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Parameter Optimization of No Bake Core Making Process by Using Taguchi Method

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ABSTRACT- ***No bake core making is an efficient means to produce complex castings. Input parameters were evaluated by Taguchi method for obtaining higher scratch hardness and shear strength. The results revealed that combination of medium level of parameters helps in improvement in the productivity and the stability of the casting process****.*

Keywords— No Bake core, Taguchi method, Productivity, Stability

I. Introduction

A core is used in casting and moulding processes to produce internal cavities. The core is normally a disposable item that is destroyed.. They are most commonly used in sand casting. The selection of the correct type of core depends on production quantity, production rate, required precision, required surface finish, and the type of metal being used.

Green-sand cores are mostly used in the foundry. Their major disadvantage is their lack of strength obtained which makes casting long narrow features difficult or impossible. As the metal casting industry's second favourite method for producing cast components (green sand moulding is the first), no bake moulding has proven its worth as an efficient means to produce medium and low volumes of complex castings in both ferrous and nonferrous metals. i

In no bake process, sand is mixed with a chemical binder and then moulded around the cope and drag halves of the tooling ii. After a specified period of time (depending upon mould size), the sand mixture hardens to form the mould halves and the tooling is drawn. Then, a refractory coating may be applied to both mould halves before they are brought together to form one complete mould for pouring. (No bake moulded cores also can be produced using a similar method and assembled into the mould to form more complex shapes by optimising the input parameters iii.)

Virtually all metals can be cast via no bake moulding with component weights ranging from less than kilograms to several hundred thousand kilograms. For casting designers, no bake moulding offers:

- Good dimensional tolerances.
- Compatibility with most pattern materials
- Design flexibility for intricate casting shapes.
- Reduced opportunity for gas-related defects.
- Fine surface finishes.
- In addition, no bake can go for Low to medium volume production capability with runs from 1-5000 parts/yr.

Fig.1 indicates the different causes for the core related casting defects iv.

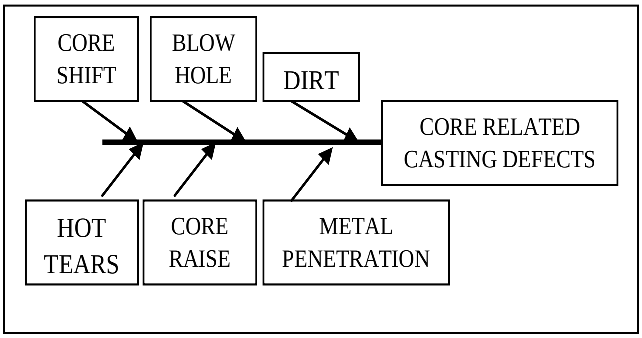

Fig.1. Fish bone diagram for core related casting defect

A. Taguchi Method

The term 'Taguchi methods' is normally used to cover two related ideas v. The first is use of statistical methods concerned with the analysis of variance vi, experiments may be constructed which enable identification of the important design factors responsible for degrading product performance. The second concept is that when judging the effectiveness of designs, the degree of loss is a function of the deviation of any design parameter from its target value. Taguchi methodology emphasizes the importance of the middle (parameter design) stage in the total design process vii. The important aspect of the Taguchi methodology - the Taguchi loss function or quality loss function viii maintains that there is an increasing loss both for producers and for society at large, which is a function of the deviation or variability from the ideal.

Robust parameter design uses Taguchi designs (orthogonal arrays), which allow to analyze many factors with few runs. In Minitab we can calculate response tables, linear model results, and generates main effects and interaction plots.

II. TAGUCHI EXPERIMENT CASE STUDY

The design of experiment (DOE) method has been widely used by industries (especially in automotive) to improve the quality of products. The objective of the experiments is to make comparisons between the effects of different factors and then determine the best setting for each factor. Taguchi's orthogonal arrays are highly fractional orthogonal designs proposed by Dr. Genichi Taguchi, a

Japanese industrialist. These designs can be used to estimate main effects using only a few experimental runs. An orthogonal array is a major tool used in the Taguchi design which is used to study several design parameters by means of a single quality characteristic.

A. Selection of Orthogonal arrays (OA's)

The selection of which OA to use mainly depends on

- The number of factors and interactions of interest,
- The number of levels for the factors of interest.

As per the study to be conducted the parameter interactions between the binder and hardener reveals that nonlinear behaviour among the parameters can only be determined if more than two levels of parameters used viii. Therefore each parameter was analyzed at three levels hence L9 OA was chosen and the details of L9 O as in Table.1.

Table .1. Three Levels Orthogonal Array Selection (L9 standard Array) ix

TRAIL NO	COLUMN NO		
	A	B	C
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	3
5	2	2	1
6	2	3	2
7	3	1	2
8	3	2	3
9	3	3	1

III. EXPERIMENTAL SET UP

Experimental parameters were decided after discussion with industry expert in the above area and following levels and values were chosen as in Table 2. Once the parameters and its interactions are assigned to a particular column of Table 3 the selected orthogonal array. Specimens were prepared and study was conducted.

Table 2. Experimental parameters with level and values

Parameter Designation	Process Parameter	Level		
		Low	Medium	High
A	Binder (Litre)	2	2.1	2.2
B	Hardener (Litre)	1	1.05	1.1
C	Drying Duration (min)	60	90	120

Table.3. Parameters and its interactions are assigned to a particular column of the selected orthogonal array

TRAIL NO	COLUMN NO		
	A	B	C
1	2	1	60
2	2	1.05	90
3	2	1.1	120
4	2.1	1	120
5	2.1	1.05	60
6	2.1	1.1	90
7	2.2	1	90
8	2.2	1.05	120
9	2.2	1.1	60

A. Preparation of core sand mix

Sand samples were prepared by using the Core sand of (100 Kg) with range for GFN 50-52 (which during the entire study and preparation of the sand specimen was controlled) and Binder (Metacold 310) (2 litre).The mixer was put in the Fig.2.Muller and the power is switched on the mixer. The sand and the binder were mixed homogenously and the mixer was taken out. While preparing the standard specimen the hardener (Metacold 320) (1 litre) was mixed and the mix is finally ready.

Fig.2. Muller used for mixing the sand mix

B. Preparation of standard test specimen

Standard test specimen is cylindrical in shape with diameter 50mm, height 50mm. To obtain these specific shape 150 gm of sand mix is transferred to steel tube and placed under the pistonof standard rammer Fig.3. The dead weight of the rammer is transferred to sand mix by applying three strokes.

Each stroke consists of raising the dead weight and allowing it to fall suddenly with help of CAM mechanism. The specimen is removed from the steel tube and is ready for the strength and scratch test. The Scratch tester and Hydraulic Universal strength testing machine was used to estimate the scratch resistance and shear strength of No bake core sand on standard sand samples. So as to reduce the error 2 Samples of same composition with varying levels as per the table were prepared by varying the composition and for different drying duration were tested and results are obtained.

Fig.3. Standard rammer

IV. RESULTS AND DISCUSSION

The experiments were conducted on the above set of test pieces and following results were obtained during shear and scratch test

A. Strength Test

The Universal strength testing machine with dial indicator Fig.4. is fitted to the machine. The grippers with step surface are inserted in the stationery end and moving end. The standard specimen is placed between the grippers. The force is applied gradually by slowly rotating the hand wheel. As the force is applied the needle deflection in the dial indicator shows the compressive force. When the force applied reaches maximum the test specimen collapses and reading is noted down when the sample fails to withstand shear force .The shear force in terms of Kilo Pascal (kPa) was noted as in Table 4.

Fig.4. Universal strength testing machine

B. Scratch Test

Core hardness tester Fig.5. resembles a dial gauge and having a plunger protruding from flat base .The tester is placed base down on the core surface, the plunger gets pressed and forced into the specimen x .The distance through which it moves

Without making a permanent mark depends on the hardness this movement will actuate the plunger and value are as in Table.4

Fig.5. Core hardness tester

Table.4 Results of Scratch hardness and Shear strength (kPa)

TRAIL NO	Results	
	Scratch Hardness	Shear Strength (kPa)
1	57.5	170
2	61	400
3	66.5	675
4	65	640
5	68.5	870
6	77	1190
7	73.5	1075
8	77	1190
9	75.5	1145

Fig.6. and Fig.7. Show the following observations:-

- Scratch hardness (SH) and shear strength (SS) are affected significantly by factors A and C compared to factor B.
- Though the middle level of factor B produces higher SH and SS compared to level 1 and 3 the total variation in SH and SS at any level of B is very less.
- It is evident from the figures that middle level of factor A & C yield higher SH and SS compared to lower level. However higher level does not influence significantly. The same is depicted in interaction plots for both SH and SH. This is also evident from Fig.8. & Fig.9. are the interaction plot for SS and SH
- Hence factors A and C must be set at middle level rather than higher level. This will help in optimizing scratch hardness and shear strength.

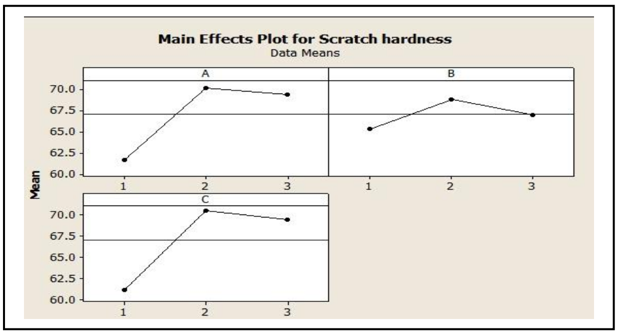

Fig.6. Main Effects and mean plot for Scratch hardness

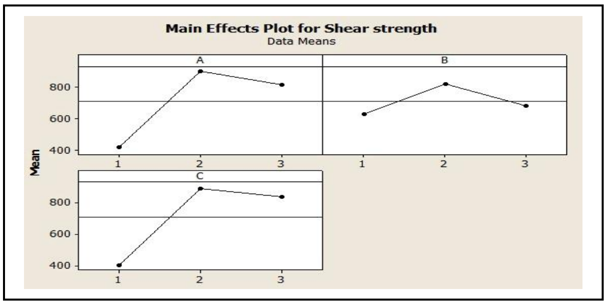

Fig.7. Main Effects and mean plot for Shear strength

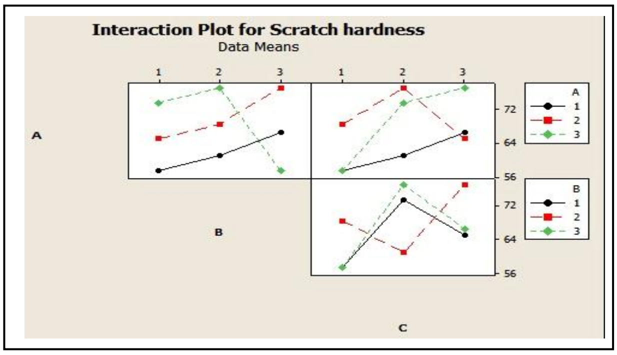

Fig.8. Interaction plot for scratch hardness

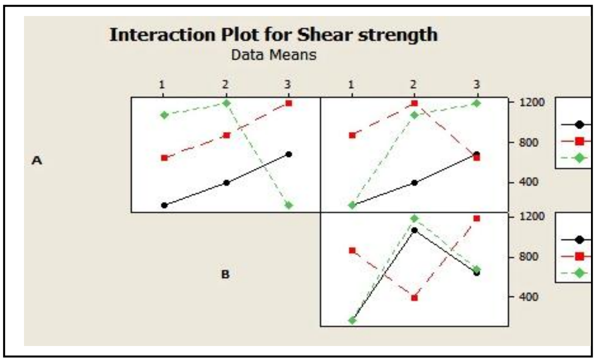

Fig.9. Interaction plot for Shear Strength

V. CONCLUSION

This paper attempts to optimize the scratch hardness and shear strength of the core made from No bake process. The results show that the middle level setting of 2.1 litre binder and drying duration of 90 min yield high scratch hardness of 77 and high shear strength of 1190 kPa.

VI. ACKNOWLEDGEMENT

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