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Casting Blemishes and Supply Chain Relationship in Cast Iron Foundry

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Abstract

In the competitive environment, foundry industries need to perform efficiently with minimum percentage of rejections there by reducing manufacturing cost. Foundries are using state of art processes with the involvement of experienced and knowledgeable people but the experience and knowledge needs to be transformed for the growth of the industries. Some foundries are working in a trial and error mode and get their work done. Many foundries have very less control on the rejections since they are in urgent need of meeting production targets and they ignore the rejections and salvage the castings. They need to have effective quality control aiming for blemishes free castings with minimum production cost. Strategic decision makers need comprehensive models to guide them in efficient decision making that increases the profitability of the entire chain. The objective of the paper is to analyze the various blemishes from Cast Iron Foundry and remedies for the blemishes in a day to day activity of an iron foundry. This paper presents the necessity of Quality in supply chain model of a medium size industrial iron foundry under different delay conditions, rejection rates and various other factors. This paper examines the relationship between supply chain processes and quality as a key role in supply chain management.

Keywords: Supply Chain, Quality, key role, blemishes

1 Introduction

Supply chain management (SCM) plays a vital role in the growth of the industry, survival in the market, the production rate and the dynamic interaction among the suppliers and the customers. SCM has been met with increased recognition during the last decade both by academicians as well as practitioners. SCM of a medium size cast iron foundry is taken and its system dynamics & simulation model is studied. System Dynamics (SD) is a methodology whereby complex, dynamic and nonlinear interactions in the systems can be analyzed and new structures and policies can be designed to improve the system behavior. SD modeling requires two types of flows, one is the physical flows, and another is the information flow. In today’s highly competitive marketplace a successful winner is one who has the ability to satisfy the end customer requirement. Foundry which was studied for this purpose is Ammarun Foundries (AF). Established in the year 1991,AF is a large Ferrous Foundry setup located in Southern part of India. Committed to high technology from the very start, AF producesGrey Iron -from low tensile to high tensile strength grades, DuctileIron - Pearliticthe Ductile Iron to various ranges of Ferrite Ductile Irons. Company also specializes in the production range of Automotive items like Brake Drums, Brake Discs, Hubs, Flywheels, Timing case, Oil sump and Gear Box Housings, Housings, castings for tractor application, Valve body assembly castings, Motor and pump castings, Compressor part castings, Castings for General Engineering Industries, Castings for textile machinery application. Company has secured various State and Central Government awards including ”BEST FOUNDRY AWARD” for the year 2003.AF is committed to green environment through deployment of cleaner technology, preservation of natural resources and committed to Corporate Social Responsibility. AF has developed alternate sources for power through wind mill project for self generation of electricity by installing two machines of 850KW capacity (Gamesa Make of Spain). AF has ongoing projects concerning preservation of rare materials used in the foundry. AF has successfully developed in-house,sand reclamation process wherein silica sand is recovered from used CO2 bonded mould sands. The company has put up a working model ofthe same in house.The Foundry is certified to Environment Management System ISO 14001:2004 standards by Det Norske Veritas AS, Netherlands.

2 Related Works

Related work are summarized in Table 1.

Table 1 - Related Work

S. No	Author & Year	Techniques used	Result
1	Forrester (1961)	Developed supply chain for afactory.	Examined deviation between actual and targeted inventories
2	M.M.Naim(1996)	Developed Real World dynamic analysis for SCM	process of planning, implementing and controlling operations of the supply chain
3	David Simchi-Levi(2008)	Developed two stage supply chain	Retailer/manufactur er and supplier supply chain
4	Yossi Aviv-(2007)	studied interaction between inventory and forecasting ina two stage supply chain	faces stochastic demand
5	Tae CheolKwa k(2006)	supplier - buyer model for bargaining process	supplier -leading model buyer - driven model
6	Terry (2007)	supply chain relation and contract	Impact of repeated interactionon capacity investment and procurement
7	Chi-Leung(200 9) S.D.Sharm a(2008)	scalable methodology supply chain inventory	Total cost of the system is minimum with EOQ and EPQ
8	Fangruo Chen(2001)	coordination mechanism for one supplier and multipleretaile rs	holding cost rates depends on whole prices of the items
9	Benita M.Beamon (1998)	supply chain design and analysis	models and methods for multi stage supply chain
10	Shotaro Minegishi(2000)	dynamic modelling and simulation for food supply chain	presented practical simulation results
11	Patroklos(2 005)	modelling and analysis tool	strategic supply chain management

3 Foundry Processes

The output of the foundry is in the range of 1500 tons of good castings per month and out of which 850 Tons from SINTO high pressure molding line, 600 Tons from conventional ARPA molding line and 50 Tons by hand molding. Table 2 shows list of main equipments installed in the foundry and Fig. 1 shows the foundry process in detail.

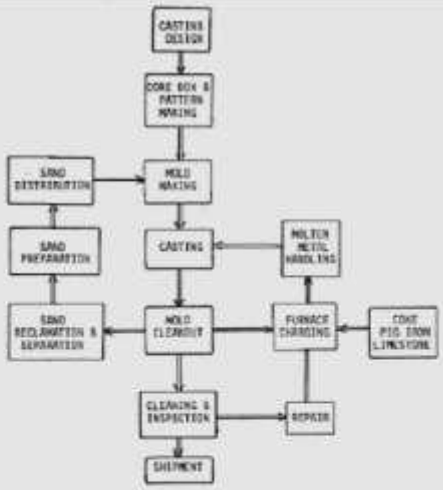


Fig.1 Foundry Processes

Table 2 Foundry Process and equipments

S.No	Foundry Process	Equipment used
1	Pattern making	pattern is supplied by the customer. Only day to day development activity is in process
2	Core Making	Core shooter 3 Nos Core Oven 2 Nos
3	Moulding	High pressure moulding line and ARPA moulding line
4	Sand Plant	Automatic sand plant with fluidised bed cooler
5	Melting	Induction furnace 1.5 T (2 Nos), 2 T (2 Nos)
6	Fettling	Shot blasting Machines and pedestal grinders
7	Painting	Immersed type

Spectro-meter ARL Thermo electron Corporation Switzerland make is equipped to analyze 20 elements with metallographic image analyzer to precisely to estimate the various micro structural constituents. Mechanical testing laboratory equipped to estimate tensile strength, hardness and sand laboratory to monitor foundry sand quality on a continual basis.

4 Process Views of Supply Chain

There are two different ways to view the processes performed in a supply chain:

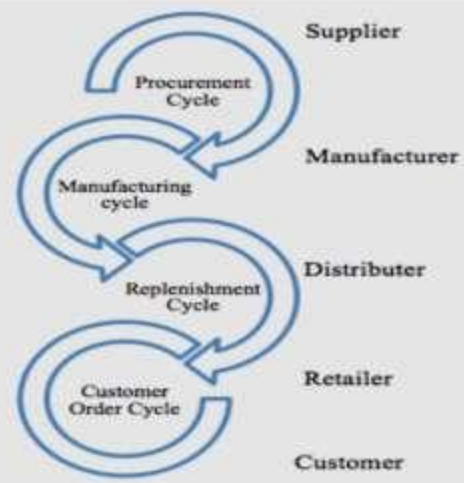


Fig.2 Supply Chain Process Cycles

Fig. 3 Push/Pull View of the Supply Chain

Cycle View: processes are divided into serious of cycles, each performed at the interface between two successive stages of a supply chain as in Fig.2.

Push/Pull View: Pull processes are initiated by a customer order, whereas push processes are initiated and performed in anticipation of customer orders as in Fig.3.

5 Types of Blemishes and Remedies

The molding process causes blemishes in castings which may be eliminated with best molding practices or repaired using method such as welding and other metal working processes. Some of the major blemishes in sand casting production are listed in Table 3.

Table 3 Casting Defects

No	Defect Type	Defect	Possible causes	Remedies
1	Gas Defect	blow holes, open blows, air inclusion, pin hole porosity	gas pass through mold, improper design of gating	evacuation of air and gas from the cavity and increasing the permeability of mold cores
2	Shrinkage cavity	Solidification problem	proper flow of liquid and solid state, poor casting design	proper casting design and feeding of molten metal
3	Moldmaterial defect	cuts, washes, metal penetration, fusion, run out, buckles, swell and drop	molding sand erosion and not having enough strength, higher pouring temperature and faulty molding practices	proper selection of molding sand and molding method, correct pouring temperature and suitable molding practices
4	Pour metal defect	miss run, cold shuts, slug inclusion	molten metal not filling the cavity completely, improper pouring	having sufficient molten metal in the laddle to fill the cavity, proper gating system, proper use of pouring crew and practice
5	metallurgical defect	hot tears, hot spot	poor casting design, damage at shake out.	casting design improvement, proper metallurgical control

6 Methodology

The Seven Basic Tools of Quality is a designation given to set graphical techniques and most helpful for troubleshooting issues related to quality. The tools are suitable for people with little knowledge on statistics and they can be used to solve majority of quality related issues.

They are :

1Check sheet

2Brain Storming

3Fish Bone diagram

4Control chart

5Histogram

6Scatter diagram

7Pareto chart

The data collected from AF for actuator part no.1701 (AF-5092) are used for analysis. The castings are produced in automatic molding machine where the initial settings are important. Check sheet, brain storming, fish bone diagram, control chartand histogramare used for the analysis.

6.1Check Sheet

The rejection data was obtained from the foundry and placed in a tabulated form for the convenience to use and understand. Rejection data sheet are large data sheet showing all the information about the rejected items. A simplified data from the total rejection sheet is represented in the following

total poured quantity and total rejection, molding blemishes, melting blemishes, fettling blemishes and patterns blemishes during the period.

Table4 Rejection data sheet

Period	Poured	Total rejection	Defects			
			Mold	Melt	Fettle	Pattern
04/14 to 10/14	52853	1519	998	308	212	1
11/14 to 12/14	6902	142	105	25	12	0

6.2 Brain Storming

The brain storming session was conducted for finding different causes behind the blemishes and identifying the main causes and responsibility for the maximum damage. It consists of a group of members from different foundry departments which includes pattern shop manager, quality manager, melting supervisor, molding supervisor, fettling supervisor, core shop supervisor and high level management members and also shop floor members. After brain storming session, it was concluded that insufficient number of air vents are major cause for the blemishes bend and decided to increase the number of air vents from two to six considering the shape and size of the casting.

Table 5 helps in analyzing the sand inclusion blemishes with feedback from various departments. Results obtained are placed in tabulated form. Rating is from 0 to 5, higher is the number in rating more is the severity.

strength yes yes No No No 3

Table 5Inter Department Relationship Analysis for sand inclusion defect

S.No	Causes	Lab incharge	Quality Manager	Furnace supervisor	worker at furnace	Mold supervisor	Rating
1	Pouring time too long	yes	yes	No	No	yes	5
2	ladle too far above pouring basin	yes	yes	No	No	yes	4
3	Low Core strength	yes	yes	No	No	No	3
4	improper Molding	yes	yes	yes	Yes	No	2
5	Damaged pattern	No	No	yes	No	No	1

6.3Fish Bone Diagram

The root – cause analysis is carried out for one of the repeated defect of sand inclusion e as per Fig.4.

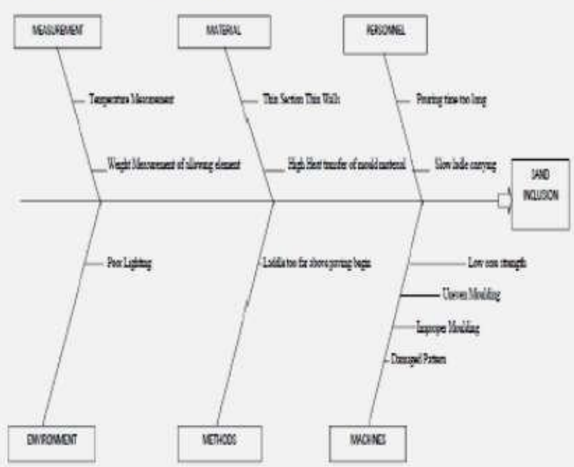


Fig. 4 Root – Cause Analysis for Sand Inclusion

6.3Fish Bone Diagram

The root – cause analysis is carried out for one of the repeated blemishes of sand inclusion e as per Fig.4.

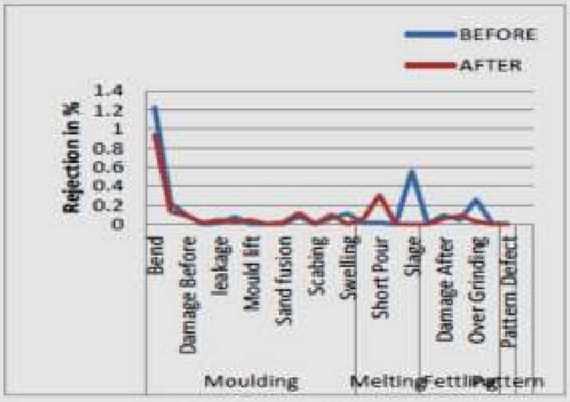


Fig. 5 Control Chart

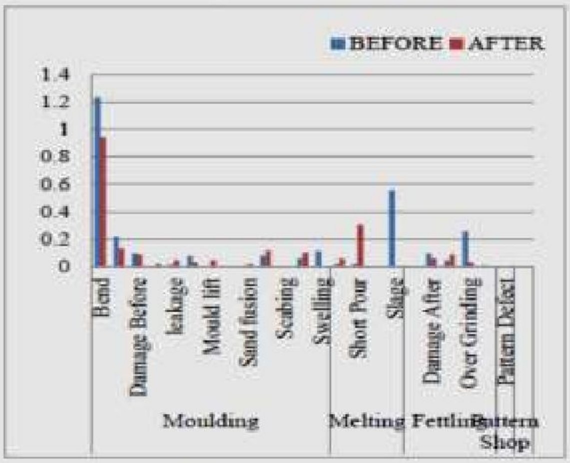


Fig. 6Histogram Chart

Control chart for rejections was plotted by collecting the details of the rejections with two numbers of air vents (before) and with six numbers of air vent (after). Table-6 shows the details of rejections before and after. The castings are produced by using automatic molding machine and the rejection percentage is in the decreasing order as per Table-5. The control charts are plotted as per details of Table-4 and the Fig.3 gives the impact of blemishes and the percentage of rejections in the decreasing order.

6.5 Histogram

The histogram shows the impact of blemishes and the percentage of rejections in the decreasing order as in Fig.6.

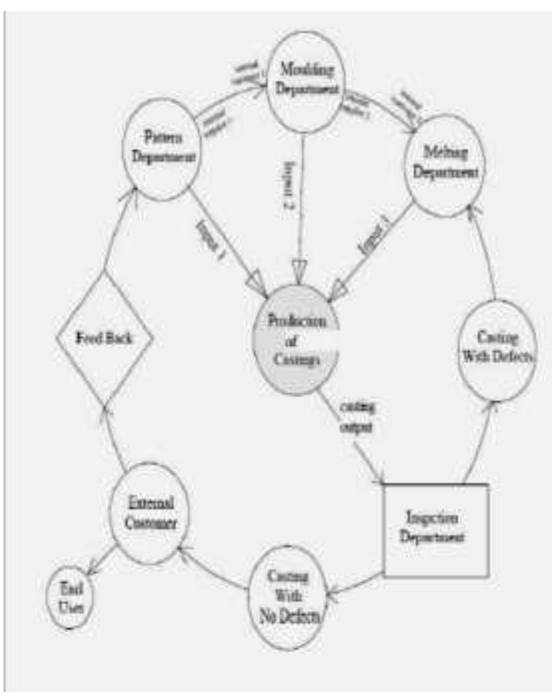
Table6 Rejections (Before & After)

AF No			5092		5092	
Component Name			Actuator		Actuator	
Part No			1701		1701	
Poured Qty			52853		6902	
Accepted Qty			51764		6787	
Rejected Qty			1519		142	
Rejection %			2.874		2.057	
S.No	Dept	Defects	BEFORE		AFTER	
			Qty	rej %	Qty	rej %
1	Molding	Bend	652	1.234	65	0.942
2		Blow	115	0.218	9	0.130
3		Damage	50	0.095	6	0.087
4		Hot tears	0	0	1	0.014
5		Leakage	6	0.011	3	0.043
6		Mold Broken	40	0.076	2	0.029
7		Mold lift	0	0	3	0.043
8		Pin holes	0	0	0	0
9		Sand fusion	2	0.004	1	0.014
10		Sand inclusion	42	0.079	8	0.116
11		Scabbing	1	0.002	0	0
12		Shift	31	0.059	7	0.101
13		Swelling	59	0.112	0	0
		TOTAL	**998**	**1.888**	**105**	**1.521**
14	Melting	Cold metal	7	0.013	4	0.058
15		Short pour	7	0.013	0	0
16		Shrinkage	0	0	0	0
17		Slage	294	0.556	21	0.304
		TOTAL	**308**	**0.583**	**25**	**0.362**
18	Fettling	Crack	1	0.002	0	0
19		Damage	50	0.095	4	0.058
20		Gating damage	22	0.042	6	0.087
21		Over grinding	136	0.257	2	0.029
22		Over short	3	0.006	0	0
		TOTAL	**212**	**0.401**	**12**	**0.174**
23	Patt.	Pattern defect	1	0.002	0	0
		TOTAL	**1**	**0.002**	0	0
GRAND TOTAL			**1519**	**2.874**	**142**	**2.057**

7 Results and Discussion

A study and discussion with all the stakeholders showed that insufficient number of air vents was the major cause for the blemishes. Based on the shape and size of the casting, the number of vents were increased to six and the results show that this has a positive effect. Table5 shows clearly the rejection percentage before and after providing additional air vents. The introduction of this method over some of the major blemishes are: bend blemishes due to molding reduced from 1.234% to 0.942%, blow blemishes reduced from 0.218% to 0.13%, mold broken reduced from 0.079% to 0.029% and there is no blemishes due to pattern. Due to this improvement the supply chain between internal customers and external customers improved as the percentage of overall rejection got reduced from 2.874% to 2.057%.

Fig. 7 Supply Chain Linkages in Foundry Processes



8 Conclusion

This paper considered a simple supply chain model, where the relationships and various parameters were identified. Fig 7 shows the supply chain linkages in jobbing foundry processes. The rejection due to casting blemishes can be reduced with effective supply chain linkages between pattern dept., molding dept., and melting dept., to satisfy the external customer and with feedback from the external customer, the rejections can be further reduced with continuous improvement. This work has allowed exploring and understanding the complex behavior of molding sand, core sand effect to the production of iron castings and its rejections, good customer satisfaction, thereby improving the supply chain efficiency. It is useful to take the decisions by studying the graphs with regard to the products and its quality with respect to blemishes. It is useful to make inventory policies and by taking the yearly demand, one can able to estimate the casting rejections, sand level and core level and also the rate of production.

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