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Optimization of Green Sand Casting Process parameters by Taguchi Method & Artificial Neural Network

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***ABSTRACT**: In this paper the taguchi method and Artificial neural network techniques are combined to analyze sand and mould related casting defects. An attempt has been made to obtain the optimum values of process parameters using Taguchi's experimental approach. The critical process parameters to be selected are Moisture, Permeability, LOI, Compressive strength, Volatile content, Vent holes, Pouring time, Pouring temperature and mould hardness. Taguchi based L27 orthogonal array is selected for the experiment purpose.ANN use to forecast the casting defects by entering the values of process parameters. The network is trained using **nntool**. The network is trained by entering the values of process parameters and percentages of casting defects by input and output process variables which trains the network and trained network is used to forecast the casting defects by entering the values of process parameters in the trained network.*

***Keywords**: ANN, Casting defect, nn tool, orthogonal array, Taguchi method*

I. Introduction

To optimize a green sand casting process, the trial and error method is used to identify the best parameters to manufacture a quality product. However, this method demands extensive experimental work and results in a great waste of time and money. Thus, design of experiments appears to be an important tool for continuous and rapid improvements in quality

The Taguchi Method is an experimental technique that helps to investigate the best combinations of process parameters, changing quantities, levels and combinations in order to obtain results statically reliable. It is a systematic route that may be followed so as to find solutions to industrial process problems with greater objectivity by means of experimental and statistical techniques. The green sand casting process is controlled by several parameters.

In order to optimize the process control factors like moisture, green compressive strength, mold hardness, permeability, pouring time, pouring temperature and pressure are identified. Each factor is considered at three levels. To capture the effect of noise factors casting defects were measured.

II. Literature Review

Dr. R.L.Naro in his investigation has studied the effect of phenolic urethane no bake resin system that consists of two resin components. Part-I consists phenolic resin and Part-II consists polymeric di-isocytane resin. He studied the effect of these binders in mold metal interface to the porosity defect due to core decomposition gases. Dr. R.L.Naro concluded with his experiment that the effect on binder ratio from part I to part II is **35:65** ratio which had normally resulted moderate to severe porosity defects in earlier binder ratio and level experiments.

B. Chokkalingam, S.S. Mohammad Nazirudeen, has been worked on defect analysis from different process like pattern making, molding, core making and melting etc, with the use of techniques of root card analysis, the root cause for this major defect was identified through defect diagnostic study approach. Finally, by taking necessary remedial actions the total rejection rate was reduced to 4% from 28%. Conclusion of the work is the root card analysis and systematically approach of the work is effectively possible to eliminate and control the casting defect

Data Collection from Foundry

The following datas are collected from krislur castomach-G.I.D.C.Bhavnagar:

Table-I Data collection from krislur castomach

Name of defect	Quantity
Blowholes	**79**
Sand inclusion	**26**
Porosity	**33**
Shrink	**0**
Hard	**2**
Short poured	**0**
Slag inclusion	**0**
Breakage	**0**
Run out	**13**
Leakage	**3**
Machine rejection	**12**
Total Rejection	**168**
% Rejection	**29.6**

Table-II Process parameters with their factors and levels

PROCESS PARAMETER	RANGE	LEVEL 1	LEVEL 2	LEVEL 3
Moisture(A)	3-4	3	3.5	4
Permeability(B)	90-150	90	120	150
Loss on ignition(C)	4-6	4	5	6
Compressive strength(D)	1300-1500	1300	1400	1500
Volatile content(E)	2-3.5	2	3	3.5
Vent holes(F)	6-8	6	7	8
Pouring time(G)	30-60 Sec	30	45	60
Pouring temperature(H)	1325-1375	1325	1350	1375
Mold hardness(I)	80-95	80	90	95

Table-III Design of Experiment with L27 Orthogonal array

NO.	A	B	C	D	E	F	G	H	I	% DEFECT
1	3	90	4	1300	2	6	30	1325	80	20.1
2	3	90	5	1400	3	7	45	1350	90	19.4
3	3	90	6	1500	3.5	8	60	1375	95	19.7
4	3	120	4	1400	3	7	60	1375	95	18
5	3	120	5	1500	3.5	8	30	1325	80	18.2
6	3	120	6	1300	2	6	45	1350	90	16.8
7	3	150	4	1500	3.5	8	45	1350	90	19.3
8	3	150	5	1300	2	6	60	1375	95	20.3
9	3	150	6	1400	3	7	30	1325	80	20
10	3.5	90	4	1300	3	8	30	1350	95	18.2
11	3.5	90	5	1400	3.5	6	45	1375	80	17.3
12	3.5	90	6	1500	2	7	60	1325	90	16.5
13	3.5	120	4	1400	3.5	6	60	1325	90	15.6
14	3.5	120	5	1500	2	7	30	1350	95	18.8
15	3.5	120	6	1300	3	8	45	1375	80	19.2
16	3.5	150	4	1500	2	7	45	1375	80	19
17	3.5	150	5	1300	3	8	60	1325	80	19.5
18	3.5	150	6	1400	3.5	6	30	1350	90	20.3
19	4	90	4	1300	3.5	7	45	1375	90	20.4
20	4	90	5	1400	2	8	60	1325	95	17.5
21	4	90	6	1500	3	6	60	1350	80	18.8
22	4	120	4	1400	2	7	60	1350	80	19.1
23	4	120	5	1500	3	8	30	1375	90	20.1
24	4	120	6	1300	3.5	6	45	1325	95	16.7
25	4	150	4	1300	3	6	45	1325	95	17.3
26	4	150	5	1400	3.5	7	60	1350	80	18.9
27	4	150	6	1500	2	8	30	1375	90	19.1

Table-IV Observed Casting defects with S/N Ratio

Trial	Defects in Trial 1	Defects in Trial 2	Defects in Trial 3	Average Percentage of defects	S/N Ratio
1	20.2	20.1	20	20.1	-26.06
2	19.6	19.2	19.4	19.4	-25.75
3	19.7	19.6	19.8	19.7	-25.88
4	17.50	18.65	17.90	18	-25.11
5	18.15	18.22	18.23	18.2	-25.20
6	16	17.2	17.2	16.8	-24.51
7	19.7	19.1	19.3	19.3	-25.75
8	20.5	20.4	20	20.3	-26.15
9	21	20.5	18.5	20	-26.03
10	18.3	18	18.3	18.2	-25.20
11	17	17.2	17.7	17.3	-24.76
12	16.2	16.1	17.2	16.5	-24.35
13	15.8	15.3	15.7	15.6	-23.86
14	18	19	19.4	18.8	-25.48
15	19.3	19.1	19.2	19.2	-25.66
16	18.8	19.7	18.5	19	-25.57
17	19	19.2	20.3	19.5	-25.80
18	21	21.2	18.7	20.3	-26.16
19	22	20.2	19	20.4	-26.20
20	17.7	19	15.8	17.5	-24.88
21	19	17.6	19.8	18.8	-25.49
22	16	19.9	21.4	19.1	-25.68
23	20.3	20.5	19.5	20.1	-26.6
24	17	17.2	15.9	16.7	-24.45
25	18	19	14.9	17.3	-24.80
26	20.2	21	15.5	18.9	-25.60
27	19.2	16.8	21.3	19.1	-25.66

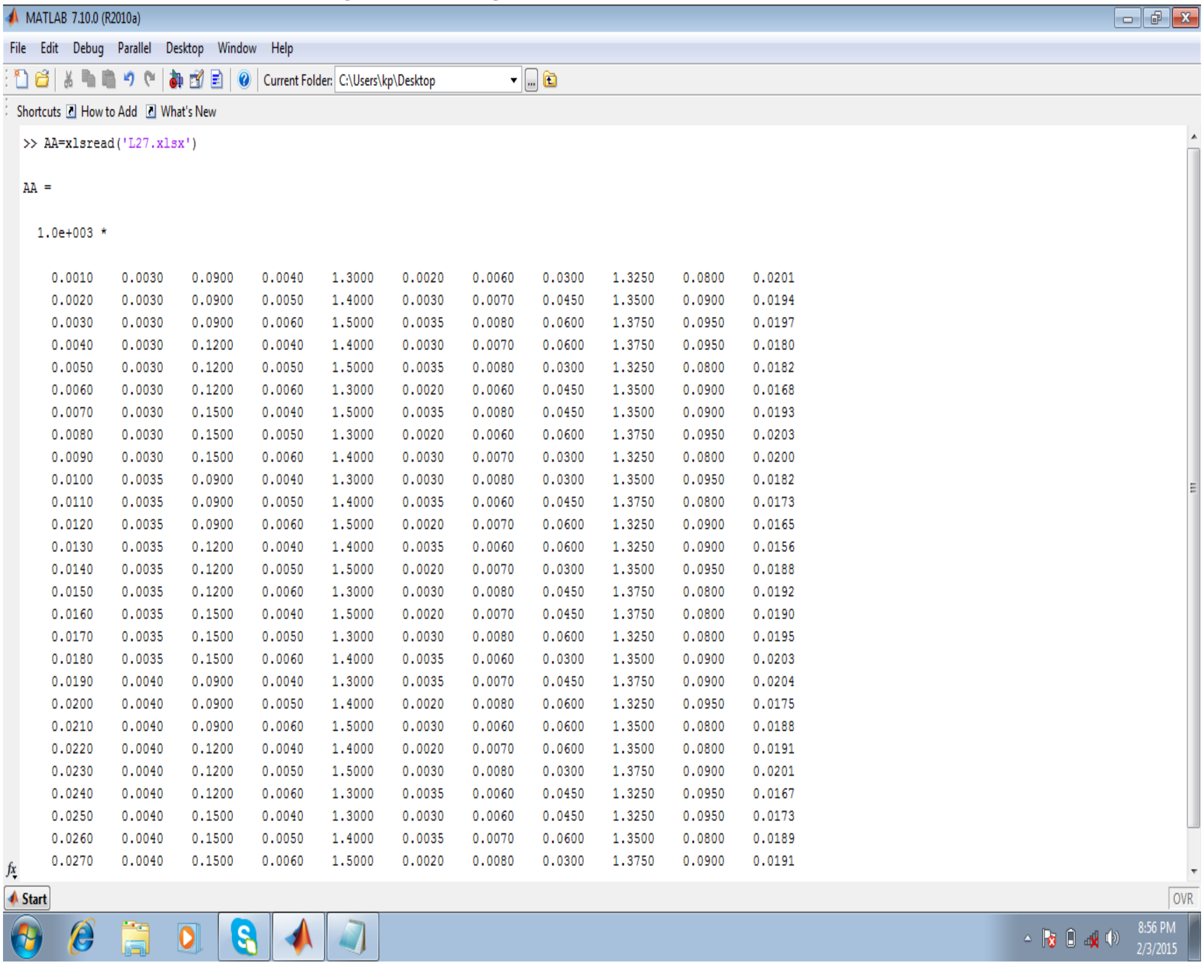
S/N ratio is maximum for trial 13 so, optimum parameters are:

- Moisture 3.5
- Permeability 120
- LOI 4
- C.S. 1400
- Volatile content 3.5
- Vent holes 6
- Pouring time 60 sec
- Pouring tem 1325
- Mould hardness 90

III. Discussion on Neural Network

In present work, neural network model is developed using matlab software. L27 orthogonal array is entered as input and prediction of casting defects is output of the system. Here **nn tool** is used to train the network. **AA** is the function for including excel file of parameters in matlab neural network tool box. **BB** is the function for representing the input parameters. **CC** is the function for representing the output parameters. **DD** is the inverse matrix of input parameters. **EE** is the inverse matrix of output parameters. **DD** and **EE** are the input and target data respectively

Fig.-I Collecting data into matlab from excel sheet



0.0010	0.0030	0.0900	0.0040	1.3000	0.0020	0.0060	0.0300	1.3250	0.0800	0.0201
0.0020	0.0030	0.0900	0.0050	1.4000	0.0030	0.0070	0.0450	1.3500	0.0900	0.0194
0.0030	0.0030	0.0900	0.0060	1.5000	0.0035	0.0080	0.0600	1.3750	0.0950	0.0197
0.0040	0.0030	0.1200	0.0040	1.4000	0.0030	0.0070	0.0600	1.3750	0.0950	0.0180
0.0050	0.0030	0.1200	0.0050	1.5000	0.0035	0.0080	0.0300	1.3250	0.0800	0.0182
0.0060	0.0030	0.1200	0.0060	1.3000	0.0020	0.0060	0.0450	1.3500	0.0900	0.0168
0.0070	0.0030	0.1500	0.0040	1.5000	0.0035	0.0080	0.0450	1.3500	0.0900	0.0193
0.0080	0.0030	0.1500	0.0050	1.3000	0.0020	0.0060	0.0600	1.3750	0.0950	0.0203
0.0090	0.0030	0.1500	0.0060	1.4000	0.0030	0.0070	0.0300	1.3250	0.0800	0.0200
0.0100	0.0035	0.0900	0.0040	1.3000	0.0030	0.0080	0.0300	1.3500	0.0950	0.0182
0.0110	0.0035	0.0900	0.0050	1.4000	0.0035	0.0060	0.0450	1.3750	0.0800	0.0173
0.0120	0.0035	0.0900	0.0060	1.5000	0.0020	0.0070	0.0600	1.3250	0.0900	0.0165
0.0130	0.0035	0.1200	0.0040	1.4000	0.0035	0.0060	0.0600	1.3250	0.0900	0.0156
0.0140	0.0035	0.1200	0.0050	1.5000	0.0020	0.0070	0.0300	1.3500	0.0950	0.0188
0.0150	0.0035	0.1200	0.0060	1.3000	0.0030	0.0080	0.0450	1.3750	0.0800	0.0192
0.0160	0.0035	0.1500	0.0040	1.5000	0.0020	0.0070	0.0450	1.3750	0.0800	0.0190
0.0170	0.0035	0.1500	0.0050	1.3000	0.0030	0.0080	0.0600	1.3250	0.0800	0.0195
0.0180	0.0035	0.1500	0.0060	1.4000	0.0035	0.0060	0.0300	1.3500	0.0900	0.0203
0.0190	0.0040	0.0900	0.0040	1.3000	0.0035	0.0070	0.0450	1.3750	0.0900	0.0204
0.0200	0.0040	0.0900	0.0050	1.4000	0.0020	0.0080	0.0600	1.3250	0.0950	0.0175
0.0210	0.0040	0.0900	0.0060	1.5000	0.0030	0.0060	0.0600	1.3500	0.0800	0.0188
0.0220	0.0040	0.1200	0.0040	1.4000	0.0020	0.0070	0.0600	1.3500	0.0800	0.0191
0.0230	0.0040	0.1200	0.0050	1.5000	0.0030	0.0080	0.0300	1.3750	0.0900	0.0201
0.0240	0.0040	0.1200	0.0060	1.3000	0.0035	0.0060	0.0450	1.3250	0.0950	0.0167
0.0250	0.0040	0.1500	0.0040	1.3000	0.0030	0.0060	0.0450	1.3250	0.0950	0.0173
0.0260	0.0040	0.1500	0.0050	1.4000	0.0035	0.0070	0.0600	1.3500	0.0800	0.0189
0.0270	0.0040	0.1500	0.0060	1.5000	0.0020	0.0080	0.0300	1.3750	0.0900	0.0191

Fig.-II Neural network model with two hidden layers

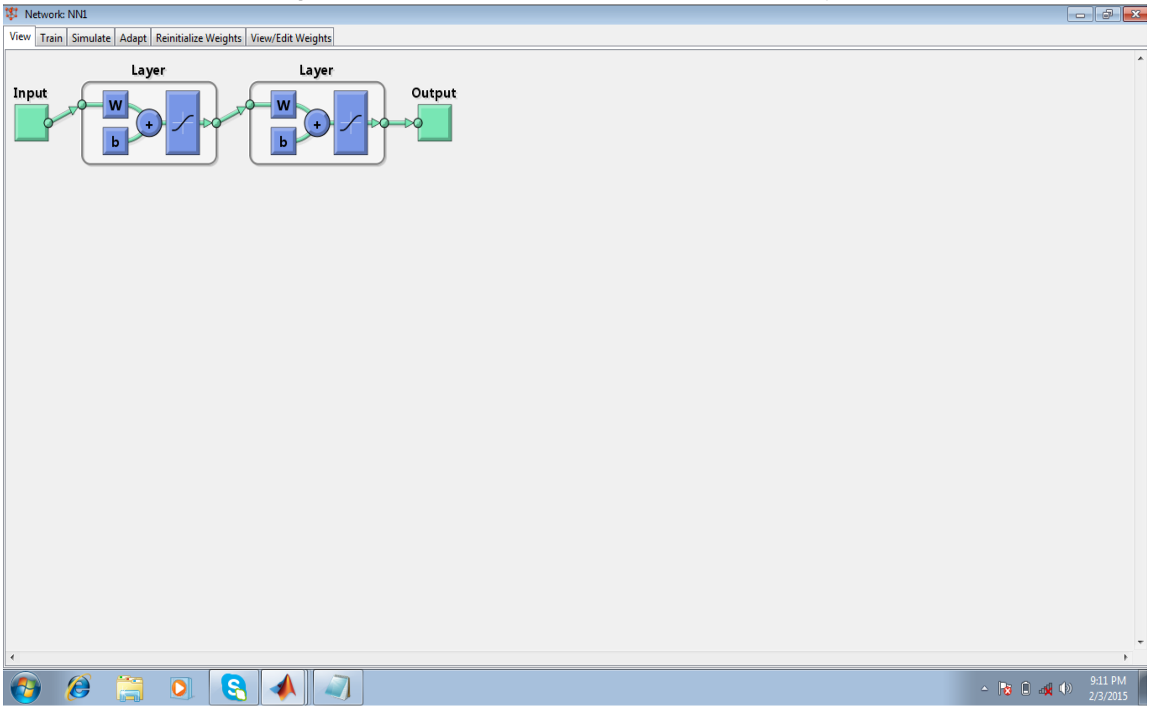


Fig.III Training of Neural network

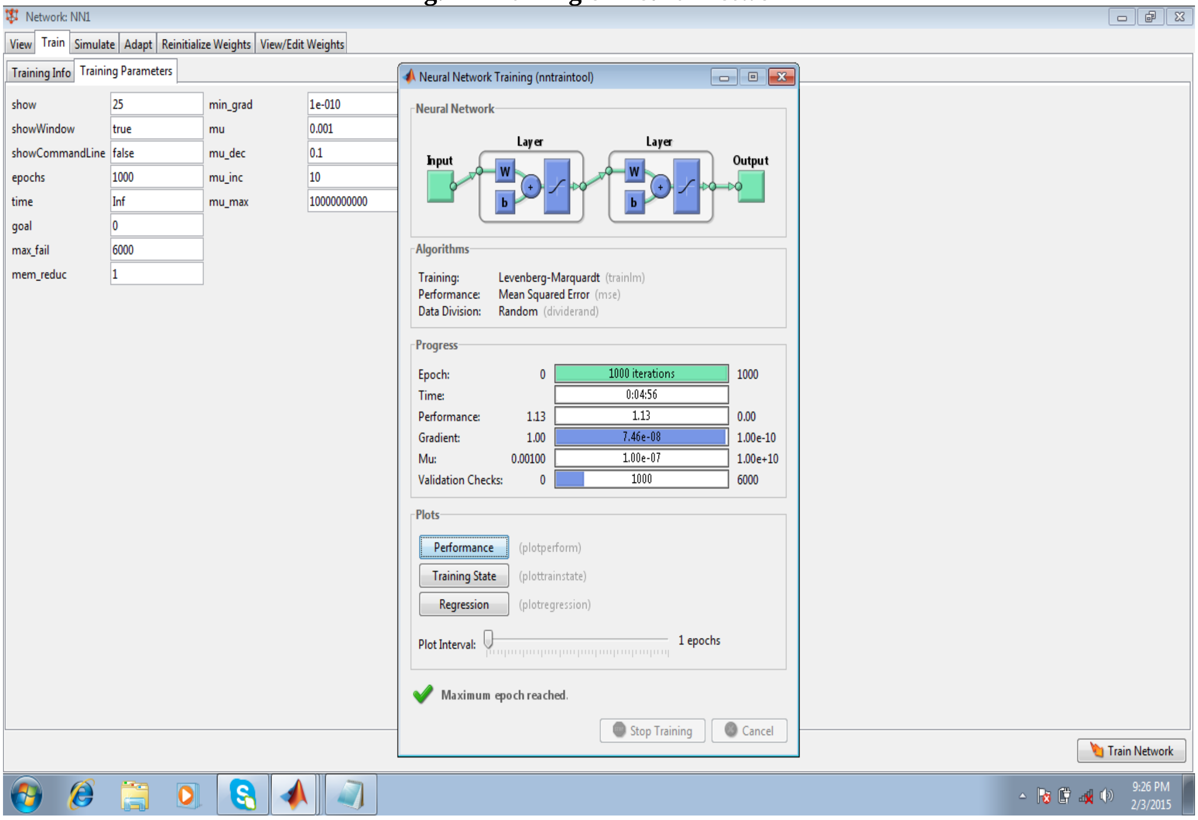


Fig. IV Regression Analysis

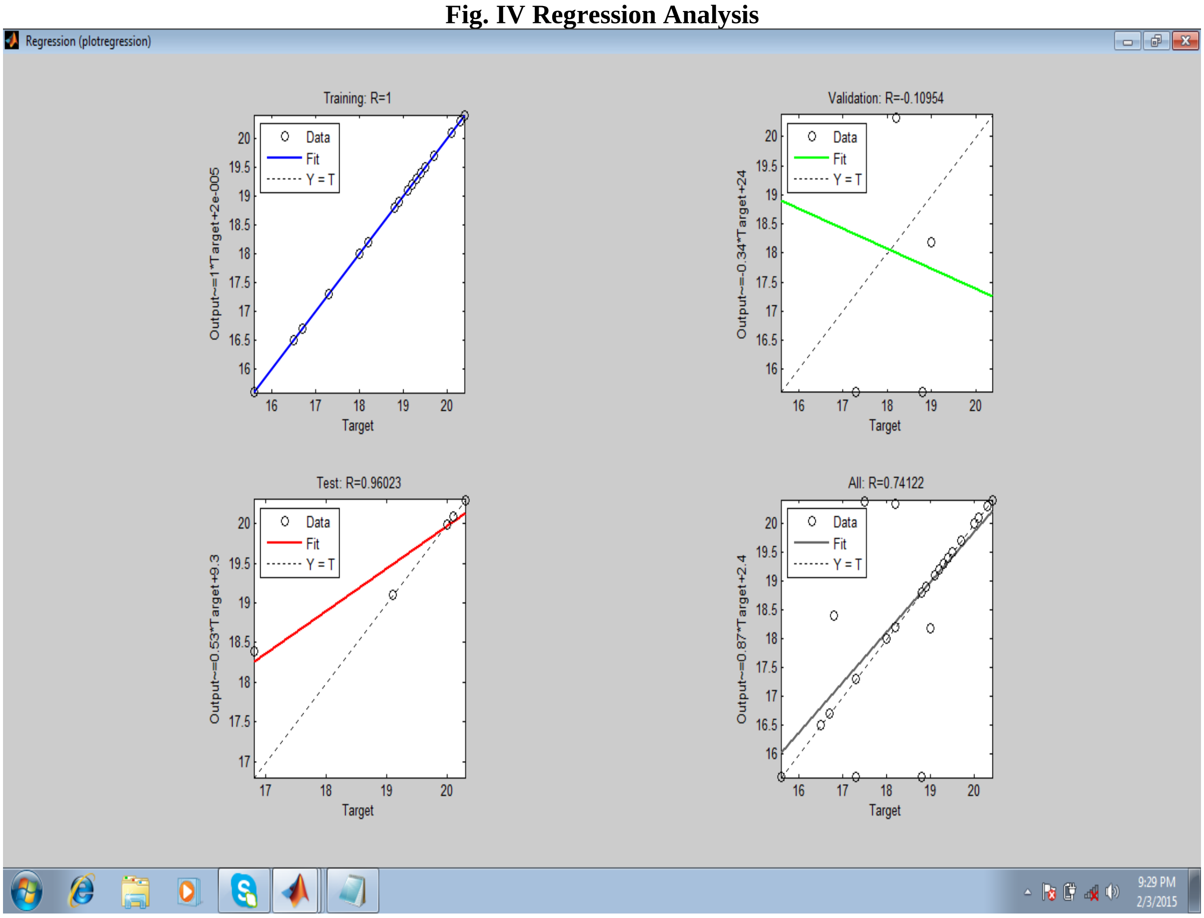


Table V Comparison of Trained Neural network and Actual Casting Defect Data

Trial	Actual Defects	Predicted defects	Errors
1	20.1	20.0996	0.0004
2	19.4	19.4041	-0.0041
3	19.7	19.7055	-0.0055
4	18	18.2	-0.2
5	18.2	20.2985	-2.09
6	16.8	19.98	-3.18
7	19.3	18.246	1.054
8	20.3	17.313	2.987
9	20	20.1	-0.1
10	18.2	18.1	0.1
11	17.3	17	0.3
12	16.5	16.6	-0.1
13	15.6	15.55	0.05
14	18.8	18.5	0.3
15	19.2	19	0.2
16	19	19	0
17	19.5	19.30	0.20
18	20.3	20.1	0.20
19	20.4	20.35	0.05
20	17.5	17.8	-0.3
21	18.8	19.2	-0.4
22	19.1	19.2	-0.1
23	20.1	20	0.1
24	16.7	16.55	0.15
25	17.3	17.2	0.1
26	18.9	18.89	0.01
27	19.1	19.3	-0.2

IV. CONCLUSION

From this work the optimum process parameters using Taguchi methods are:

- Moisture 3.5
- Permeability 120
- LOI 4
- C.S. 1400
- Volatile content 3.5
- Vent holes 6
- Pouring time 60 sec
- Pouring tem 1325
- Mould hardness 90

Also, we can train the neural network which can forecast the casting defects .

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