Some Study on Determination of Riser Sizes for Aluminium Alloy Castings by Using Shape Factor Method

T. Nandi[1], S. Koyal[2] and G. Sutradhar[3]

[1]Associate Professor, Mechanical Engineering Department, Jadavpur University, Kolkata

[2]Research Scholar, Jadavpur University, Kolkata

[3]Professor, Mechanical Engineering Department, Jadavpur University, Kolkata

ABSTRACT

In this study, riser sizes for aluminium alloy (LM6) castings of various sizes have been determined by the shape factor method. The experimental results have also been verified by computer simulation. It is expected that this work will be of interest to both industries and academicians.

Keywords: Shrinkage, Solidification, Simulation, Modulus, Optimization, Shape factor

INTRODUCTION

A riser, also known as a feeder is a reservoir built into a metal casting mould to prevent formation of cavities due to shrinkage. Most metals are less dense as a liquid than that as a solid. So castings develop a void at the last point to solidify. Risers prevent this by providing molten metal to the casting as it solidifies, so that the cavity forms in the riser and not in the casting. Risers are less effective on materials that have a large freezing range, because directional solidification is not easily possible. They are also not suitable for casting processes that utilised pressure to fill the mould cavity.

A variety of methods have been devised to calculate the riser size needed to ensure that liquid feed metal will be available as long as the solidifying casting requires. Several commonly used methods are:

i) Shape factor method

ii) Geometric method

iii) Modulus method

iv) Computerized method

Drawing on the theoretical work of Caine, researchers at the U.S. Naval Research Laboratory (NRL) devised a method to determine riser size of any steel casting by calculating a shape factor by adding the length and width of a casting section and dividing this sum by the section thickness.

In case of aluminium alloys, the shape factor method has not been tried out adequately. In the present study, an attempt has been made to develop nomograms which may be used by industries for producing quality castings.

METHODOLOGY

In the present work, riser design for plate castings of aluminium alloy (LM6) has been investigated. The length and width of the plates are maintained constant at 100mm × 100mm while the thicknesses are varied. Shape factors varies from 4 to 36. The required diameter and the height of risers are calculated by modulus method.,castings are produced by green sand casting method.

The patterns and risers were made by a CNC machine. The ingredients of the green moulding sand are given Table -1.

Table -1

Silica sand	Bentonite clay	Moisture	Coal dust
86%	8%	5%	1%

The mould box was of 330mm × 330mm (Fig 3). Aluminium–silicon alloy (LM6), has been used as the casting alloy in the present experiments. The chemical composition of the Al alloy (LM6) and the physical characteristics of moulding sand have been given in the

Table-2 and Table-3. The aluminium alloy was melted in a clay graphite crucible in an electric resistance furnace (Fig. 2). The molten metal was poured at a temperature of 720 ^{0}C into a plate-shaped silica sand mould.

Fig: 1

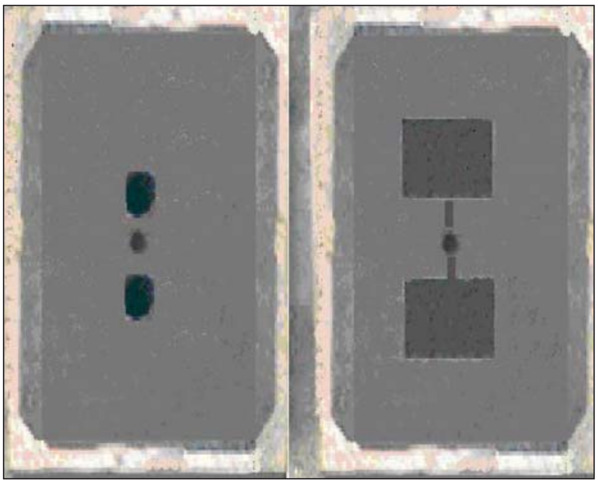

Fig: 2

OPTIMIZATION

The required dimensions of risers of all the castings were also calculated following the modulus method. Optimisation of riser sizes was done by trial and error method. For example, in case of actual riser size 67.5mm dia x135mm height, sizes of 65mmx130mm 63mmx126mm, 61mmx122mm, 59mmx118mm and 60mmx120mm were also tried. Upto 61mm dia x122mm height, the castings were found to be defect-free, but for a 59mm dia x118mm height riser, the casting was observed to be defective. But, for a calculated riser size of 60mm dia x120mm height, the casting was found to be defect-free. Table-5 illustrates the detailed dimensions of riser sizes, corresponding optimum riser sizes and shape factor data.

Figure 4 to Fig. 8 show the physical appearance of castings produced in the laboratory. The presence of shrinkage, if any, was also critically examined. The result of simulation

Table-3 :Thermo-Physical Properties of Moulding Sand

Properties	Sand
Density(gm/cm^3)	1.6
Thermal conductivity(W/m/K)	0.52
Specific heat (j/Kg/K)	1170

Table-4: The riser dimensions as per modulus method

L	W	T	SF	Riser Dim.as Per Modulus Method
100	100	50	4	67.5 × 135
100	100	25	8	45 × 90
100	100	16.7	12	33.8 × 67.5
100	100	12.5	16	27 × 54
100	100	10	20	22.5 × 45
100	100	8.4	24	19.3 × 38.6
100	100	7.2	28	16.9 × 33.8
100	100	6.3	32	15 × 30
100	100	5.6	36	13.5 × 27

Table-2 :_Chemical Composition (LM6)

Elements	Si	Cu	Mg	Fe	Mn	Ni	Zn	Pb	Sb	Ti	Al
Percentage(%)	10-13	0.1	0.6	0.5	0.1	0.1	0.1	0.05	0.2	0.1	Rest

Table-5: Finding of Optimized Riser Size from Riser Dimensions as per Modulus Method

L	W	T	SF	RISER DIM.AS PER MOD METHOD	INTERMEDIATE STEPS TO FIND THE OPTIMUM RISER DIMENSIONS	REMARKS
100	100	50	4	67.5 × 135	67.5 × 135	O.K
					65 × 130	O.K
					63 × 126	O.K
					61 × 122	O.K
					59 × 118	DEFECTIVE
					60 × 120	O.K
100	100	25	8	45 × 90	45 × 90	O.K
					43 × 86	O.K
					41 × 82	O.K
					39 × 78	DEFECTIVE
					39.5 × 79	DEFECTIVE
					40 × 80	O.K
100	100	16.7	12	33.8 6 × 7.5	33.8 × 67.5	O.K
					35 × 70	O.K
					33 × 66	O.K
					31 × 62	O.K
					29 × 58	DEFECTIVE
					30 × 60	O.K
100	100	12.5	16	27 × 54	27 × 54	O.K
					26.5 × 53	O.K
					25.5 × 51	O.K
					24.5 × 49	O.K
					23.5 × 47	DEFECTIVE
					24 × 48	O.K
100	100	10	20	22.5 × 45	22.5 × 45	O.K
					22 × 44	O.K
					21.5 × 43	O.K
					21 × 42	O.K
					19.5 × 39	DEFECTIVE
					20 × 40	O.K
100	100	8.4	24	19.3 × 38.6	19.3 × 38.6	O.K
					19 × 38	O.K
					18.5 × 37	O.K
					18 × 36	O.K
					17.5 × 35	DEFECTIVE
					17 × 34	O.K

L	W	T	SF	RISER DIM.AS PER MOD METHOD	INTERMEDIATE STEPS TO FIND THE OPTIMUM RISER DIMENSIONS	REMARKS
100	100	7.2	28	16.9 × 33.8	16.9 × 33.8	O.K
					16.5 × 33	O.K
					15.5 × 31	O.K
					14.5 × 29	DEFECTIVE
					15 × 30	O.K
100	100	6.3	32	15 × 30	15 × 30	O.K
					14.5 × 29	O.K
					14 × 28	O.K
					13 × 26	DEFECTIVE
					13.5 × 27	O.K
100	100	5.6	36	13.5 × 27	13.5 × 27	O.K
					13 × 26	O.K
					12.5 × 25	O.K
					11.5 × 23	DEFECTIVE
					12 × 24	O.K

Table-6: The Optimum Riser Dimensions

L	W	T	SF	OPTIMUM RISER SIZE
100	100	50	4	60 × 120
100	100	25	8	40 × 80
100	100	16.7	12	30 × 60
100	100	12.5	16	24 × 48
100	100	10	20	20 × 40
100	100	8.4	24	17 × 34
100	100	7.2	28	15 × 30
100	100	6.3	32	13.5 × 27
100	100	5.6	36	12 × 24

is presented in Fig. 9.The optimum net dimensions, as determined from this study are listed in Table-6. The optimum volume of riser (v_r) and the volume of casting (v_c) and the corresponding shape factors are tabulated in Table-7.

From these data, a nomogram, as illustrated in Fig. 10, has been developed. In this nomogram, the ratio of the optimum volume of the riser (v_r) and the volume of the casting (v_c) (Table-6) has been plotted against the shape factor of the castings. The regions for sound and unsound castings are shown in the nomogram. It may therefore be used conveniently by LM6 alloy casting producers.

Findings:

The NRL method is generally used to determine the riser size for steel castings only. From the above graph, the volume of riser can be found easily from any riser volume of LM6 alloy casting.

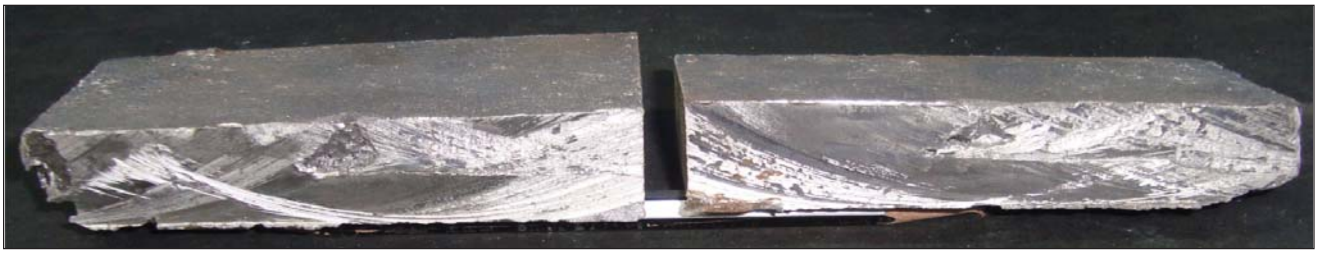

Fig.3: Plate casting with riser Ø 59 mm×118 mm height (S.F 4)

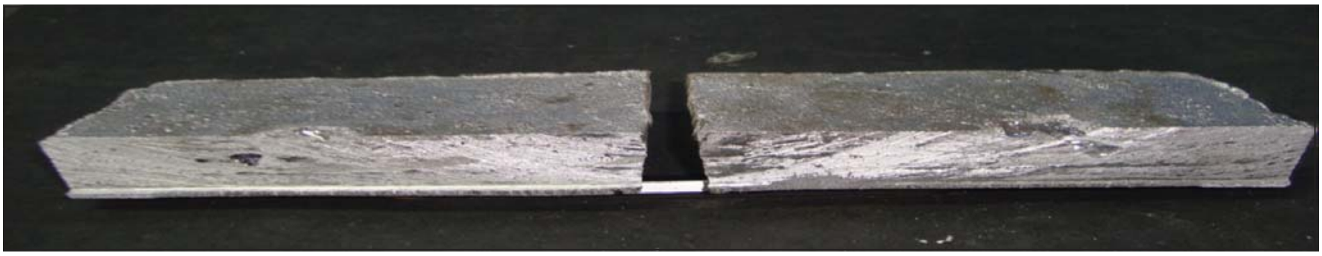

Fig.4: Plate casting with riser Ø 60 mm×120 mm height (S.F 4)

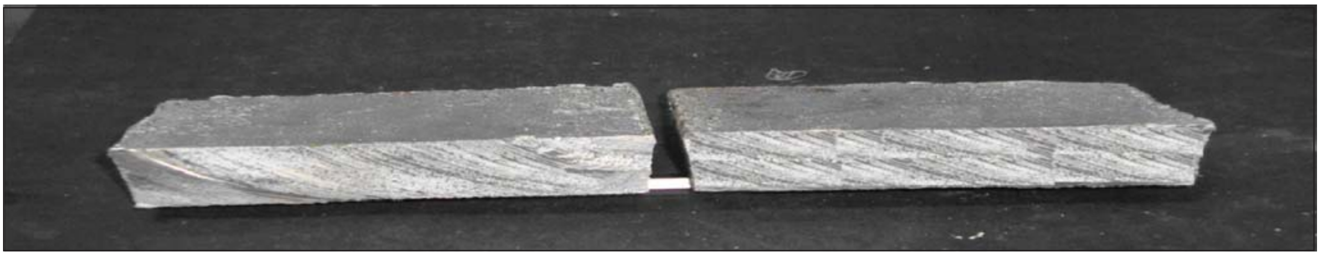

Fig.5: Plate casting with riser Ø 40 mm×80 mm height (S.F 8)

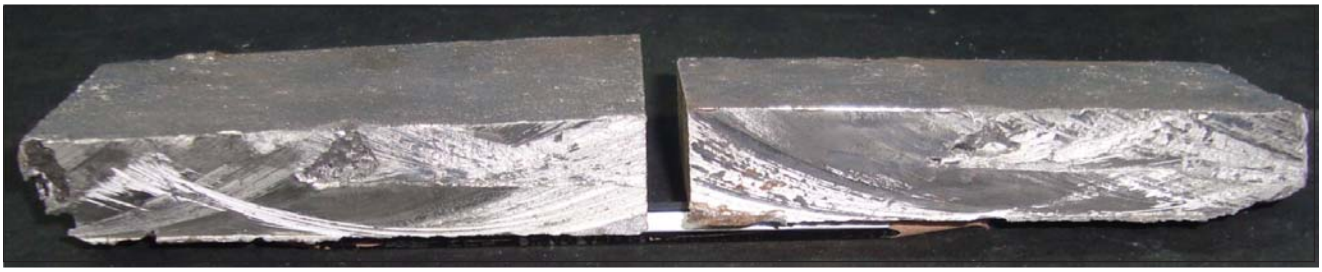

Fig. 6: Plate casting with riser Ø 29 mm×58 mm height (S.F 12)

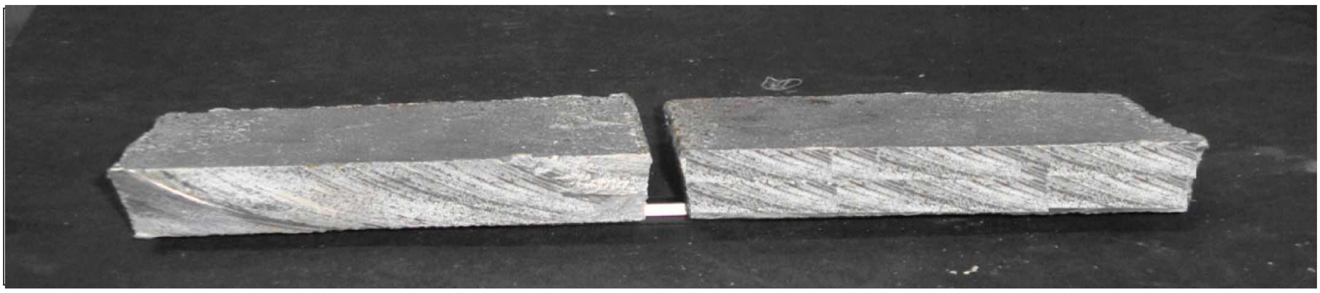

Fig. 7: Plate casting with riser Ø 12 mm×24 mm height (S.F 36)

Table-7: V_r/V_c ratios

L	W	T	SF	OPTIMUM RISER SIZE	Vr	Vc	Vr/Vc
100	100	50	4	60 × 120	339292	500000	.68
100	100	25	8	40 × 80	100531	250000	.4
100	100	16.7	12	30 × 60	42411	166700	.25
100	100	12.5	16	24 × 48	21715	125000	.17
100	100	10	20	20 × 40	12566	100000	.13
100	100	8.4	24	17 × 34	7717	83340	.09
100	100	7.2	28	15 × 30	5301	71400	.07
100	100	6.3	32	13.5 × 27	3865	62500	.06
100	100	5.6	36	12 × 24	2714	55500	.05

Simulation results:

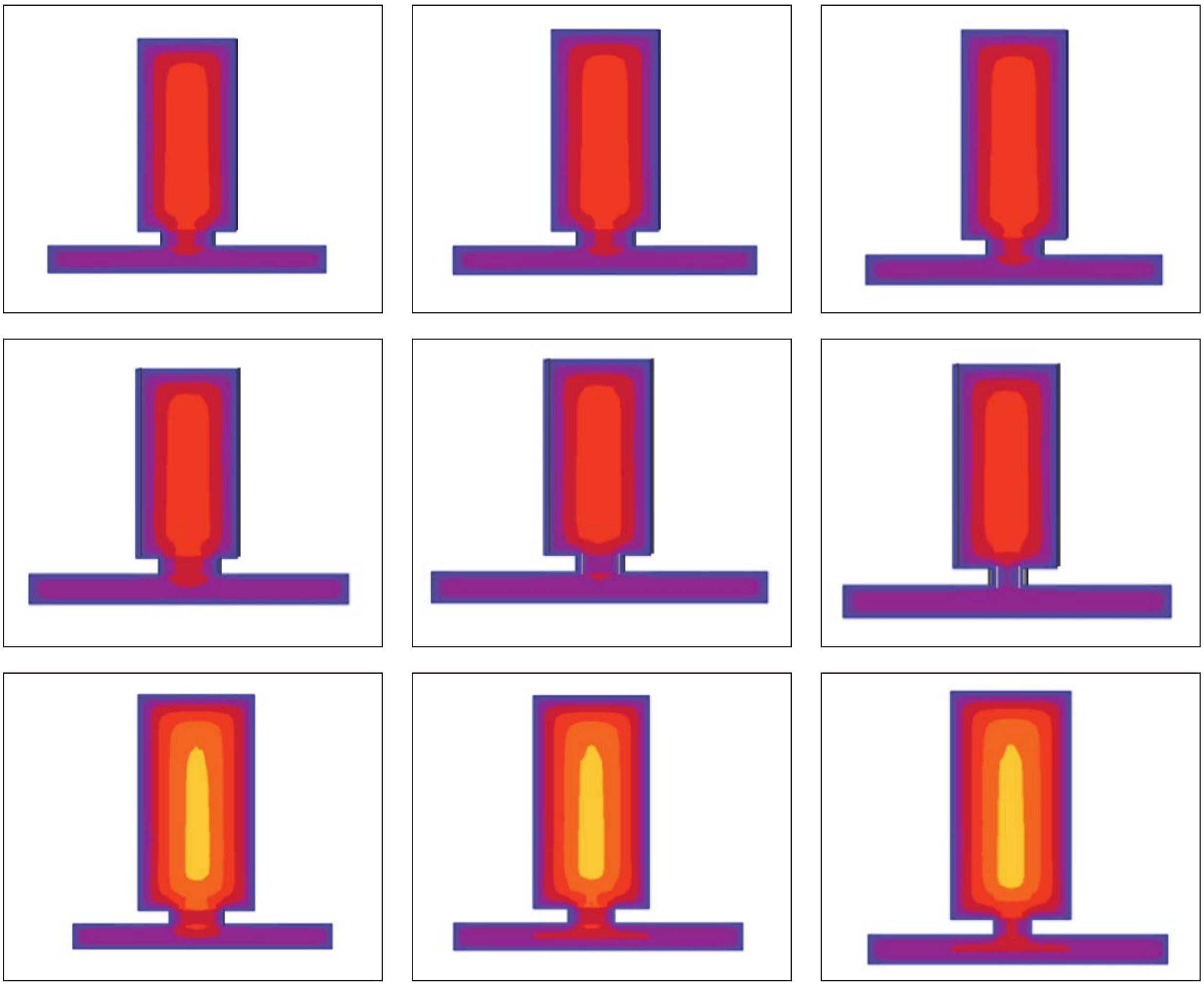

Fig. 8 : Simulation Results

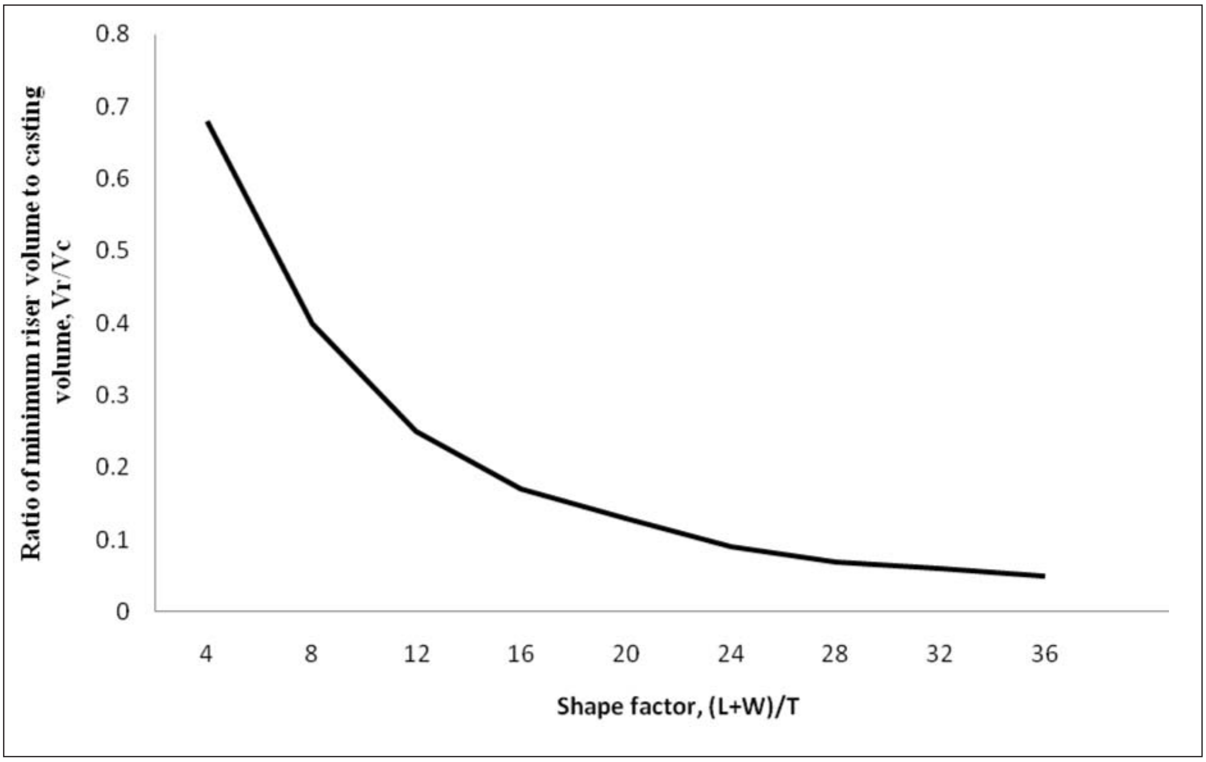

Fig. 9

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