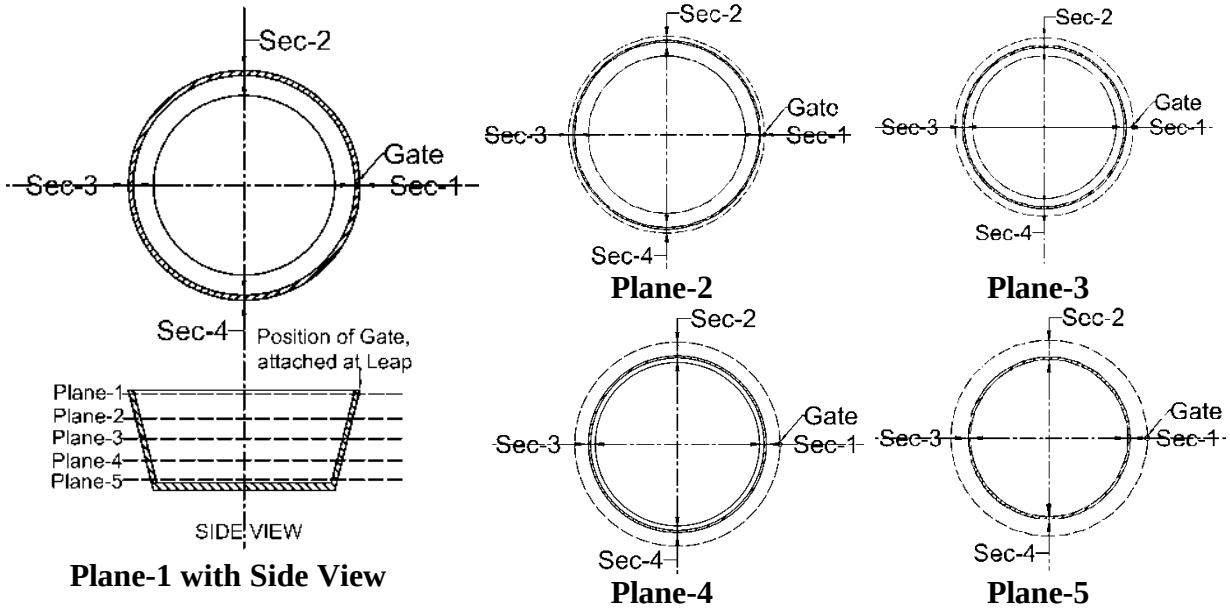


Figure 4: Schematic Diagram of Sectional view of thin wall in different planes of Cosmetics Case.

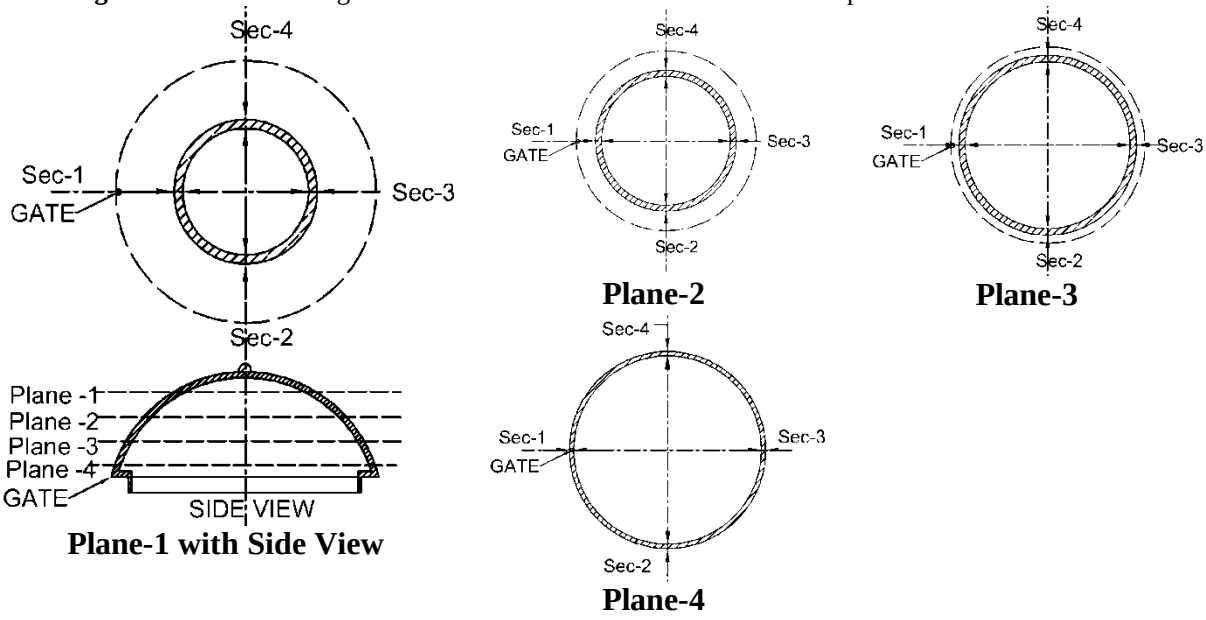


Figure 5: Schematic Diagram of Sectional view of thin wall in different planes of Cosmetics Cap.

Figure 6: Pictorial View of **(a): Type-I**: Central Axial Top Gating system, **(b):Type-II**: Peripheral Axial Top Gating system, **(c):Type-III**: Peripheral Radial Top Gating system, **(d):Type-IV**: Peripheral Radial Bottom Gating system of Cosmetics Case

Figure 7: Pictorial View of **(a): Type-I**: Central Axial Top Gating system, **(b):Type-II**: Peripheral Axial Top Gating system, **(c):Type-III**: Peripheral Radial Top Gating system, **(d):Type-IV**: Peripheral Radial Bottom Gating system of Cosmetics Case

Figure 8: Pictorial View of All the Gating type of Candle Holder

III. RESULT AND DISCUSSION

Comparison of metal thickness and surface roughness was done for the thin walled investment cast products.

Comparison of Uniformity of Metal Thickness

Mean variation of width tabulated by Root Mean Square Method in table-1. Data chart of average metal thickness in different plane and different section (according to Fig. 3a, 4 and 5) are given in Figure-9 for Candle Stand, Figure-10 for cosmetics case Figure-11 for cosmetics cap.

Table 1: R.M.S value of Mean Variation (mm)

Gating Type	Candle Stand	Cosmetics Case	Cosmetics Cap
Type-I	0.476	0.551	0.226
Type-II	0.286	0.504	0.442
Type-III	0.282	0.374	0.369
Type-IV	0.545	0.333	0.428

Comparison of Surface Quality

To characterize the Surfaces, Visible inspection was done for all Samples and Surface roughness was measured for Candle Stand.

Surface Roughness measurement

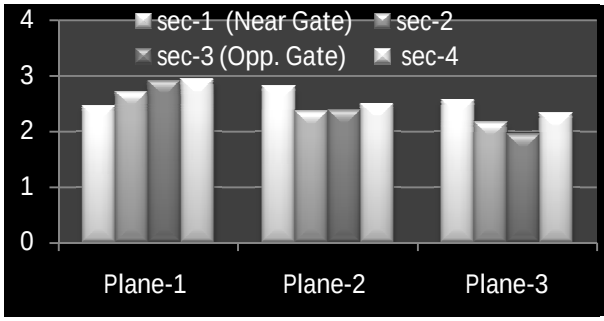
Surface roughness of Candle Stand were measured at different position by Taylor- Hobson (Model-Srtronic3+) and tabulated in Table-2. Arithmetic mean of departures (Ra) and its RMS parameters (Rq) are measured .

Visible Inspection

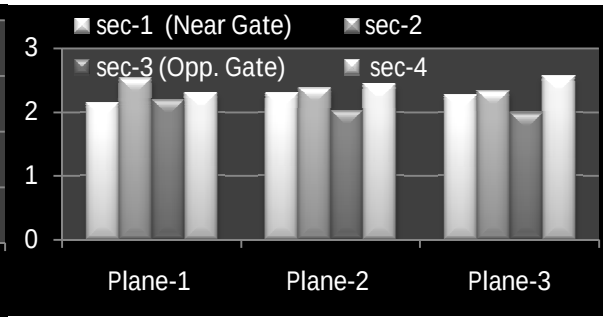
Visible inspection was done and the images of the surface by optical camera were shown according to different gating type. In Figure-12, the surfaces near to gate and figure-13 for the surfaces distant from the gate of Candle Stand were shown, in Figure-14, the surfaces of cosmetics case and in Figure-15, the surfaces of its caps are shown.

Table 2: Surface Roughness of Candle Stand

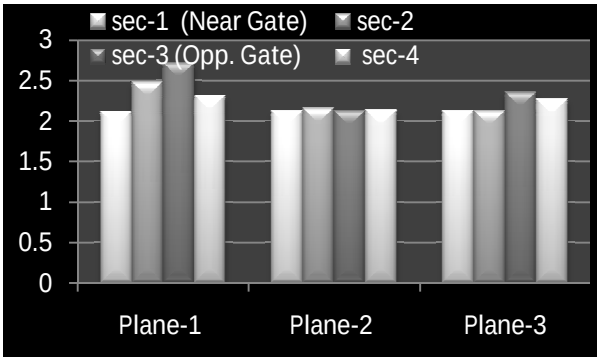
	Near to Gate		Mid Position		Distant from Gate	
	Ra	**Rq**	**Ra**	**Rq**	**Ra**	**Rq**
Type I	1.09	1.32	1.73	2.15	2.67	3.49
Type II	1.48	1.7	1.63	2.12	3.41	3.87
Type III	1.58	2.07	1.98	2.5	3.76	4.44
Type IV	0.938	1.17	2.23	2.97	1.69	2.05



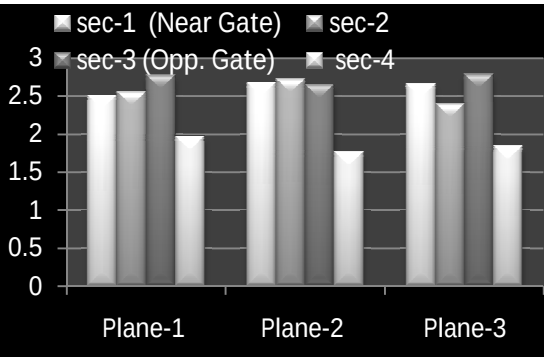
(a) Gating Type-I



(b) Gating Type-II

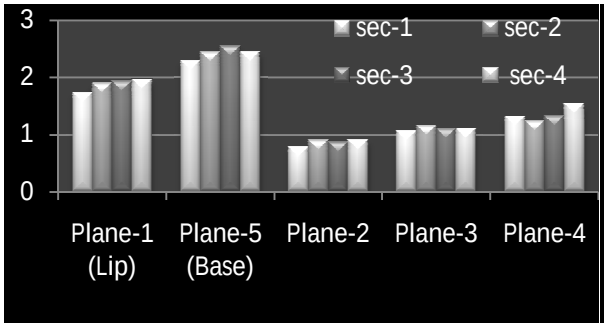


(c) Gating Type-III

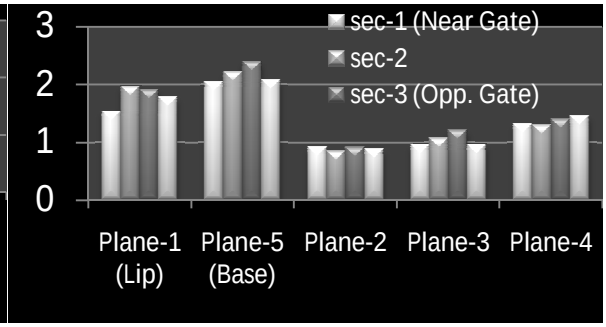


(d) Gating Type-IV

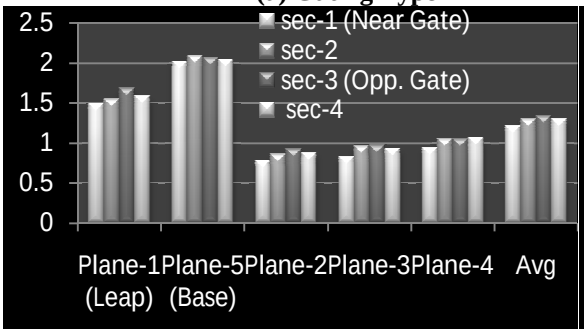
Figure - 9: Chart of metal thickness of Candle Stand at different Sections at different Plane



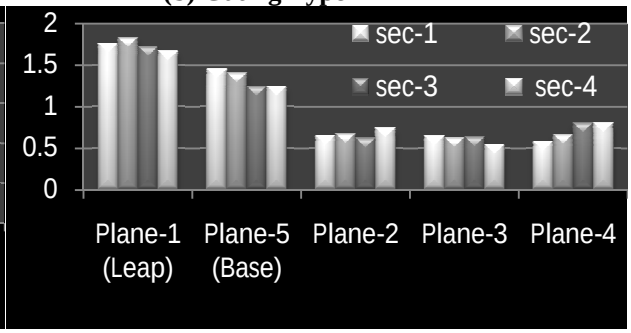
(a) Gating Type-I



(b) Gating Type-II

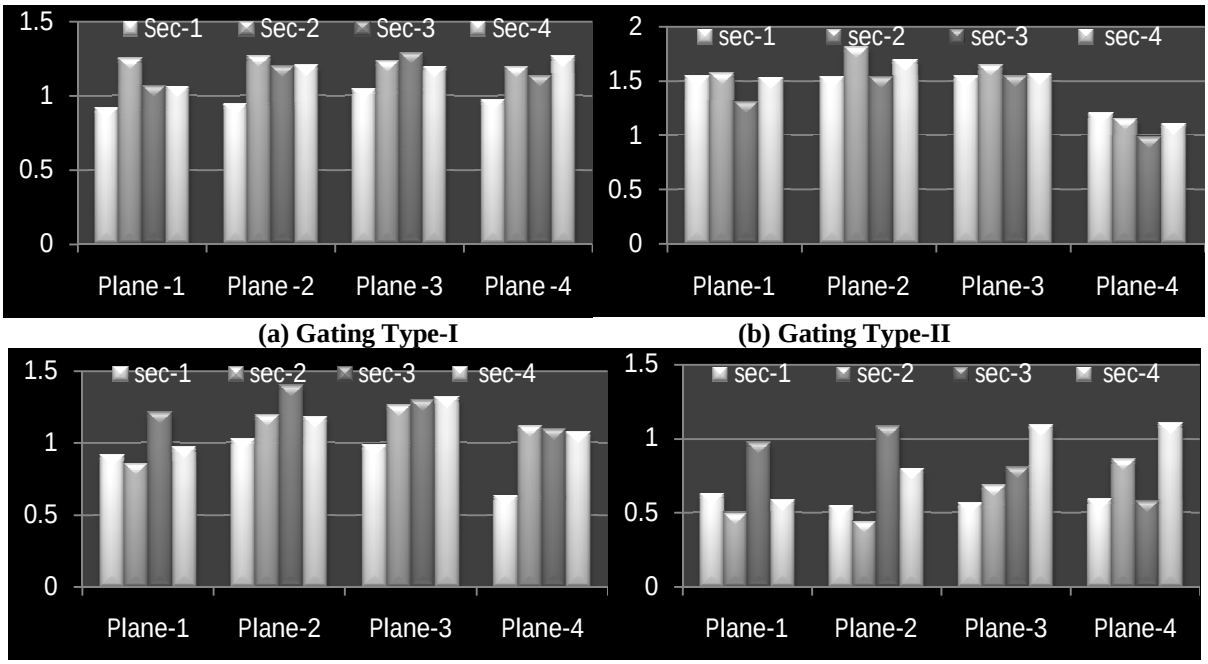


(c) Gating Type-III



(d) Gating Type-IV

Figure- 10: Chart of metal thickness of Cosmetics Case at different Sections at different Plane



(a) Gating Type-I **(b) Gating Type-II**

(c) Gating Type-III **(d) Gating Type-IV**

Figure- 11: Chart of metal thickness of Cosmetics Cap at different Sections at different Plane

Type-I Type-II Type-III Type-IV

Figure-12: Surface Quality Near to Gate of Candle Stand

Type-I Type-II Type-III Type-IV

Figure-13: Surface Quality Distant from Gate of Candle Stand

Type-I Type-II Type-III Type-IV

Figure-14: Surface Quality of finished Cosmetic Case

Type-I Type-II Type-III Type-IV

Figure-15: Surface Quality of finished Cosmetic Cap

According to experiments, preferable gating system(s) for the particular items are given below:

Table 3: Preferable Gating System

Product	Geometrical Shape	Preferable Gating System
Candle Stand	Cylindrical Shape	Type-I
Cosmetics Case	Truncated Cone	i. Type-III ii. Type-I
Cosmetics Cap	Hemispherical shape	Type-I

IV. CONCLUSION

i. Metal sections near to the gate are thinnest for most of the cases.. It is due to supply of liquid metal for Liquid-Liquid and Liquid- Solid Shrinkage during solidification.

ii. For Central Axial Top Gating System (Type-I), Wall thickness in different section is uniform and also the surface roughness is better.

iii. Surface Roughness found better at closer part of the gating system, but poor at the distant part from the gate.

iv. Unfilled section was found at opposite to the gate for bottom gating system. Also the dimension variation is large for bottom gating system. So, Bottom gating system is not economic for thin walled investment casting.

v. Gating system should be chosen according to shape and size of the product. Gating type and position should be chosen such a way that the liquid metal flow will be smoother.

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