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Study of Regression Relationship Involving Compressive Strength, Resin Addition and Time of Soaking of Foundry Sand Samples during Mould Making in a Foundry Unit

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ABSTRACT

Achieving proper strength in sand molds by varying addition of resin and soaking period for casting metal is a matter of experience by the operating personnel. Therefor Regression analysis was carried out to know the role of resin addition and time of soaking as dependent parameters on the independent parameter namely compressive strength of the sand mold samples . Cylindrical samples were made with varying amount of resin additions (upto a maximum of 1.3%) with varying soaking period (up to a maximum of 24 hours). Initially an exponential relationship involving compressive strength and resin additiononly ($S= k R^n$wherewhere S= compressive strength in kg/sq.cm, k= numerical constant (presumed constant) R= Resin percentage and n= empirical constant) were tried. The data points exhibited wide variationswithout having any relationship . Therefore, an exponential relationship involving both resin addition and time of soaking with compressive strength of the samples was made ($S= kR^{\alpha}t^{\beta}$, where S= compressive strength, R= resin percentage and t=time of soaking at a fixed resin percentage, and α and β are empirical constants).

It was observed that the values of ' α ' as regards relationship between resin addition and compressive strength was same (followed the same curve) and were therefore of no significant importance. As regards relationship between time of soaking and compressive strength (βvalues)distinct relationship between compressive strength and time of soaking was observed such that the lower soaking period gave less compressive strength in comparison to that subjected to higher soaking period.This analysis indicates that time of soaking of moulds is more important in achieving strength and the addition of resin has no significance as regards strength of the moulds are concerned.

key words: mold, regression analysis, resin

1.INTRODUCTION

In sand mold making , the sand particles are held together by a typical mixture of 90% silica sand, 3% water and 5% - 7% clay. Other bonding agents can be used in place of clay, including organic and inorganic binders. Additives (catalysts or hardeners) are sometimes combined with the mixture of sand and binder to enhance properties such as strength of the mold [1]. Sand casting with these mixtures is called resin bonded sand casting. It is claimed that it can give better dimensional accuracy on cast product and strength than the green sand process [2]. Resin bonded sand consists of 93-99% silica and 1-3% binders [3]. Binders give bond, cohesion and strength to the mixed sand during mold ramming to ease the shaping process and retain it shape under pressure, temperature and erosion of liquid metal during pouring process

A highly alkaline phenolic resin is used as binder in no bake process [4]. No bake process is another name for resin bonded sand casting in which resin is self-setting at room temperature.In phenolic-ester no bake mold, 1.5 – 2% of the phenolic resin (based on the weight of sand) is first blended into the sand, followed by about 20% of an ester (based on weight of resin) [4]. The reaction between the ester and phenolic resin leads to curing and solidification. Since the binders are free of nitrogen and sulfur, it gives strength advantages for steel, nodular iron and aluminum casting.Additives arealso added to the molding components to improve: surface finish, dry strength, refractoriness, and "cushioning properties".Up to 5% of reducing agents, such as coal powder, pitch, creosote, and fuel oil, may be added to the molding material to prevent wetting (prevention of liquid metal sticking to sand particles, thus leaving them on the casting surface), improve

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surface finish, decrease metal penetration, and burn-on defects. These additives achieve this by creating gases at the surface of the mold cavity, which prevent the liquid metal from adhering to the sand. Reducing agents are not used with steel casting, because they can carburize the metal during casting.Up to 3% of "cushioning material", such as wood flour, saw dust, powdered husks, peat, and straw, can be added to reduce scabbing, hot tear, and hot crack casting defects when casting high temperature metals. These materials are beneficial because burn-off when the metal is poured creating voids in the mold, which allow it to expand. They also increase collapsibility and reduce shakeout time.

Sand testing is essential to understand the properties of the resin bonded sand mold. Some of the most important sand testing are moisture, permeability, strength, compactability and loss of ignition (LOI) test [2].

In this study, compression testing and LOI were employed as a preliminary measuring parameters to assess mould quality..This study is a preliminary work to evaluate the effect of resin and time of soaking on the compressive strength of prepared molds as determined from compression testing measurements on laboratory prepared blocks. It may be mentioned that till date the effect of binders on strength and effect of time on strength (due mainly to sintering of sand particles) have not been systematically carried out. .Moreover with temperature the resin burns out leaving only silica particles to sinter at higher temperature. Therefore empirical equations were made givingindividual relationship between strength and amount of resin ($S= kR^{n}$.....Eqn(1) where S= strength in kg/sq.cm, k= numerical constant (presumed constant) R= Resin percentage and n= empirical constant) with different amounts of resin addition. Similarly empirical equations giving relationship between strength, resin addition and time of soaking was made ($S= kR^{\alpha}t^{\beta}$….eqn(2), where S= compressive strength, R= resin percentage and t=time of soaking at a fixed resin percentage, and α and β are empirical constants).

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1(a).OBJECTIVES OF THE STUDY

The objectives of this work were, to study the effect of different amount of binders(resin,below 5% (2)) on the compressive strength and secondly, to give a mathematical co-relation between compressive strength , amount of resin and time of soaking. In general it is observed that with increasing soaking time the compressive strength increase for all the different resin additions although the loss on ignition value remains almost unaffected. This study therefore is presumed to give a comparative relationshipbehavior between compressive strength and amount of resin addition and time of soaking so that optimum strength, optimum resin addition and optimum soaking time parameters can be evaluated from empirical relationships.

1(b).Loss on Ignition (LOI)

Loss on ignition was performed to test and measure amount of moisture and organic impurities loss when the sample was ignited.Sand mixture according to ratio set was weighted for 10 g and put into a crucible. The samples were then heated at 1000 ° C for 30 minutes. After the samples were taken out of the kiln or oven, they were immediately placed in desiccators.The samples were again weighted and LOI was measured according to initial weight minus final weight and divided by the initial weight in unit gram.

2. EQUIPMENTS AND MATERIALS USED

A Muffle furnace (6”x6”x12”) , Analytical balance, Compressive strength testing machine to test specimen of 50 mm height by 50 mm Diameter, Sand mullers with two mullers and an Crib made up of mild steel plates were used.for preparation of samples Different amount of resin binders (below 5%) were used and the compressive strength after soaking the samples at different time periods with measured amount of resin addition were determined.

Compressive strength test was performed using a universal testing machine (UTM). Samples for the test were cylindrical shape with 50 mm diameter and 50 mm height . The sample was placed in between a compression holder. The samples was pressed at load until they are broken.

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3. RESULTS AND ANALYSIS

Table 1 shows one such experimental data carried out with fixed amount of resin addition and the compressive strengths obtained after soaking at varying time periods.

Table-1 Compressive strength for various time cured samples with varying resin percentages. (LOI-1.15%)

SNO	Resin Percentage	Compression strength for various time cured mixtures (Kg/cm^2)				
		1 Hr	2 Hr	4 Hr	8 Hr	24 Hr
1.	1.1	0.1	1.06	2.64	6.56	7.58
2.	1.2	0.1	1.32	4.38	4.53	9.67
3.	1.3	0.15	1.42	4.73	5.84	11.61
4.	1.4	0.1	2.85	4.63	6.23	12.83
5.	1.5	0.15	3.05	4.84	9.88	13.08

3(a) **Relationship between compressive strength and different amount of resin addition with 4 hours and 24 hours soaked samples(S= k R^{n}where S= compressive strength in kg/sq.cm, k= numerical constant (presumed constant) R= Resin percentage and n= empirical constant)**

Fig(1) shows the relationship between empirical constant ‘n’ (resin addition 1.1% - 1.35%) , loss on ignition (1.15% -1.35%) with 4 hours and 24 hours soaking period.. In general it is observed that the values of ‘ n ‘ did not give any conclusive evidence as regards compressive strength and different amount of resin additions with increase of soaking period from 4hours to 24 hours.It was therefore felt necessary to include both resin addition and time of soaking period jointly to have a relationship with compressive strength.

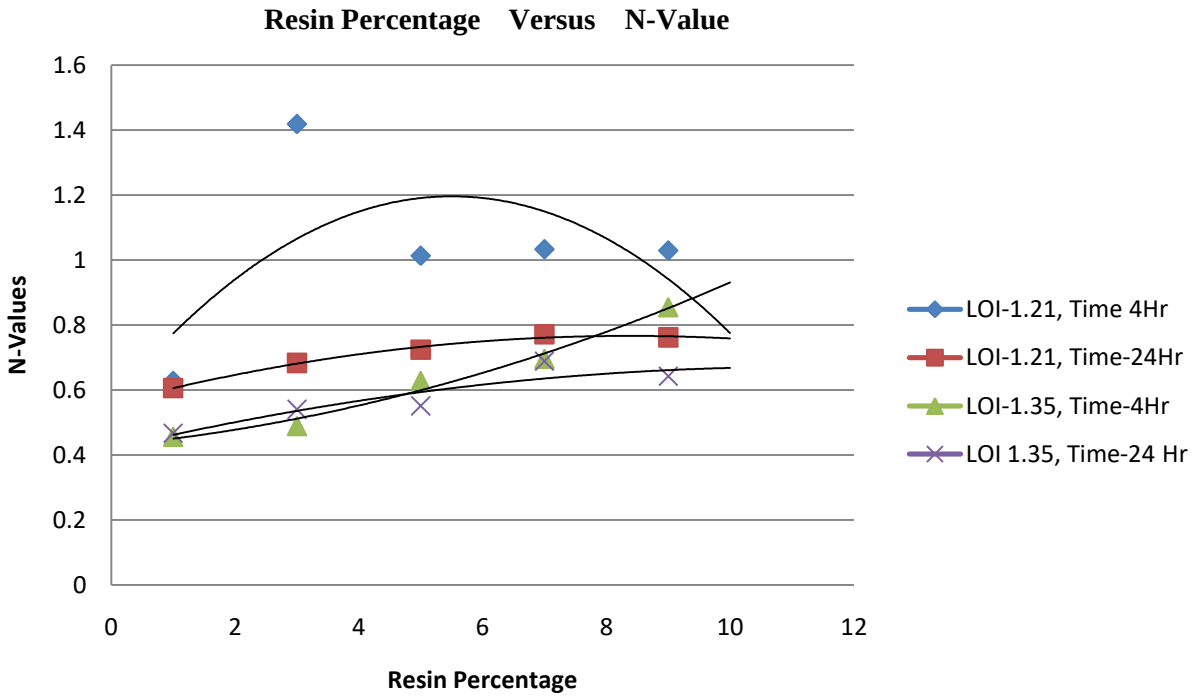

FIGURE-01 RESIN PERCENTAGE Vs N-VALUE

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3(b) **Relationship between compressive strength, resin percentage addition and time of soaking ($S= kR^{\alpha}t^{\beta}$, where S= compressive strength, R= resin percentage addition and t=time of soaking,, and α and β are empirical constants)**

Fig(2) gives the relationship between α ,β and different resin addition with 4 hours and 24 hours soaking period. It will be observed that despite different additions all the graphs show an increasing tendency of α values from α=(-)24.16 (with 1.1% resin addition) to α= (-)4.6 (with 1.5% resin addition) indicating the fact that increasing resin addition leads to increasing compressive strength behavior. The nature of the curve is however asymptotic in nature. This indicates that the amountof addition is critical in increasing strength of the compacts. Moreover it is observed that all the different resin additions (1.1% and 1.3%) follow the same curve .

The β values(Fig 3) however gives increasing trend of 'n' values with 24 hour soaking as compared to 4 hour soaking. This is consistent with both 1.15% and 1.35% addition.

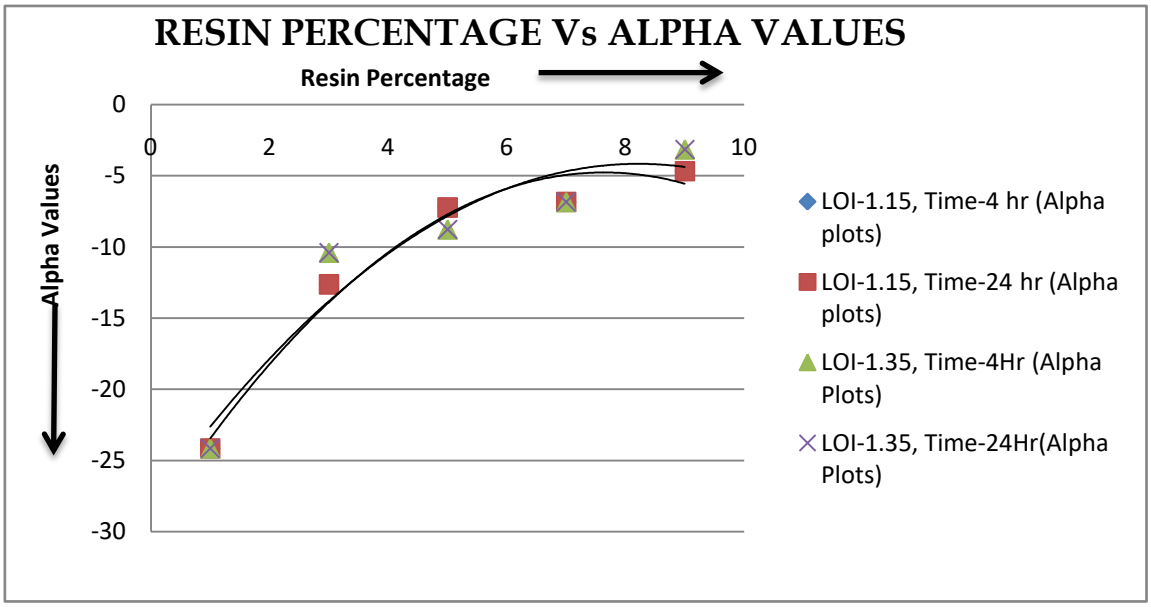

FIGURE-02 RESIN PERCENTAGE Vs ALPHA VALUES

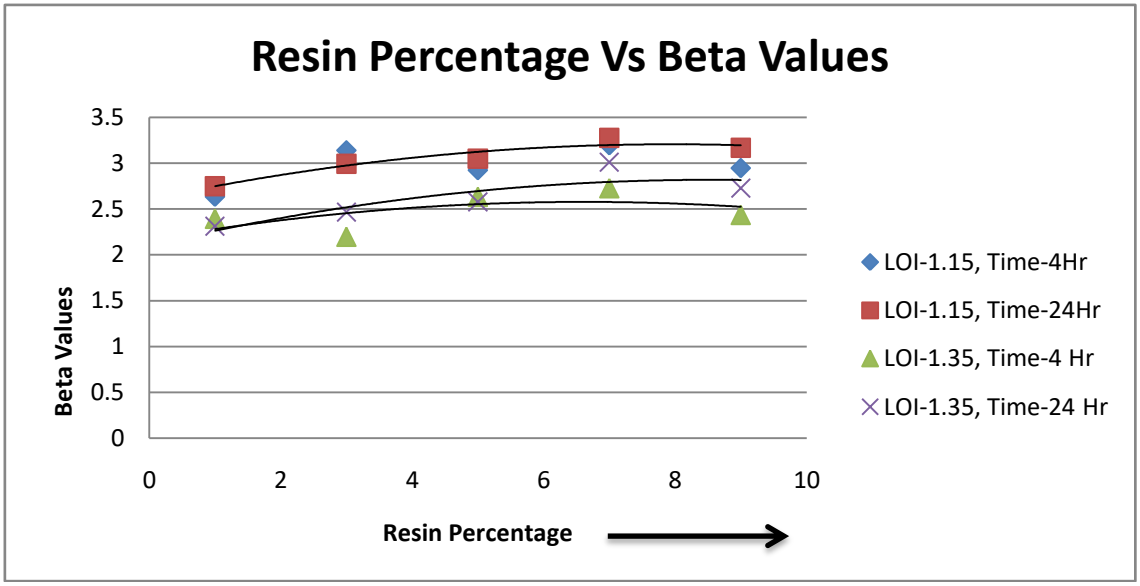

FIGURE-03 RESIN PERCENTAGE Vs BETA VALUES

4. CONCLUSION

It is concluded that the time of soaking and different amount of resin binder additions has a significant influence with the compressive strength of the foundry sand sample compacts . It is observed that time of soaking and amount of binder addition influences compressive strength when taken jointly.As regards α values (compressive strength vs resin addition)it is observed that the change in amount of resin addition has no significant influence with increased soaking period at higher temperature as the curves merge with each other .As regards β values (time of soaking and compressive strength) it is observed that with increasing amount of resin addition (from 1.15% to 1.35%) and increased amount of soaking period β values increased progressively..

However empirical relationship between compressive strength and resin addition individually showed that there is no correlation

It is concluded that amount of soaking is more important in evaluating compressive strength in comparison to amount of resin addition.

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