International Journal of Engineering Research And Management (IJERM)
ISSN : 2349- 2058, Volume-01, Issue-09, December 2014

Modeling of Critical Stand-still Time of Poured Mould in Vertically Parted Automatic Flaskless Green Sand Casting Process

Raghwendra Banchhor, S.K.Ganguly

Abstract— **In the automatic flaskless green sand casting process the critical stand-still time of poured mould is important parameter for better transportability of poured over conveyors. Critical stand-still time of the mould string is the maximum time that the poured string of moulds can be left on the automatic mould conveyor without causing transport troubles.**

In present work an attempt has been made to predict critical stand-still time using multiple linear regression analysis. The parameter sand metal ratio, pattern plate utilization factor, margins of casting cavity from the edges of the mould and pouring temperature of metal are taken as input and critical stand-still time of poured mould as output. The proposed model can be employed to generate a database of minimum gaps for various combinations of part geometry, pattern plate layout and metal to predict the critical stand-still time.

Index Terms— **Flaskless mould, Critical stand-still time, Sand-metal ratio, Pattern plate utilization, multiple linear regressions analysis.**

I. INTRODUCTION

Vertically parted automatic flaskless casting process consists of a molding machine and mold transporting conveyor. It applies clay bonded sand mixtures, also called green molding sands due to its moisture content. Such mixtures consist of silica sand, clay called bentonite and few other additives. Their main component is relatively cheap silica (SiO_2) sand, one the most common compounds on the Earth. The molding sand mixture is blown by means of compressed air into a rectangular steel chamber, squeezed to a mold by two patterns fasted to the two opposed side plates of the chamber. After squeezing one of the chamber plates retracts and swings upwards and the opposite plates pushes the ready mold out of the chamber on a mold transporting conveyor. Here cores can be set automatically into the mold cavity while the next mould is about to be prepared. The above cycle repeats until a chain of such molds closed-up to each other has been established on the conveyor. The molds can now be filled with molten metal and the poured molds will be moved forward on the cooling conveyor in the same pace as the fabrication of new moulds takes place. At the end of the conveyor the solidified castings are separated from the molds and processed further, while the sand is directed to the sand preparation plant for reconditioning and reuse in the next cycles of the molding process.

The molding process has several advantages comparing to other molding processes. It does not use flasks, which avoids a need of their transporting, storing and maintaining. It is very productive and fully automatic. This reduces the labor consumption. Molding sand consumption can be minimized due to variable mold thickness that can be adjusted to the necessary minimum. The castings produced on the molding lines are very accurate dimensionally since once the molds have been cored and closed there are no perpendicular forces affecting the mould string. There are very few wear parts and movable parts in the molding machine. This decreases spare parts consumption and increases efficiency of the molding line. For the above reasons the process is particularly suitable for mass manufacturing of metal castings that are crucial components in the car and machine industry, civil engineering and many other fields.Today a modern molding line can mold at the rate of 500 sand molds per hour. Maximal mismatch of two half's of the castings made on the DISA lines does not exceed 0.1 mm. The reliability of the molding lines exceeds 98%. The range of moulding lines covers mold sizes from 400 x 500 to 850 x 1200 millimeters [1-5].

A modern automation can be completed with automatic casting and sand cooling drums, robotized devices for extracting castings from the molds and automatic casting cleaning and shot blasting machines placed inline with the moulding line.In the automatic flaskless green sand casting process the critical stand-still time of poured mould is important parameter for better transportability of poured over conveyors. Critical stand-still time of the mould string is the maximum time that the poured string can be left on the automatic mould conveyor without causing transport troubles [6, 7].

Regression analysis (RA) is a statistical method for determining the relationships among number of independent variables and dependent variable. Regression analysis also gives the information about how the dependent variable changes when any one of the independent variables is varied, while the other independent variable is held constant. The objective of studying regression analysis is to assess the predictive power of set of independent variables on the dependent variable. In Regression analysis the relationship is expressed as equation that predict response variable also called a dependent variable or criterion from a function of regressor variable also called independent variables, predictors , explanatory variable, factors or carriers. The parameters are adjusted so that a measure of fit is optimized. [8]

Manuscript received Dec 17, 2014

Raghwendra Banchhor, Associate Professor in Department of Mechanical Engineering, Bhilai Institute of Technology, Durg, India

S.K.Ganguly, Professor in Department of Mechanical Engineering Bhilai Institute of Technology, Durg, India

II. Literature Review

A. P. Ihom et al proposed the analysis and prediction of green permeability values in sand moulds using multiple linear regression model [9]. Luke Haung et al formed multiple regression model to predict surface roughness in turning operation [10].Delijaicov et al applied multiple regression and neural network to synthethize a model for peen forming process planning [11].

III. Methodology

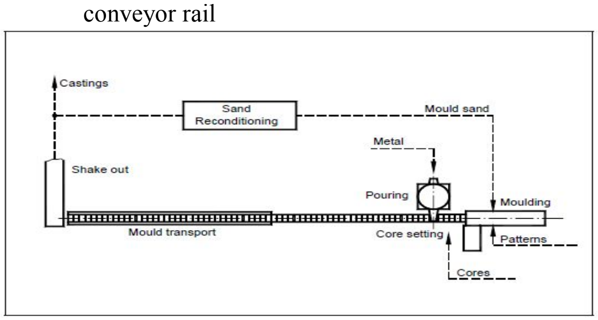
3.1. Description of problem

Critical stand still time of the mould string is the maximum time that the poured string can be left on the conveyor without causing transport troubles. The moulding sand which is thermally shocked by the hot metal loses its strength properties after some time causing the mould to disintegrate. The first stage disintegration the mould sides fall-off does not destroy casting metallurgy or mould string transport sit is strictly superficial.

Further mould collapse takes place in the next stage rigidity, integrity and the contact areas of the mould parting lines, thus hampering transport condition. The mould into which hot metal is poured is fairly damp because of the moisture content of the sand. The effect of pouring hot metal casting is to cause condensation on the conveyor rails, as heat from the casting transfer moisture through the moulds.

This result in:

- Reduced strength of the mould so that the rails of the conveyor cut into the mould bottom , preventing further mould string transport
- Sticky sand in the bottom of mould adhere to the conveyor rail



If production on the moulding line has to stop for a period of time, the critical stand-still time must be considered and the mould conveyor and synchronized belt conveyor should be emptied

3.2. Identification of influencing factors

The critical stand-still time depends on many factors, such as:

- Sand metal ratio
- Pattern plate utilization
- Location of casting cavity in the mould
- Pouring temperature of metal

Sand- Metal Ratio (SMR):

$$SMR = \frac{\text{Weight of sand per mould}}{\text{Weight of metal poured per mould}}$$

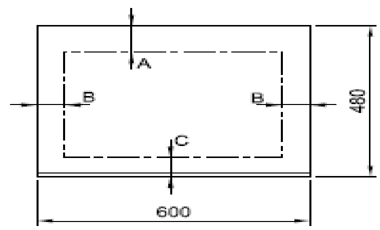
Pattern plate utilization (PPU):

$$PPU = \frac{\text{Pattern plate area covered by pattern and gating system}}{\text{Total pattern plate area}}$$

Location of casting cavity in mould

Depending on the casting wall thickness or modulus of solidification and total pattern height the patterns are mounted on the pattern plates providing the safety dimensions from the top, the sides and the bottom.

- Distance from the casting and to mould top "A"
- Distance from the casting and gating system to mould sides "B"
- Distance from the casting and gating system to mould bottom "C"



Pouring Temperature:

Pouring temperature of thin section casting (thickness < 6 mm) = 1450 ±10°C

Pouring temperature of thick section casting (thickness > 6 mm) = 1430±10°C

3.3. Data Collection

Sl.	Independent variables						Dependent variables
	A (mm)	B (mm)	C (mm)	PPU %	SMR (nu)	t°C	Critical stand-still time (Minutes)
1	72	36	42	59.8	5.22	1452	155
2	72	36	42	59.8	5.22	1446	150
3	74	35	37	58.7	8.42	1435	210
4	74	35	37	58.7	8.42	1442	215
5	72	36	40	55.6	7.53	1455	205
6	72	36	40	55.6	7.53	1456	200
7	74	57	56	58.4	6.71	1447	185
8	74	57	56	58.4	6.71	1445	175
9	75	69	67	55.2	7.28	1459	200
10	75	69	67	55.2	7.28	1446	195

11	77	76	75	54.8	7.87	1447	202
12	77	76	75	54.8	7.87	1456	210
13	70	72	74	57.9	5.78	1453	165
14	70	72	74	57.9	5.78	1447	160
15	74	59	56	56.3	7.93	1453	205
16	74	59	56	56.3	7.93	1435	200
17	75	68	67	51.6	6.67	1435	170
18	75	68	67	51.6	6.67	1442	175
19	75	76	74	62.4	8.33	1455	220
20	75	76	74	62.4	8.33	1456	220
21	70	72	75	52.7	7.64	1447	195
22	70	72	75	52.7	7.64	1455	200
23	69	94	96	56.8	5.6	1452	160
24	69	94	96	56.8	5.6	1452	165
25	72	92	94	51.7	9.2	1447	230
26	72	92	94	51.7	9.2	1453	225
27	75	64	66	49.8	5.82	1437	155
28	75	64	66	49.8	5.82	1439	150
29	70	76	74	47.9	6.76	1438	175
30	70	76	74	47.9	6.76	1442	170
31	70	84	86	51.3	8.1	1437	200
32	70	84	86	51.3	8.1	1437	205
33	75	84	86	60.3	9.21	1435	230
34	75	84	86	60.3	9.21	1436	230
35	68	94	96	48.9	7.68	1442	190
36	68	94	96	48.9	7.68	1446	200
37	70	104	102	47.9	6.96	1442	180
38	70	104	102	47.9	6.96	1435	180
39	72	74	75	42.1	7.46	1437	185
40	72	74	75	42.1	7.46	1430	180
41	71	84	86	46.7	7.56	1438	185
42	71	84	86	46.7	7.56	1432	185
43	74	84	86	51.1	8.32	1438	205
44	74	84	86	51.1	8.32	1437	200
45	75	94	96	39.8	9.12	1428	210
46	75	94	96	39.8	9.12	1429	210
47	72	106	102	42.1	6.79	1435	175
48	72	106	102	42.1	6.79	1437	170
49	70	115	108	36.9	8.56	1429	200
50	70	115	108	36.9	8.56	1426	190
51	72	125	128	47.9	7.32	1428	180
52	72	125	128	47.9	7.32	1430	185

3.4. Results

The objective of this paper is to suggest a mathematical model for critical stand still time of the poured mould in automated flaskless green sand casting foundry. Multiple regression analysis is applied for model formulation. The software used for modeling is IBM SPSS 20.0.

Regression coefficient model

Critical Stand Still time

= -674.023 +0.055*A +0.034*B +0.002*C +0.636*PPU +19.871*SMR +0.469*t

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.990[a]	.980	.977	3.23539	.980	362.567	6	45	.000

a. Predictors: (Constant), t, A, SMR, B, PPU, C

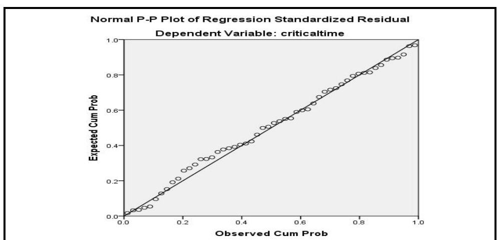
b. Dependent Variable: critical time

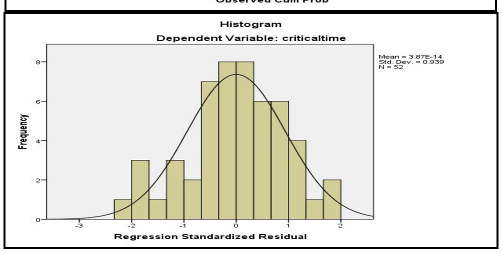
ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	22771.623	6	3795.271	362.567	.000[b]
	Residual	471.050	45	10.468		
	Total	23242.673	51			

a. Dependent Variable: critical time

b. Predictors: (Constant), t, A, SMR, B, PPU, C





Discussion

Mathematical equation for critical stand-still time clearly indicates that input variables having high coefficient have more impact on response variable i.e. critical stand-still time. The regression equation appears to be very useful for making prediction since the value of R^2 is close to 1.

Coefficient of variable SMR (sand metal ratio) is the largest. It means moulds with high sand metal ratio can be left for longer period on the conveyor without causing transport troubles

Coefficient of variable C (distance from the casting and gating system to mould bottom) is least. It clearly indicates that its effect on stand-still time is minimum on the response variable.

Conclusion

In this work, modeling of critical stand-still time for vertically parted automatic flaskless casting process was considered. The data was collected from a medium size S.G. iron foundry in India.After regression modeling guidelines for prediction of critical stand-still time is suggested so that automatic mould conveyor and synchronized belt conveyor can be emptied before mould disintegration.

References

[1] Moulding solutions, www.disagroup.com

[2] Disamatic moulding explained, www.metaltechnology.com

[3] Variation of green sand molding, Flaskless molding, www.engineershandbook.com

[4] Vertical and Flaskless moulding, www.industrialmetalcasting.com

[5] DISA MATCH article by Michael Colditz, "State of the art in the manufacture of flaskless, horizontally parted moulds"18/06/2012

[6] Per Larson, "Iron melt flow in thin walled section cast in vertically parted green sand mould", Industrial research project at DISA Industries, Technical University of Denmark

[7] DISA SHUTTLE -Extended in-mould cooling in restricted space, DISA shaping industry, www.disagroup.com

[8] Vijay Gupta, "Regression explained in simple terms", A Vijay Gupta Publication, SPSS for beginners (2000)

[9] P. Ihom et al., "Analysis and prediction of green permeability values in sand moulds using multiple linear regression model", *African Journal of Engineering Research* Vol. 2(1), pp. 8-13, February 2014 ISSN: 2354-2144.

[10] Luke Hang et al, "A multiple regression model to predict in process surface roughness in turning operation via accelerometer", Journal of industrial engineering, Volume 17, No.2, 2012

[11] S. Delijaicov, A. T. Fleury, F.P.R. Martins, " Application of multiple regression and neural network to synthesize a model for peen forming process planning" Journal of achievement in material and manufacturing engineering", Volume 43,Issue 2, (2010)

[12] Richard W Heine, Carl R Loper, Pilip C Rosenthal, "Principle of metal casting", Tata McGrahill, New Delhi,2014

[13] Serope Kalpakjian and Steven R. Schmid , " Manufacturing Engineering and Technology ", 4th edition , Pearson,New Delhi,2013

[14] Raghwendra Banchhor,S.K.Ganguly, "Critical Assessment of Green Sand Moulding Processes", International Journal of Recent Development in Engineering and Technology Website: www.ijrdet.com (ISSN 2347 - 6435 (Online) Volume 2, Issue 4, April 2014) 90

[15] Raghwendra Banchhor, S.K. Ganguly, 'Optimization in Green Sand Casting Process for Efficient, Economical and Quality Casting", Int J Adv Engg Tech/Vol. V/Issue I/Jan.-March,2014/25-29