

Chapter 15

Lean Management in a Medium-Scale Foundry to Improve Productivity



Dhruv P. Parmar and Yogesh M. Puri

Abstract In the present, highly competitive market, foundries need to implement lean principles to cope up with demands and to supply superior-quality casting products. Foundries need to produce quality castings with minimum production cost and lead time. Lean manufacturing is generally inspired by the Toyota Production System which has been expended on the subtraction of seven types of waste and refining the client's delight. This chapter addresses the identification of critical product by Pareto analysis of previous year sales data of the medium-scale foundry. The current state Value Stream Map of Critical Product was drawn to understand material flow and information flow. After that, the Kaizen event was conducted with the assistance of the Kaizen team for five days to identify bottleneck activities and the Kaizen report was generated for the possible elimination of it. The Special Purpose Venting Machine was designed and developed to make venting operations faster and more accurate. The drying mold system is recommended to improve mold drying process regarding the elimination of casting defects like blow holes and substantially less time in drying operation. With the help of future state Value Stream Map, the possible improvements are exposed.

Keywords Lean management · Pareto analysis · Value stream mapping · Kaizen · Foundry · Sand mold venting machine

15.1 Introduction

A foundry is a manufacturing facility that produces metal castings. Metal casting is one among the oldest metal shaping approach acknowledged. Sand Casting interprets as the pouring of molten metal into a sand mold and letting it solidify inside the mold [1]. Molds are generally provided with a cavity of the shape to be made. The pattern is used to build a mold cavity. Geometry and dimension of the pattern are the same as the final part to be cast with some allowances like shrinkage allowance, draft allowance,

D. P. Parmar (✉) · Y. M. Puri
Visvesvaraya National Institute of Technology, Nagpur 440010, India
e-mail: dhruvparmar09@hotmail.com

© Springer Nature Singapore Pte Ltd. 2021
A. Sachdeva et al. (eds.), *Operations Management and Systems Engineering*,
Lecture Notes on Multidisciplinary Industrial Engineering,
https://doi.org/10.1007/978-981-15-6017-0_15

machining allowance [1]. Relying on production volume, different pattern materials especially wooden, aluminum, ferrous metal are utilized in practice. Sand casting contributes approximately 60% of total metal casting worldwide. Lean is outlined as a technique for achieving vital continuous improvement in performance through the elimination of all wastes of resources. Lean manufacturing is a methodology that specializes in minimizing seven types of waste inside the production system at the same time as concurrently maximizing productivity. The seven types of waste are Overproduction, Inventory, Waiting, Motion, Transportation, Rework and Over processing [2]. Lean manufacturing is based on some the unique concepts, together with Kaizen. Kaizen is a Japanese word that means continuous improvement, the word ‘Kai’ means continuous and ‘Zen’ means improvement. Kaizen thinking may be pragmatic to any workplace situation due to its simple nature [3].

The Indian foundry industry manufacturers metal cast components for applications in Auto, Tractor, Railways, Machine tools, Sanitary, Pipe Fittings, Defense, Aerospace, Earth Moving, Textile, Cement, Electrical, Power Machinery, Pumps/Valves, Wind turbine generators, etc. Foundry Industry has a turnover of approx. USD 19 billion with export approx. USD 2.7 billion in FY 2018–2019. There are approx. 5000 units out of which 90% can be classified as MSMEs (source: Foundry Informatics Centre). Hence foundry is the backbone of other industries. The growth of other industries depends on the foundry. The foundries are the mother of other industries and the development of industrialization and industrial success will be measured by the progress of this foundry industry of a nation. India has emanated as the third-largest casting manufacturer in the world followed by China and the United State of America, respectively. India has installed capacity of 15 million tonnes per year but actual annual casting production bent on between 6 and 9.5 million tonnes which mean 9,000,000 tonnes (60%) to 550,000 tonnes (37%) per year lagging behind of total capacity (refer Figs. 15.1 and 15.2) [1]. This statistics illustration itself that improper utilization of available recourses in India. Thousands of MSME foundry units have tackled the threat of a shutdown. When the government of India is concentrating on employment generation with persuasive attention on skill development, the foundry is a sector that faces thousands of skilled workers

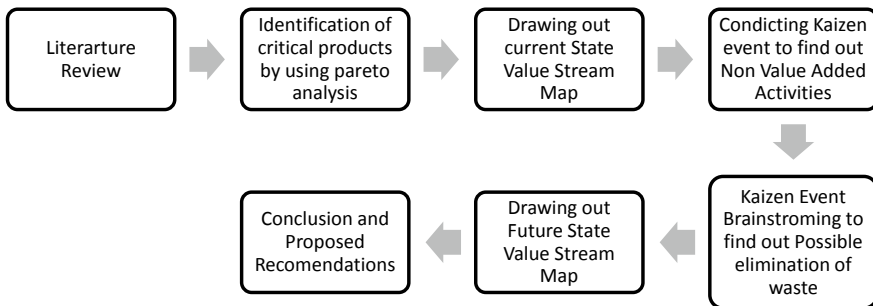


Fig. 15.1 Methodology of project

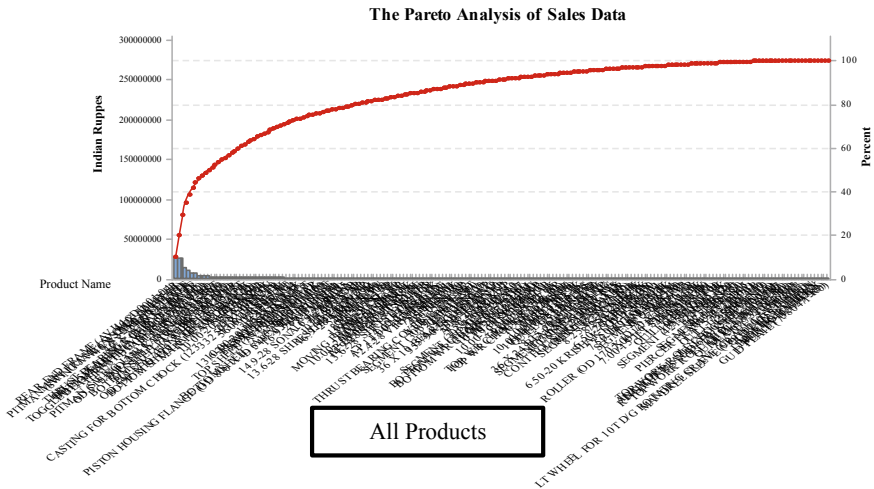


Fig. 15.2 The Pareto analysis of sales data of the financial year 2017–18

leaving this industry to choose alternative means of survival. Also, due to ensure government policy, the next generation of existing foundry unitholders has initiated migrating into high yielding sectors including information technology and others. Thus, a homogeneous approach is needed to long-term development of this foundry sector.

The foundries are underneath lots of pressure because of the increasing sophistication of markets and frequent changes in decisions of customers and international competition. It is evident that there is a priority to the boost performance of the product development process, as the time taken to introduce a new product in the market is critically necessary for competitiveness and long-term survival of the product. So, in this post-capitalist society organizations must perform continuous process improvement in their production processes and be innovative to achieve success. From the past few years, industrial organizations view Continuous Improvement (CI) as a tool to attain a competitive edge through better control of the production process and product quality. The foundries are underneath lots of pressure because of the increasing sophistication of markets and frequent changes in decisions of customers and international competition. It is evident that there is a priority to the boost performance of the product development process, as the time taken to introduce a new product in the market is critically necessary for competitiveness and long-term survival of the product. So, in this post-capitalist society organizations must perform continuous process improvement in their production processes and be innovative to achieve success. From the past few years, industrial organizations view Continuous Improvement (CI) as a tool to attain a competitive edge through better control of the production process and product quality.

Lean Manufacturing (LM) is seen as a major advance method and is widely employed by major industries all over the globe. The goal of LM is to retrenchment the

production cost and lowering Cycle Time (CT) by eradicating the Non-value-added Activities (NVA). The concept of LM is to make a production system pull production system. In the pull production system flow of material is driven by downstream as opposed to traditional batch-based production in which production is pushed from upstream to downstream based on a production schedule. The LM suggests that the finished product is the sum of all value-added-activities in the company. But in reality, there are three types of activities arise in the company.

These three types of activities are the following:

1. Value-added Activities (VA) (for these activities customer pays).
2. Necessary Non-value-added Activities (NVA) which support the value-adding activities.
3. Unnecessary Non-value-added Activities (NVA).

15.2 Methodology

A case study is conducted at Shree Steel Casting Pvt. Ltd. Higna, Nagpur, Maharashtra which is a medium-scale foundry. The methodology used is shown in Fig. 15.1.

15.3 Identification of Critical Products Using the Pareto Analysis

The Pareto principles state that in any situation, 20% of inputs or activities, are responsible for 80% of outputs or results. The principal named after an Italian economist, Vilfredo Pareto and it's also known as 80/20 rule. But the inverse is also true, which means the other 80% of inputs are only generating 20% of results.

It is better to concentrate on products that earn a major percent share of the total revenue of the Shree Steel Castings Pvt. Ltd. These products can be discovered from Pareto analysis as shown in Fig. 15.2. The Pareto analysis identifies that 20% of the input creates 80% of the result. The author has congregated the data by himself and received from the employees of Shree Steel Castings Pvt. Ltd. in terms of two genera, qualitative and quantitative [4].

The qualitative method is used when interviews are conducted and the quantitative method is used when the data is collected and analyzed. In the financial year, 2017–2018 the Shree Steel Castings Pvt. Ltd. has sold 201 different castings with different quantities and earned revenue of ₹273,875,140/-, in which 40 castings has earned revenue of ₹202,288,790/- that is 74% of total revenue. Pareto analysis has been done on sales data of the financial year 2017–2018 and found that 20% of product generated 74% share of total revenue.

15.4 Current State Value Stream Mapping

A value stream is a set of all actions (value-added as well Non-value-added) which might be required to convey a product (or a group of products that use the same resources) through the main flows, beginning with raw material and ending the customer [5]. The Value-added ratio (VAR) defines as value-added activity time to the lead time. The Value Stream Map of ‘Rear-end frame’ shown in Fig. 15.3 is drawn because it is a critical product that shares 10% revenue of total revenue. It is found that lead time (LT) and Value-added ratio (VAR) for ‘Rear-end frame’ is 15,589 min and 24.50%, respectively.

15.4.1 Takt Time

Takt time is the maximum amount of time wherein a product needs to be produced so that it will fulfill customer demand. Mathematically takt time is the ratio of available time for production to the production demand [6]. The takt time calculation of ‘Rear-end frame’ is the following:

- Available production time = $7.5 \text{ h/shift} \times 2 \text{ shift/day} \times 26 \text{ days/month} \times 12 \text{ months/year} = 280,800 \text{ min}$

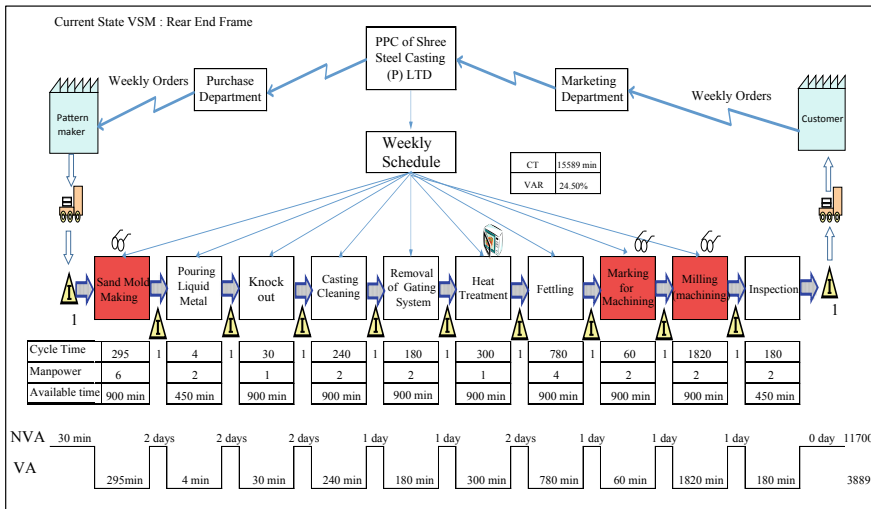


Fig. 15.3 Current state VSM of rear-end frame

- Customer demand in the past 10 years is shown in Table 15.1

$$\begin{aligned} \text{Takt time} &= \frac{280,800 \text{ (min available time per year)}}{33.3 \text{ (average demand per year)}} \\ &= 8432.43 \text{ min/Rear-end frame.} \end{aligned}$$

If lead time and takt time of the product are equal that means on-time delivery of the product to the customer. In this case, a lead time is approximately 15,589 min and takt time is around 8432 min that means takt time very less than lead time. The Shree Steel Castings Pvt. Ltd. recently facing a problem of delivery date mismatching which leads to penalties and customer dissatisfaction.

15.4.2 *Kaizen Event*

Kaizen, or continuous incremental improvement, refers to a philosophy that is a manner of thinking and behaving. It is about empowering and unleashing the innovative power of individuals who actually do the work, with a purpose to design greater effective and efficient processes [7]. The Kaizen event was conducted at the Shree Steel Castings Pvt. Ltd. for 5 days and Kaizen charter is prepared which is shown in Fig. 15.4. The targeted department was pattern inventory, sand molding and machining shop. In this Kaizen event, four waste (Muda) is identified which is inventory of casting pattern, under processing of vent hole-making operation at molding section, under processing of mold drying process at molding section and waiting at the machine shop. The Kaizen event charter contains every detail of the Kaizen event and some of the details are the following:

- The scope of the Kaizen event is to find out bottleneck activities or activities that are not adding any value to the material.
- In the Kaizen event charter, the areas or particular station is mentioned which contains waste (Muda). In this Kaizen charter targeted areas are pattern inventory, molding shop, marking for machining and machining shop.
- The team member and their belonging department are also mentioned in the Kaizen event charter.
- The metrics are selected to optimize them, in this Kaizen charter mold cycle time, pattern withdrawal time from pattern inventory and machining time is selected to optimize.
- In the end, short term and long-term objectives are mentioned.

Table 15.1 Customer demand in the past 10 years

Year	2008–2009	2009–2010	2010–2011	2011–2012	2012–2013	2013–2014	2014–2015	2015–2016	2016–2017	2017–2018	Average demand
Demand	9	15	18	20	30	25	45	40	58	73	33.3


SHREE STEEL CASTING PVT LTD						Date: 23/02/2019				
Kaizen Event Charter										
Event No.	1		Event Date	21-02-2019		Scheduled Hours or Days	5 Days			
Scope	To find out bottleneck activities using Value Stream Mapping and reduce CT of these activities by applying KAIZEN methodology					Event Priority	H	M	Y	L
						Area				Pattern Inventory, Molding shop, Marking for Machining and Machine Shop
Facilitator	Mr.Mahesh Khanderkar		Assistant	Mr.Kalpesh Tiwari						
Team Members	Department	Role		Team Members	Department	Role				
Arun Sharma	Molding	Supervisor		Dhananjay	Machine Shop	Supervisor				
Rajan	Molding	Molder		Sunil Shrivastav	Machine Shop	Operator				
Rohit	Closing	Molder								
Akhilesh	Closing	Helper								
Current State Description					Metrics					
Cycle Time of Rear Frame End is around 22,639 minutes (15.72 days). As per initial study there are four processes found bottleneck based on its working conditions and amount of labour. The processes are Withdrawal of Pattern from Pattern Inventory, Molding making, Mold Closing, Machine shop Scheduling. By initial study the cycle time of this bottleneck processes are found and that are listed as :					Metric	Value				
					Molding Productivity	3 molds/Day				
					Molding Cycle time	295 minutes				
					Pattern Withdrawal time	30 min				
					Machining time	1820 min				
					Total C.T.	22,639 min				
Short-Term Objectives					Long-Term Objectives					
<ul style="list-style-type: none"> • Foundry productivity to be increased by some percentage. • Lead time reduction by some percentage. • Making all Bottleneck processes correct. • Labour productivity to be increased. 					<ul style="list-style-type: none"> • Increase employee involvement in process decisions • Improve the Overall Quality of castings • To satisfy customers by providing on-time delivery 					

Fig. 15.4 Kaizen event charter

15.4.3 Kaizen Event Brainstorming Sheet

The brainstorming sessions have been done with top to bottom level employees and finally brainstorming sheet is prepared which describes corrective action, the feasibility of an idea, complexity to make it possible and possible potential returns illustrated in Table 15.2.

The brainstorming sessions can give birth to new ideas to improve current foundry practices. The brainstorming session has done with the Kaizen team at Shree Steel Casting Pvt. Ltd. As the Kaizen team having members from each department, all kinds of ideas for improvement can be possible.

The best ideas are noted in a sheet that includes the feasibility of the idea, complexity of the idea and potential return out of the idea. Based on the scale of 1–3 these parameters are evaluated. The best possible solutions are mentioned in this table.

15.5 Kaizen Reports

A Kaizen report is a document that illustrates a summary of continuous improvement activities. It is used to share improvements and best practices across an organization, division or group. The Kaizen event report documents that characterize the results after the completion of the Kaizen event. A Kaizen Report is a form that leaflets and

Table 15.2 Brainstorming sheet for Kaizen event

SHREE STEEL CASTING PVT LTD					
KAIZEN EVENT BRAINSTORMING SHEET					28/02/2019
Sr. No.	Corrective action description	Feasibility (Y/N)	Complexity	Potential Return	Comments
1	Properly sorting out of Pattern Inventory	Y	1	2	Pattern withdrawal time will be less and less chance of deterioration of pattern which leads to the more useful life of pattern
2	Designing Special Purpose Venting Machine	Y	2	3	Initial cost is moderate but the operation of making venting holes makes easier, fast and accurate
3	Use of mold drying system	Y	2	3	Initial cost is moderate but using mold drying system reduces heating time as well as uniform heating across the mold
4	Use of Compressed Air Coating Gun then Brush in Coating	Y	1	2	Coating Time will be saved
5	Application of Big surface plate for dimension marking	Y	1	2	By using big surface plate, two rear end frame can marked
6	Use of LEKIN Scheduling software for Machine shop	Y	1	2	Using Scheduling software leads to saving in WIP inventory
1 = Low ; 2 = Medium ; 3 = High					

recapitulates continuous improvement activities. It is used to share improvements and best practices across the foundry. There are many ways to share Kaizen reports including public display boards, dedicated Kaizen bulletin boards, emails and the intranet. In all cases, Kaizen activities should be written clear and simple so that every team member can easily understand them. Additionally, Kaizen reports with photos and drawings tend to capture more attention.

15.5.1 5S in Pattern Inventory

In Shree Steel Castings Pvt. Ltd., the withdrawal time of casting patterns is significantly high and fluctuating. As shown in figure casting patterns are set haphazardly in pattern inventory. Implementing 5S will solve this problem and preserves the casting pattern. The guideline for 5S implementation is shown in Fig. 15.5. Guidelines for 5S in a pattern inventory is shown in Table 15.3. In the Kaizen event, it is observed that patterns are set haphazardly and unorganized in the inventory which is shown in Fig. 15.6.

The withdrawal time of pattern for making a mold is uncertain and considerably large because of this messy inventory of patterns.

The Kaizen report 1 is shown in Fig. 15.5 which illustrates the before vs after situation and advantages. The benefits of 5S in pattern inventory is the following:


Sheet 1 of 6		Kaizen Report	
Subject		Concerned Process / Project	
5S		Pattern Inventory	
Before (Include pictures, diagrams, etc.)		After (Include pictures, diagrams, etc.)	
Average withdrawal time of pattern for casting is 30 min (approx), because inventory in a haphazard fashion		Implementing 5S in Pattern Inventory lead to less withdrawal time as well as less tendency to damage the pattern	5S: Sort (Seiri) Set In Order (Seiton) Shine (Seiso) Standardize (Seiketsu) Sustain/Self-discipline (Shitsuke)
Benefits			
<ul style="list-style-type: none"> ●Pattern withdrawal time can be reduced upto 66.66% ●Pattern damage chances will be less ●Well organized inventory 			
Originated By	Validated By	Approved By	
Mr. Dhruv Parmar	Mr. Mahesh Khanderkar	Not yet	

Fig. 15.5 Kaizen sheet 1

Table 15.3 5S guidelines for pattern inventory

Sort (Seiri)	Worn-out patterns and sodium tank should be removed from pattern inventory
Set in order (Seiton)	Patterns should be kept based on annual usage (i.e. FSN analysis) fast-moving patterns should be placed in close proximity, in an easy to reach the spot and in a logical order which is heavy patterns should be kept at bottom and the light one is at top
Shine (Seiso)	When a pattern is in contact of moisture it will expand as most of the patterns made of wood, so dimensions will be deteriorated hence dust-free as well as moisture-free environment is a must
Standardize (Seiketsu)	Launch procedures and schedules to guarantee the recurrence of the first three ‘S’ practices
Sustain (Shitsuke)	Ensure that the 5S approach is followed by organizing training sessions

- The withdrawal time of the pattern will be less as the location of each pattern is documented.
- The material of the pattern is wood and characteristics of wood are to absorb moisture which leads to change in geometry and dimension. Careful preservation and protection can abolish this scenario.



Fig. 15.6 Pattern inventory at SSCPL

- A well-organized pattern inventory tends to decline the damage of wooden patterns, hence improvement in useful life and lessens pattern repair cost.
- A clean and pleasant work environment enhances the morale of workers towards their job.

15.5.2 Special Purpose Venting Machine

The vent holes are made to escape hot gasses when molten metal is poured in a mold cavity. Making venting is tedious, repetitive and laborious work. As shown in figure Special Venting Machine is designed in SolidWorks2013 which can reduce the time of venting operation and centre distance vent hole will be accurate (refer Fig. 15.7).

The venting operation in mold making is time-consuming and laborious. Also, vent holes of cope and drag mismatch their alignment because it made randomly by workers. An unaligned vent hole does not permit to pass hot gasses easily when pouring molten metal into the mold. These unescaped gasses stay in the mold and generate blow holes in casting part. Hence there is a need to design a machine that reduces the cycle time of operation and reduces human intervention. The special purpose venting machine is designed after rigorous brainstorming with the Kaizen team to semi-automate the venting operation.

The special purpose machine can reduce the cycle time of operation and align the vent holes of cope and drag which facilitates the hot gasses to pass. Here the word 'special' is used because this machine is not universal for every mold box (flask), but it covering the domain of 2500 mm × 1800 mm size of the mold box.

In Fig. 15.8 the CAD model of the special purpose venting machine is shown with each component of the machine. This machine contains the structure frame made by 2" × 2" of angle which having sliding rod. The array of venting rods is


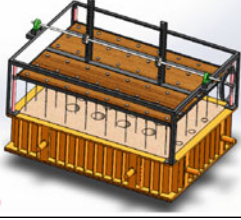
Sheet 2 of 6		Kaizen Report	
Subject		Concerned Process / Project	
Special Purpose Venting Machine		Mold Making	
Before (Include pictures, diagrams, etc.)		After (Include pictures, diagrams, etc.)	
<p>For CO₂ gas filling the operator needs to dig venting holes in both top and bottom mold box and then have to fill the gas in each hole that takes around 30 mins.</p> 	<p>We made design of Special Venting Machine. By using this machine approx. 70% process step time will be reduced</p> 		
Benefits			
<ul style="list-style-type: none"> ● Process Cycle Time greatly reduced. ● It is versatile machine can be used on many castings which is casted in 2500mm x 1800mm mold flask ● Center distance between two vent hole will be accurate. ● Vent holes of cope and drag align with each other which facilitates hot gases to escape easily. ● Human effort is reduced up to huge extent 			
Originated By	Validated By	Approved By	
Mr. Dhruv Parmar	Mr. Mahesh Khanderkar	Mr. Mahesh Khanderkar	

Fig. 15.7 Kaizen sheet 2

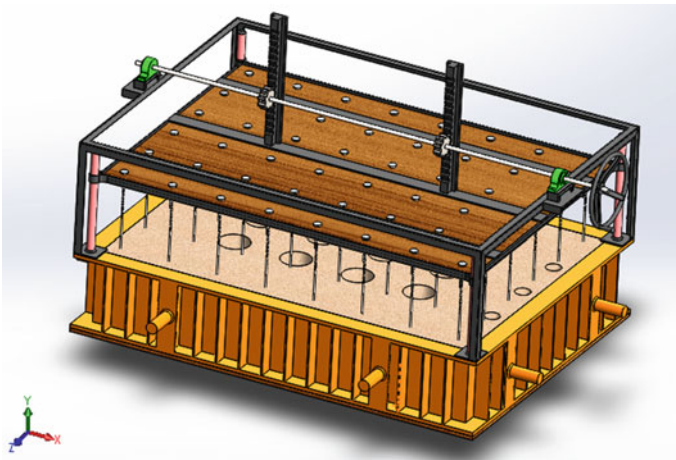


Fig. 15.8 The CAD model of the special purpose venting machine

assembled with a piece of wood which reciprocates in sliding rod. The manual handle is provided having rack and pinion arrangement with a wooden piece of an array of venting rods. In Fig. 15.10 the exploded view of the special purpose venting machine is shown.

The alignment of the vent hole of cope and drag can be achieved by the special purpose machine is shown in Fig. 15.9.

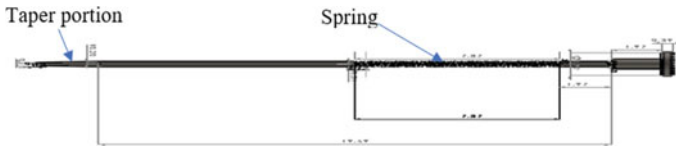


Fig. 15.9 The CAD model of venting rod

The optimum distance between two vent holes is one foot, total 48 vent hole is required for the mold of the rear-end frame. The spring is provided with venting rod to deflect vent rod when it touches the pattern inside the sand mold, the CAD model of venting rod is shown in Fig. 15.10.

The alignment of the vent hole of cope and drag can be achieved by the special purpose machine is shown in Fig. 15.11. The optimum distance between two vent holes is one foot, total 48 vent hole is required for the mold of the rear-end frame. The spring is provided with venting rod to deflect vent rod when it touches the pattern inside the sand mold.

The first step is to place the machine on the mold box with the help of Electric Overhead Traveling (EOT) crane and then handwheel is rotated by the worker. The torque applied on handwheel by the worker is transfer via a shaft to pinion and pinion to rack. The rotary motion of pinion is converted in a reciprocal motion of rack. This rack is fabricated with trolley or assembly structure which contains an array of venting rods. The required force to make vent hole is calculated using thumb rule.

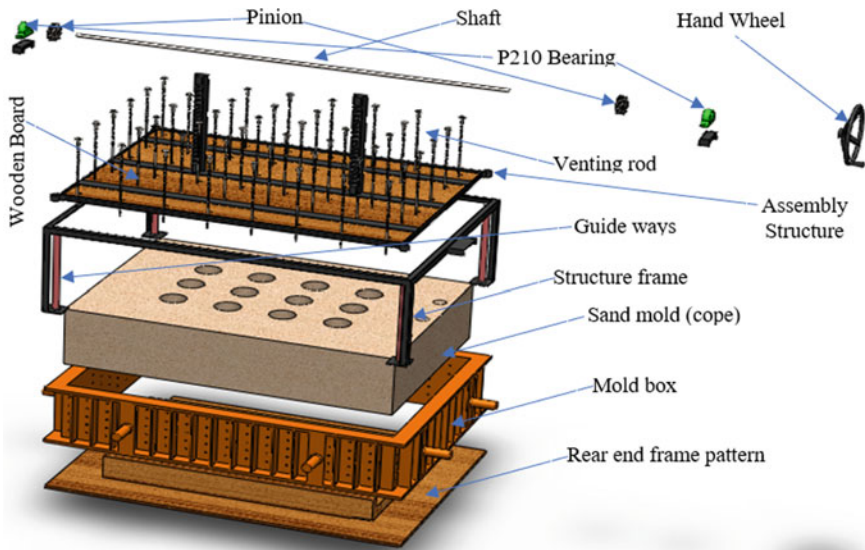


Fig. 15.10 The exploded view of the special purpose machine

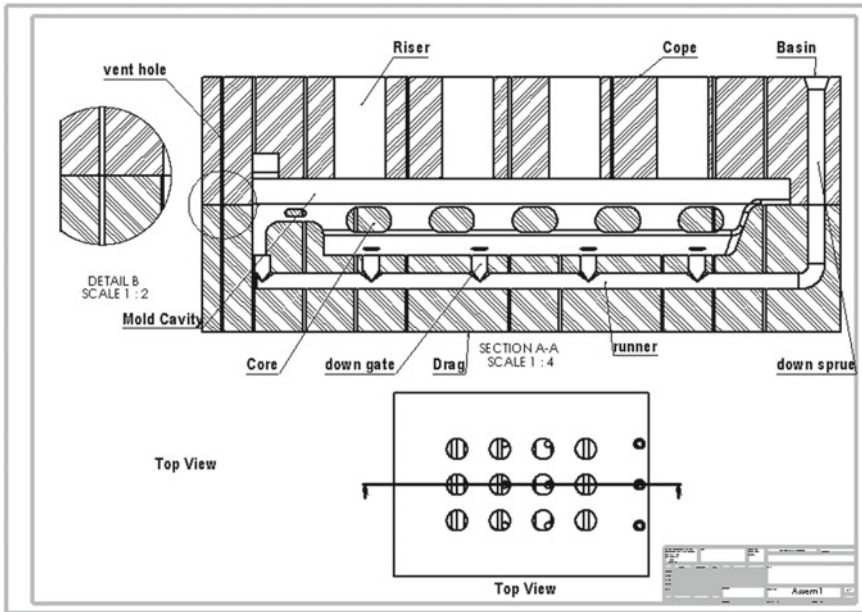


Fig. 15.11 A vent hole alignment of cope and drag

The weight of the wooden board, venting rod and structure exerts the force downwards so this force is also calculated and considered here. The force calculation is given below:

- Weight of Wooden Board = Required Volume \times Density of Teak Wood
 $= 0.12 \text{ m}^3 \times 630 \text{ kg/m}^3$
 $= 72.33 \text{ kg}$

- Weight of Assembly Structure = Require Volume \times Density of Cast iron Angle
 $= 0.02 \text{ m}^3 \times 7200 \text{ kg/m}^3$
 $= 135.05 \text{ kg}$

- Weight of one venting rod = Require Volume \times Density of Steel
 $= 0.000066 \text{ m}^3 \times 7870 \text{ kg/m}^3$
 $= 0.52 \text{ kg}$

- Weight for 48 venting rod = $0.52 \text{ kg} \times 48$ venting rods
 $= 24.96 \text{ kg}$

- Total Weight = Weight of Wooden Board + Weight of Assembly Structure
 + Weight of 48 venting rod
 = 72.33 + 135.05 + 24.96
 = 233.89 kg

- The Gravitational Force = Total Weight \times Gravitation Acceleration
 = 233.89 kg \times 9.81 m/s²
 = 2294.47 kg m/s²
 = 2.30 kN

- Total Force = Number of venting rods \times Cross-section area of venting rod (mm²)
 \times Resisting stress of Sodium Silicate (N/mm²)
 = 48 \times $\frac{\pi}{4}$ (5)² \times 10.20
 = 9608.4 N
 = 9.6 kN

- Required Force = Total Force – The Gravitational Force
 = 9.6 kN – 2.3 kN
 = 7.3 kN.

15.5.3 Mold Drying System

The mold drying system can uniformly remove moisture from the sand mold. Moisture-free sand mold can produce defect-free casting parts [8] (refer to Fig. 15.12). The moisture-free mold can produce defect-free castings. The biggest opponent of casting is moisture content in a sand mold. Especially in monsoon and winter season, the moisture content is very high in the atmosphere. In current practice, foundries are using a gas flame torch to heat up the mold to remove the moisture. But in this method moisture remains in the boundary portion of the mold and non-uniform heating of sand mold which leads to defect like blowholes. The mold drying system is designed to eliminate this problem completely. The Kaizen report 3 is shown in Fig. 15.13 which explains the benefits of the mold drying system.

The following are components of the drying mold system:

- Blower
- Heater


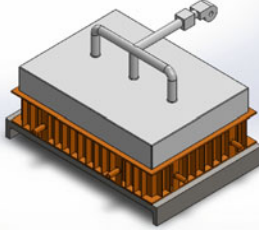
Sheet 3 of 6		Kaizen Report	
Subject		Concerned Process / Project	
Mold drying system		Mold Closing	
Before (Include pictures, diagrams, etc.)		After (Include pictures, diagrams, etc.)	
<p>After Coating has applied on both the mold(Cope and Drag), for mold heating molder uses gas flame torch and heats both halves of mold by flame torch which took around 20 min</p>		<p>Mold drying system is available in US patent. Using this sytem moisture can be removed effectively and efficiently</p>	
Benefits			
<ul style="list-style-type: none"> ●Process Cycle Time greatly reduced. ●It is versatile machine can work on all the standard mold box. ●Human effort will considerably reduce. ●Quality of casting will also improve due to uniformly heating across the mold 			
Originated By	Validated By	Approved By	
Mr. Dhruv Parmar	Mr. Mahesh Khanderkar	Not yet	

Fig. 15.12 Kaizen sheet 3

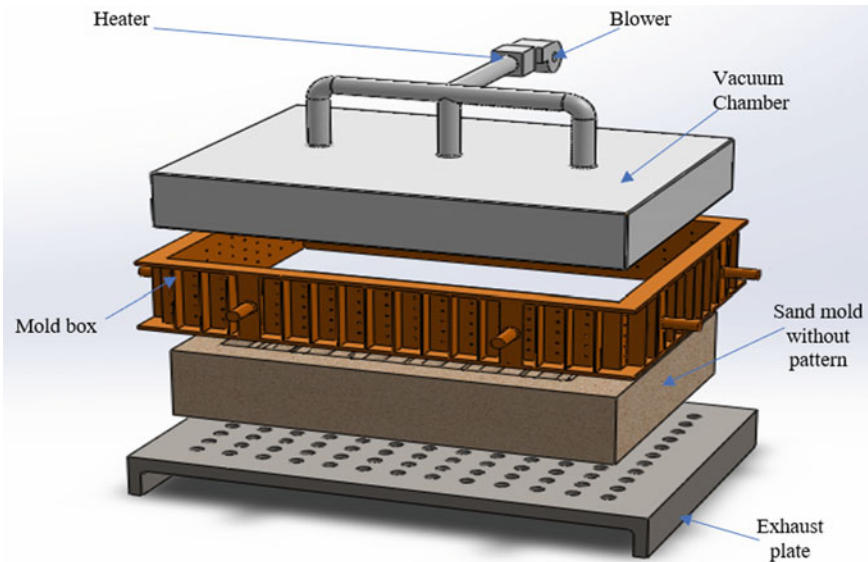


Fig. 15.13 The exploded view of the mold drying system

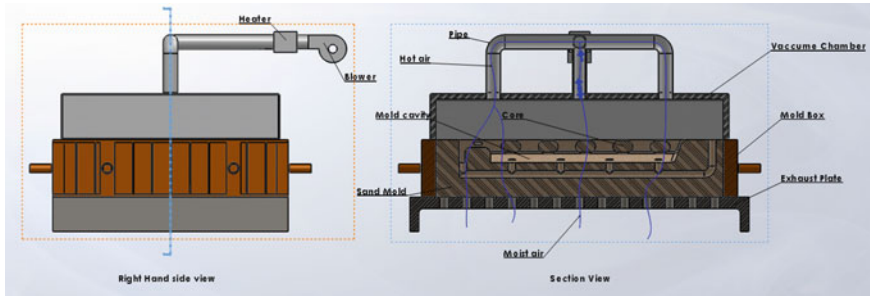


Fig. 15.14 The working of the mold drying system

- Vacuum Chamber
- Exhaust Plate

In Fig. 15.13 the components of the mold drying system are clearly shown.

The heated air is passed through the entire mold to uniform eradication of moisture. The heater raises the temperature of air blown by a blower which enters to vacuum chamber fitted on the top portion of the sand mold via a pipe. This hot air passes uniformly through entire sand mold and exits from exhaust plate. At the exhaust plate, hot air will be moist air as it absorbs the moist from the sand mold. The working of this system is shown in Fig. 15.14.

15.5.4 *Spray Gun*

The coating is done on the mold cavity surface to get a good surface finish of the casted part. Unevenly coated surface will produce a poor surface finish. This problem can be eliminated by using a compressed air spray gun. The benefits of using spray gun are displayed in the Kaizen report 4 (refer Fig. 15.15).

15.5.5 *LEKIN Scheduling Software*

LEKIN is interactive scheduling system for machine environments which is a freely available source. The LEKIN system is capable of scheduling various machine environments: (1) Single machine (2) Parallel machine (3) Flow shop (4) Flexible flow shop (5) Job shop. In this case, study Single machine scheduling is done. This software can compare different machine shop scheduling algorithms like SPT (shortest processing time), LPT (longest processing time), FCFS (First come first serve), General SB Routine, etc. [9] (refer Fig. 15.16).



Sheet 4 of 6		Kaizen Report	
Subject		ConcernedProcess / Project	
Coating of Mold & Cores		Mold Closing	
Before (Include pictures, diagrams, etc.)		After (Include pictures, diagrams, etc.)	
<p>Mold and core coating is done using hand brush and that requires approx. 20 minutes. It is labourious task and big size molds can not be evenly coat.</p>		<p>Using compressed air spray coating gun, molder can coat the entire mold and core within 10 minutes and thus 50% time can be reduced.</p>	
Benefits			
<ul style="list-style-type: none"> ● Process Cycle Time will be half reduced. ● Evenly Coat will be applied on entire mold and core. 			
Originated By		Validated By	
Mr. Dhruv Parmar		Mr. Mahesh Khandekar	
Approved By			
Mr. Dhruv Parmar		Mr. Mahesh Khandekar	

Fig. 15.15 Kaizen sheet 4


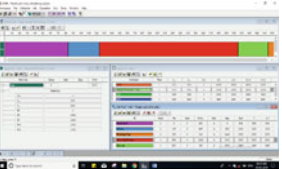
Sheet 6 of 6		Kaizen Report	
Subject		ConcernedProcess / Project	
LEKIN Scheduling software		Machining	
Before (Include pictures, diagrams, etc.)		After (Include pictures, diagrams, etc.)	
<p>Waiting time of casting is to machines is significantly high</p>		<p>Using LEKIN Scheduling software company can generate schedule plan which can reduce waiting time of castings to be machined</p>	
Benefits			
<ul style="list-style-type: none"> ● The waiting time of rear end frame is reduced by 110 min ● Maximum Utilization of resources. ● Reduces Work in process inventory 			
Originated By		Validated By	
Mr. Dhruv Parmar		Mr. Mahesh Khandekar	
Approved By			
Mr. Dhruv Parmar		Mr. Mahesh Khandekar	

Fig. 15.16 Kaizen sheet 5

15.5.6 The Big Surface Plate

The marking is done to identify unwanted material in casted parts. For rear-end frame 2 × 1 m surface plate is used for marking and requires time to mark is 60 min. If 3 × 2 m surface plate is used then two rear-end frames can be marked and cycle time will be reduced by 50%. Further details are mentioned in Fig. 15.17 Kaizen report 6.



Subject		Concerned Process / Project	
Big Surface Plate		Dimension Marking	
Before (Include pictures, diagrams, etc.)		After (Include pictures, diagrams, etc.)	
<p>For marking the dimensions of rear end frame, 2x1 meter surface plate is used.</p> <p>Only one part is marked at a time and that is why it takes 1 hour for each part</p> 	<p>Using bigger surface plate in size 3X2 meter will take less time as at a time 2 parts can simultaneously marked, so it will consume around 50% less dimension marking time.</p> 		
Benefits			
<ul style="list-style-type: none"> • Dimension marking Time will 50% reduced. • Big Surface plate will be used for inspection of every size casting components. • Dimensions will be more accurately measured because of no size constraints 			
Originated By	Validated By	Approved By	
Mr. Dhruv Parmar	Mr. Mahesh Khanderkar	Mr. Mahesh Khanderkar	

Fig. 15.17 Kaizen sheet 5

15.6 Future State Value Stream Map

The future state VSM displays the improvements by Kaizen blitz. In the molding shop three improvements are done which are venting operation, mold drying operation and mold coating. Here, the value-adding activities are optimized. In a machine shop, one improvement is done, the waste as await is reduced. The summary of improvements is shown in Table 4.5. The future state VSM is shown in Fig. 15.18

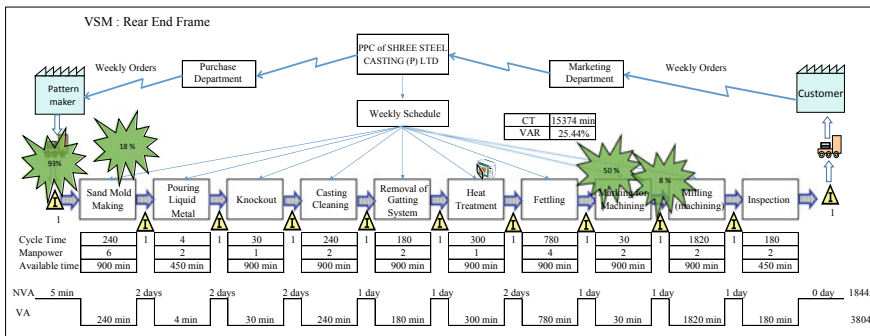


Fig. 15.18 Future state VSM of rear-end frame

Table 15.4 Current state versus future state

Improvements	Current state VA (min)	Future state VA (min)	Improved productivity	Remarks
5S in pattern inventory	30	5	83.33% reduction in withdrawal time of pattern	Reduction in necessary Non-value-added activity which is transportation waste (Muda)
Venting operation	30	10	66.66% cycle time reduction in venting operation	Optimization in a value-added activity
Mold drying	20	5	75% cycle time reduction in mold drying	Optimization in a value-added activity
Mold coating	25	10	60% cycle time reduction in mold cavity coating	Optimization in a value-added activity
Marking for machining	60	30	50% cycle time reduction in marking operation	Optimization in a value-added activity
LEKIN interface in scheduling	120	110	8 % reduction in WIP	Reduction in Non-value-added activity which is waiting waste (Muda)

15.7 Conclusion

This chapter demonstrates the recommendation of Continuous Process Improvement on a medium-scale foundry. The objective here was to optimize Value-added activities, reduction in necessary Non-value-added Activities and eradication of unnecessary Non-value-added Activities. In current state VSM, Value-added ratio and the lead time was 24.5% and 15,589 min, respectively. After a conducting Kaizen event, Future state VSM was drawn and found that VAR and LT are now 25.44% and 15,374 min, respectively. In Table 15.4 Current state vs future state is summarized with improved productivity. Continuous improvement is a never-ending cycle, more Kaizen events should be conducted for further improvements.

References

1. Wang, W., Stoll, H.W., Conley, J.G.: Rapid Tooling Guidelines for Sand Casting. Mechanical Engineering Series, pp. 1–6. Springer, New York, USA (2010)

2. Harish, K.A., Selvam, M.: Lean wastes: a study of classification from different categories and industry perspectives. *TARCE* **4**(2), 7–12 (2015)
3. Shettar, M., Hiremath, P., Nikhil, R., Chauhan, V.R.: KAIZEN—a case study. *IJERA* **5**(5), 101–103 (2015). (Part 2, ISSN: 2248-9622)
4. Sekaran, U.: *Research Methods in Business*, 3rd edn, USA (2000)
5. Abdulmalek, F.A., Rajgopal, J.: Analyzing the benefits of lean manufacturing and value stream mapping via simulation: a process sector case study. *IJPE* **107**, 223–236 (2007)
6. Raagul Srinivasan, K.A., Jawagar Shrehari, J.: Applied procedures for lead time reduction: a review. *IJETT* **43**(3) (2017)
7. Martin, K., Osterling, M.: *The Kaizen Event Planner* (2007)
8. Nicholos, A.S., Park, O.: *Preparation of Dry Sand Molds*. United States Patent Office (1945)
9. Sahu, L.K., Sridhar, K.: Scheduling Bottleneck algorithm for job shop scheduling problem. *IJSEAS* **2**(3) (2015) (ISSN: 2395-3470)