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Analysis of Cold Metal Defect in Casting by Using Six-sigma Method

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Abstract— A defect in castings does not just happen. Casting defects are unusually not by accidents, they occurbecause some step in manufacturing cycle does not get properly controlled and somewhere something goes wrong. They are caused by wrong practice in one or more of the basic operations involved in the casting process as in the equipment used, or by the design of the part. A defect may be the result of a single clearly defined cause or a combination of factors, in which case necessary preventive measures are more obscure. If not controlled the amount of rejection it may be increased randomly. In this paper our work is to identify the major occurrence defects from a leading foundry industry in Tamilnadu, which we have visited for 36 days and monitor the production of castings and identify some defects for different 12 products, the total production quantity of that 12 products are 17,365 and total amount of rejection is 1407, with the help of Six-Sigma (DMAIC) method we have identified that Cold Metal defect which is the major defect from that 12 productswhich affects the quality, more when compared to other defects, so we have taken the cold metal defect and identified the root causes and suggested some remedies to control the occurrences of the cold metal defect, so that the defective products where reduced when compared to the previous rejection percentage.

***Index Terms*— six sigma , Grey cast iron, Cold metal, Casting defect.**

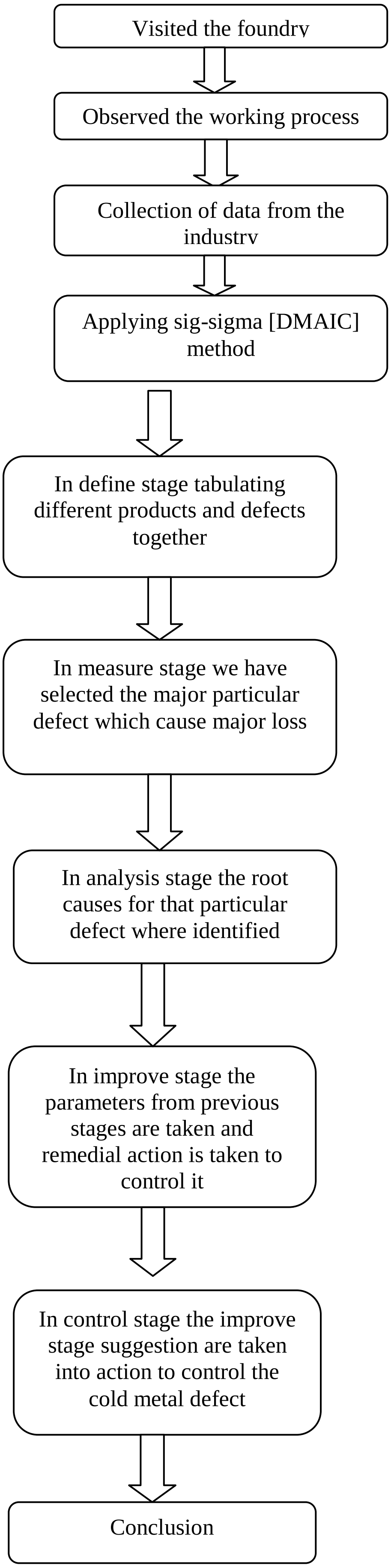
I. INTRODUCTION

Foundry, it means where metal is melted and poured in the factory to produce a number of components and products according to the requirement what we specified. The major process is that metals which are cut into shape by the process of melting them into a liquid, once the melting had finished it get poured into the shaped mold, then the process of solidification occurs that which solidifies the liquid metal. Then by removing the mold materials, the required metal shape has been obtained. The overall process of foundry is to make the quality products and components. But these process sometimes get collapsed due to some error that which can be named as casting defects. These defects may

be of various kinds. It occurs in each and every process of foundry when something went wrong. It may be of human error, machine effect or any other defect from sand mixture etc. These also many approaches and industry tools are used to rectify the problem and to solve the problem. From that various techniques, we are using the approach of six sigma [DMAIC] to give the solution. In this paper, we are going to identify and solve the casting defects by using the approach of six sigma and machine tools by the following five process[Define, Measure, Analysis, Improve and Control].

II. METHODOLOGY

In Methodology we have identifieddifferent kinds of defects for 12 products in that industry we visited. Then we have taken major percentage of defect and we give suggestions to solve the defect.In this method of casting defect analysis, our work is to identify the defect of major occurrence such as sand drop, shrinkage, cold metal, mold lift, short pouring etc. then to increase the productivity by improving the quality of metal. The method of six sigma that which is applied to give the solution. The process and steps of six sigma is followed below to make the accurate results. The flow chart of six sigma process is mentioned below.



2.1 Define Stage:

In this define stage we have defined the problem. We have visited to the casting industry in the month of Dec, Jan and Feb totally 36 days one shift per day. We get the data's of castings on that 36 days, Totally we gathered data of 12 products and their quantity is 17,365 castings for that 36 shifts. From these castings the total numbers of rejections are 1407. The products and rejections are tabulated below.

Table 1: Product Production List

Day	Product	Produced qty	Rejec-tion	Sand drop	Shrink-age	Cold metal	Short pouri-ng	Mould lift
1	S65 flange	450	34	06	04	10	5	10
2	S65 flange	475	37	04	10	15	06	04
3	S65 flange	365	33	07	08	06	05	06
4	RTS 2520 F/ COVER	540	43	5	06	10	4	10
5	RTS 2520 F/ COVER	445	31	03	08	09	06	05
6	RTS 2520 F/ COVER	625	49	08	10	18	07	06
7	GOC 90F/COVER	540	44	03	07	17	08	09
8	GOC 90F/COVER	650	54	07	12	14	08	13
9	GOC 90F/COVER	530	47	07	10	15	09	06
10	GOC 90B/COVER	540	45	02	08	12	14	09
11	GOC 90B/COVER	475	32	03	07	11	07	05
12	GOC 90B/COVER	430	37	04	09	11	10	03
13	TGB 015 COLLAR	540	34	05	09	10	01	9
14	TGB 015 COLLAR	400	35	05	08	10	6	6
15	TGB 015 COLLAR	350	29	5	6	09	3	6
16	2'' SEAL B/F FLANGE	500	45	04	07	14	08	12
17	2'' SEAL B/F FLANGE	620	51	7	07	16	11	10
18	2'' SEAL B/F FLANGE	570	44	08	07	12	10	06
19	2020 YOKE	600	52	06	12	14	15	8
20	2020 YOKE	590	48	08	12	18	06	04
21	2020 YOKE	580	43	04	10	12	9	8
22	WHEEL HUB GK	350	23	03	05	07	04	06
23	WHEEL HUB GK	420	35	08	7	09	3	9
24	WHEEL HUB GK	470	42	10	9	11	6	6
25	13221 BODY	560	36	07	07	10	05	05
26	13221 BODY	520	47	08	08	16	08	07
27	13221 BODY	480	38	08	08	09	07	06
28	9374 PISTON	520	40	08	05	10	10	07

29	9374 PISTON	490	43	08	07	13	08	07
30	9374 PISTON	410	30	05	06	09	07	03
31	EREB base	460	38	05	08	10	07	08
32	EREB base	510	44	08	09	12	07	08
33	EREB base	430	39	05	06	12	11	05
34	0234 ADAPTOR	320	25	04	05	06	05	05
35	0234 ADAPTOR	340	27	03	06	09	04	05
36	0234 ADAPTOR	370	33	07	06	09	03	08

The total percentage of rejection quantity is 8.10% which is high and due to this major loss occurs. So, we identified the different casting defects from that 17,365 and identified the cause of the defect from a particular defect.

2.2 Measure Stage:

In this stage, the 17,365 products are tabulated and the maximum defects from this is identified using histogram chart and then a maximum rejection rate product is choose from this and that particular product and defect is identified this stage. The tabulation is given below.

Table 2: Percentage of cold metal defect from total produced quantity

Day	Product	Produ-ced qty	Inspected qty	Reject -ion	Cold metal	Percentage Due to Cold metal defect from total produced quantity
1,2,3	S65 flange	1290	1290	104	31	2.403%
4,5,6	RTS 250 F/ COVER	1610	1610	123	37	2.298%
7,8,9	GOC 90 F/COVE R	1720	1720	145	46	2.674%
10,11,12	GOC 90 B/COVE R	1445	1445	114	34	2.352%
13,14,15	TGB 015 COLLAR	1290	1290	98	29	2.248%
16,17,18	2'' SEAL B/F FLANGE	1690	1690	140	42	2.485%
19,20,21	2020 YOKE	1670	1670	143	44	2.634%
22,23,24	WHEEL HUB GK	1240	1240	100	27	2.177%
25,26,27	13221 BODY	1560	1560	121	35	2.243%
28,29,30	9374 PISTON	1420	1420	113	32	2.253%
31,32,33	EREB base	1400	1400	121	34	2.428%
34,35,36	0234 ADAPTO R	1030	1030	85	24	2.330%

2.3 Analysis Stage:

This step that which mostly concentrate on where the provide cause. The attention to this step helps in making the accurate solution. The above mentioned five defects are analyzed in the industry like where it may happen whether human error, machine error, working time, sand hardness and some other new problems. The below fish-bone diagram represents the whole analysis.

Table 3: Products with major defects

Day	Product	Produ-ced qty	Inspect-ed qty	Rejecti-on	Cold metal	Percen-tage
7,8,9	GOC 90 F/COVE R	1720	1720	145	46	2.674%
19,20,21	2020 YOKE	1670	1670	143	44	2.634%
16,17,18	2'' SEAL B/F FLANGE	1690	1690	140	42	2.485%
4,5,6	RTS 250 F/ COVER	1610	1610	123	37	2.298%
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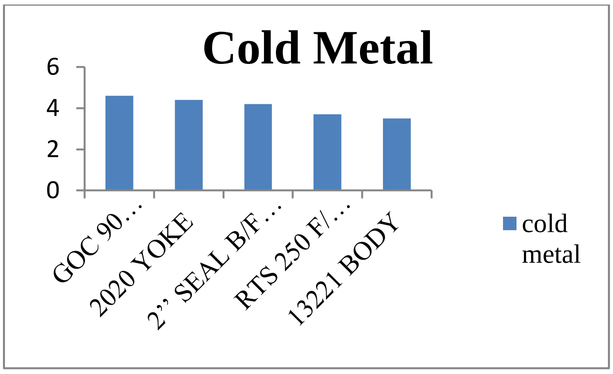

Fig.1 Histogram for cold metal defect

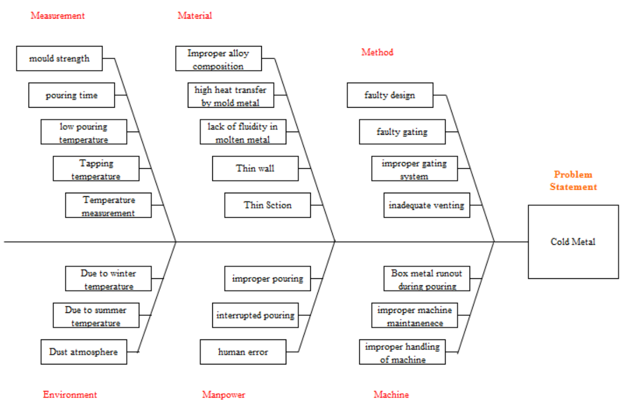

Fig.2 Fishbone diagram for cold metal

From the above tabulation we have taken the highest percentage of rejection product and its defect and we have made a cause and effect flow chart diagram from that we have considered the following parameters which affects the quality and occurance of the Cold Metal defect,

- Lack of fluidity in molten metal
- Pouring Time
- Tapping Temperature
- Human Error

2.4 Improve Stage:

In this stage the parameters which where considered in the analysis stage are taken and the problem due to that where identified and remedial action for that was concluded for each parameters.

Lack of fluidity in molten metal:

Insufficient amount of liquid metal in the laddle that which leads to incomplete filing of mold cavity. refilling of liquid metal in the remaining space in the same mold cavity that which makes the different temperature combination of liquid metal leads to the defect, every one of seven product gets defected if the same process continues.

Remedies:

- Sand should be properly rammed
- Molding sand/core sand should not be too coarse to promote metal penetration.
- Control proper metal temperature.

Pouring time:

Pouring is a process by which molten metal is transferred to the cast for cooling and solidification and thus be converted into final product. Pouring temperature is the temperature to which the molten metal has to be raised to before being poured into casts for cooling and setting. This pouring temperature must also take into account the heat loss and caused due to the transfer of metal through ladles, as a distance between furnace and cast has to be covered and also due to the heat absorbed by ladles.

Remedies:

- Fluidity of metal should be high
- Pouring rate and time should be controlled.
- Thin section should be suitable designed.

Tapping temperature:

Delay of tapping time from heating furnace to ladle leads to the major defect of tapping temperature.

The temperature that varies from heating furnace to pouring ladle.

Remedies:

- Delay of time should be controlled.
- Tapping of liquid metal from furnace to ladle should be at require temperature.

Human error :

That action performed by a human that results is something different than expected.” This one refers directly to the individual itself. Human error is responsible for more than 80 percent of failures and defects.

Remedies:

- Human laziness should be controlled
- Ladle position while pouring should be properly maintained.

2.5 Control Stage:

In this stage the solution acquired from the Improve stage is applied in the production of the same product to see wether the cold metal defect is controlled are not. We have implemented the four parameter solutions and got the results.

Table 4 : Product of very high defect

Day	Product	Produ-ced qty	Inspect-ed qty	Rejection	Cold metal	Percen-tage
1	GOC 90 F/COVER	380	380	32	5	**1.315%**

Hence we have reduced the percentage of cold metal when compared to the previous amount of rejections rate, so the amount of rejection of cold metal defect is reduce by Six-sigma method.

III. CONCLUSION

We have reduced the amount of rejection of cold metal defect in GOC 90 F/COVER, the previous rejection percentage is 2.674% but now the amount of rejection is reduce by 1.315% which is reduced half the value from its previous percentage by Six-sigma method. Hence we concluded with the help of six-sigma technique we can reduce the percentage of defects. We only focused on the Cold metal defect alone but not on the other defect so there is possibility of occurrences of some other defects also not in a high value.

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