STUDY ON RESPONSIBILITY ACCOUNTING OF A COMPANY

PULTRUSION MACHINE OEE IMPROVEMENT THROUGH TPM METHODOLOGY

UNDERTAKEN AT
CARBORUNDUM UNIVERSAL LIMITED

IN PARTIAL FULFILMENT OF

POST GRADUATE DIPLOMA IN OPERTION MANAGEMENT

MIT SCHOOL OF DISTANCE EDUCATION, PUNE.

GUIDED BY: Mr. SARFRAZ

SUBMITTED BY: M. MUNUSAMY

Student Registration No.: MIT202101299

MIT SCHOOL OF DISTANCE EDUCATION

PUNE - 411 038

YEAR 2021 – 2023

DECLARATION

I hereby declare that this project report entitled "NAME OF THE PROJECT" is a bonafide record of the project work carried out by me during the academic year 2021-2023, in fulfilment of the requirements for the award of POST GRADUATE DIPLOMA IN OPERATION MANAGEMENT of MIT School of Distance Education.

This work has not been undertaken or submitted elsewhere in connection with any other academic course.

Name: Munusamy M

Student ID: MIT202101299

ACKNOWLEDGEMENT

I would like to take this opportunity to express my sincere thanks and gratitude to Mr. Sarfraz, place of Carborundum Universal Limited, Ranipet for giving me an opportunity to do my project work in your esteemed organization and it has indeed been a great learning and enjoyable experience.

I would like to express my deep sense of gratitude and profound thanks to all staff members of Carborundum Universal Limited for their kind support and cooperation which helped me in gaining lots of knowledge and experience to do my project work successfully.

At last but not least, I am thankful to my Family and Friends for their moral support, endurance and encouragement during the course of the project.

Name: Munusamy M

Student ID : MIT202101299

murugappa

CUMI

CERTIFICATE

This is to certify that Mr. M Munusamy has completed the project report with us for his project report work on "PULTRUSION MACHINE OEE IMPROVEMENT THROUGH TPM METHODOLOGY" in fulfilment for the completion of his Course with MITSDE on "POST GRADUATE DIPLOMA IN OPERATIONAL MANAGEMNT" as prescribed By MIT SCHOOL OF DISTANCE EDUCATION, PUNE. This project is a record of authentic work carried out by him with guidance by our relevant department from 03/10/2022

Carborundum Universal Limited

Name and Signature of Guide

SARFRAZ GADKARI

ABSTRACT

Overall Equipment Effectiveness is one of the performance evaluation methods that are most common and popular in the production industries. Overall Equipment Effectiveness (OEE) plays a vital role where performance and quality of the product are of importance to the organization. The OEE is intended at minimizing the breakdowns, increasing performance and quality rate and thus improving the effectiveness of the machine/system. The availability rate of the machine, performance rate of the machine and quality rate of the products are considered as main parameters for maximizing the Overall Equipment Effectiveness (OEE) of a manufacturing system. It is found that poor performance rate contributes more than availability rate and quality rate.

The objective of this work is to enhance the pultrusion machine overall equipment effectiveness (OEE) in our plant. Pultrusion is a continuous process for manufacturing composites with constant cross-sections or structural profiles having significantly long length. It is widely employed in the composites industry due to its continuous, automated and highly productive nature. Seeing the machine production performance is very low. Output of the productivity per shift 60mtr long, in that calculation of OEE 41% as factor of the machine availability rate is 63.2%, performance rate is 70% and quality rate is 96%. These metrics help gauge machine efficiency and effectiveness and categorize these key productivity losses that occur within the pultrusion manufacturing process. The Downtime losses incudes setup time and adjustment time is reduce using the machine availability rate. Performance study is the systematic examination of the methods of carrying out activities so as to improve the effective use of resources and to set-up standards of performance for the activities being carried out. It is one of the most powerful tools that management can use to improve productivity.

Overall equipment effectiveness (OEE) improvements help manufacturing and determine the maximum machine capacity or output. Higher productivity levels among employees, it creates a happier and healthier working environment. Any task done faster, more efficiently and better than competitors give a business an edge. Increased productivity leads to increased competitiveness. Although the most well-known operational benefits include improved manufacturing lead time, optimized inventory turns, and enhanced performance. Other factors that impact operational efficiency include resource utilization, manufacturing and inventory management. Operational efficiency differs from productivity because the latter focuses on generating higher outputs using the same inputs.

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1. Introductions

1.1 About Murugappa Group

Founded in 1900, the INR 547 Billion Murugappa Group is one of India's leading business conglomerates. The Group has 28 businesses including nine listed Companies traded in NSE & BSE. Headquartered in Chennai, the major Companies of the Group include Carborundum Universal Ltd., Cholamandalam Investment and Finance Company Ltd., Cholamandalam MS General Insurance Company Ltd., Coromandel International Ltd., Coromandel Engineering Company Ltd., E.I.D. Parry (India) Ltd., Parry Agro Industries Ltd., Shanthi Gears Ltd., Tube Investments of India Ltd., and Wendt (India) Ltd. Market leaders in served segments including Abrasives, Auto Components, Transmission systems, Cycles, Sugar, Farm Inputs, Fertilisers, Plantations, Bio-products and Nutraceuticals, the Group has forged strong alliances with leading international companies such as Groupe Chimique Tunisien, Foskor, Mitsui Sumitomo, Morgan Advanced Materials, Sociedad Química y Minera de Chile (SQM), Yanmar & Co. and Compagnie Des Phosphat De Gafsa (CPG). The Group has a wide geographical presence all over India and spanning 6 continents. Renowned brands like BSA, Hercules, Montra, Ladybird, Mach City, Ballmaster, Ajax, Parry's, Chola, Gromor, Shanthi Gears, and Paramfos are from the Murugappa stable. The Group fosters an environment of professionalism and has a workforce of over 32,000 employees.

For further details, please visit at www.murugappa.com

1.2 About CUMI

Carborundum Universal Limited (CUMI), established as a tripartite joint venture in 1954, is a leading materials sciences engineering solutions provider. CUMI's consolidated sales is Rs. 4601 crores and PAT of Rs. 414 crores for the financial year 2023. CUMI, part of the 120-year-old Murugappa Group, is listed on the NSE and BSE. CUMI is a Mines to Market Company whose integrated operations include mining, power generation, fusion, manufacturing, marketing and distribution. CUMI has over 5,500 employees worldwide who collaborate, innovate and develop high-quality material solutions and world-class services in abrasives, electrominerals, ceramics, refractories and energy storage materials, serving customers in diverse industries including engineering, fabrication, auto and auto components, infrastructure, steel, glass, power generation and distribution, mining and aerospace. CUMI has a wide geographical presence spanning six continents and exports products to over 50 countries.

For further details, please visit at www.cumi-murugappa.com

1.3 About CUMI-PRODORITE Division

CUMI-Prodorite division is a pioneer and market leader in the manufacture of Acid Resistant materials and FRP fabrication, having commenced production in 1961 with Prodorite, UK collaboration. CUMI-Prodorite manufactures specialty coating & screeding systems for corrosion environment in collaboration with HiltiBauchemie, Germany, from the middle of the 1980s. We commenced production of Polymer concrete cells in the year 1998 in collaboration

with ANCOR, Chille / USA. Got technology from Ershigs, USA for abrasion-resistant composites products namely Fiberglass Reinforced plastics (FRP). It specializes in manufacturing wide range of products including Pipes, fittings, tanks scrubber, Grating Handrail and Wind turbine nacelle cover industries such as Chemical, Power, Wind Pulp & Paper, non-Ferrous, Fertilizer. etc.,

For further details, please visit at www.prodorite.com

2. FRP Composite description

FRP Composite products namely Fiberglass Reinforced plastics (FRP). FRP is manufactured using various resins like polyester, vinylester and epoxy and uses Glass fibre as reinforcement. The basic process includes resin preparation and combining it along with glass fibre. Resin is mixed with the required curing agents, fillers and pigment and solidifies after curing time. FRP allows the alignment of the glass fibres of thermoplastics to suit specific design programs. Specifying the orientation of reinforcing fibres can increase the strength and resistance to deformation of the polymer.

In an FRP composite, the fibre part usually brings most of the strength to the material. The role of the matrix is to encase the fibres and distribute the forces among the fibres. Glass fibre, for example, is stronger than steel for its weight but comes mostly as woven cloth or fibre mats. The resulting glass fibre composite is lightweight, stiff, and strong when combined with epoxy resin.

Some of the most important properties of FRP composites include:

- Extremely lightweight
- High tensile strength
- Resistance to water and corrosion
- Resistance to electrical conductivity
- Resistance to chemical substances
- Stability under UV

FRP is manufactured using various process based on the shape and size of the equipment and applications. It can be achieved through several processes, including Hand lamination of open & closed moulding, Resin transfer moulding(RTM), Vacuum assisted resin infusion method (VARIM), compression moulding (SMC & DMC), Filament winding, Pultrusion, chopper spray, bladder moulding, autoclave and vacuum bag and Moulded Grating. At this point to focus on pultrusion, which is arguably the most popular method of FRP production at the moment.

Pultrusion can be used to make a number of materials including fiberglass and carbon fiber. Like extrusions pultrusions can be made with a variety of cross sections, such as an I-beam. Materials made by pultrusion are very versatile. They are very light, and strong, and can be used in a variety of applications. Examples of the use of these materials include: structural siding, many household ladders, tool handles, and tubes.

Application and Used

- Air craft structure and parts
- Structural components in the construction industry
- Electrical insulation components
- Blades for wind turbines
- Automotive parts and components
- Recreational sports equipment's
- Industrial parts
- Agricultural equipment
- Consumer goods

2.1. FRP Pultrusion manufacturing process

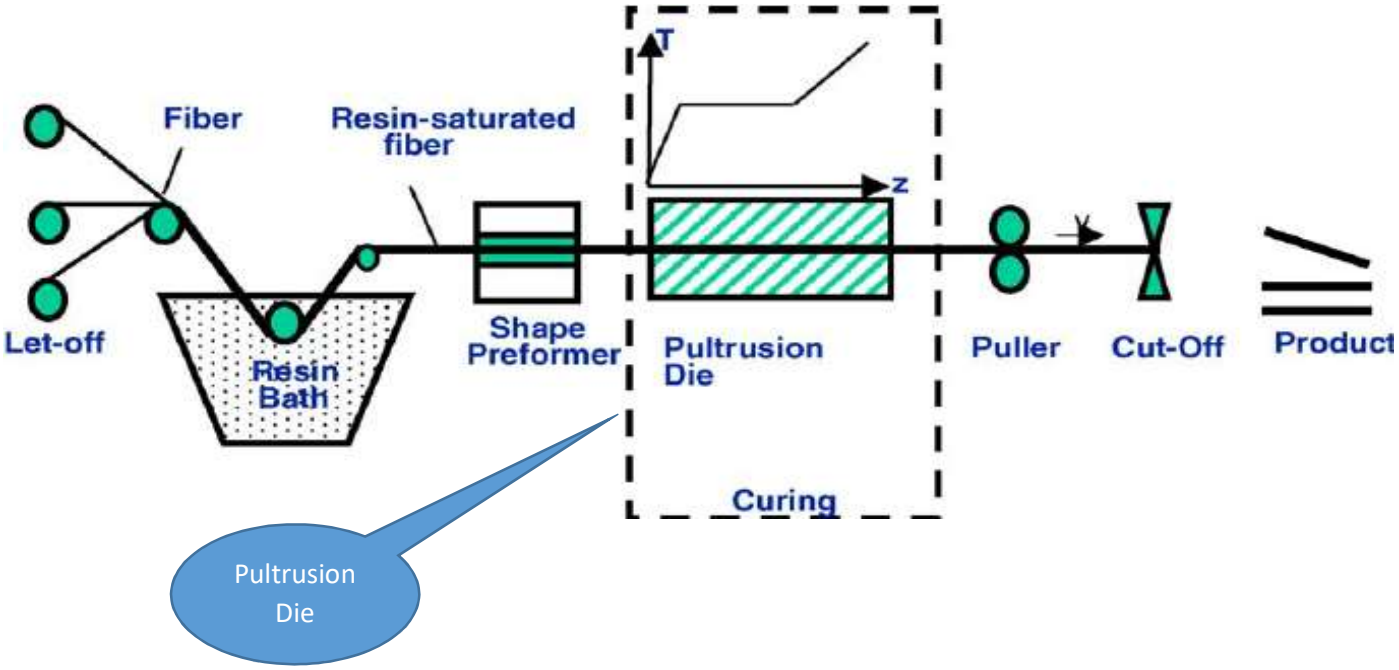
Pultrusion is a continuous composite fabrication process where continuous reinforcing fibres are impregnated with thermosetting matrix and are pulled through a heated die to form composite profiles. It has the capabilities to run continuously with constant cross section profile with the mass production volume. Thermosetting pultrusion process can be divided into three zones; heat transfer zone, pressure zone and pulling zone. Firstly, the fibres are pulled from the creel through a resin bath with the proper resin viscosity. Then, polymer solution is placed in the resin bath, which contains polymer resin, filler, catalyst, release agent, pigment, Ultra Violet (UV) stabilizer and other enhancement additives.

Thereafter the fibres are guided by a guide plate where the fibres and resin are impregnated. The fibres are pulled through pre-form guides to eliminate excess resin before entering a heated die where the composites are cured. The heated die in most of pultrusion process is divided into two zones; a low temperature for gelation and a high temperature to cure the resin. The pultrusion die is heated by a heater and the temperature is controlled using thermocouple sensor, which interacts with heater to ensure the temperature is sufficient and to avoid die from overheating which can cause the defect on the pultruded profile.

Generally, the continuous unidirectional fibres are impregnated with low viscosity thermosetting matrix before passing through the heated die for profile forming. At this stage, the resin changed from liquid to rubbery state and this transition is also known as gelation point or gel point and it continues to form solidified pultruded profile.

The puller with the rubber clamp gripped the profiles and the profiles are pulled through the cutter and are cut to desired lengths. The clamp is controlled using pneumatic controller system and it is reported that pneumatic system is better than hydraulic clamp (which was used in older version pultruded machine) in protecting the profile. The pulling speed is controlled using a programming control system and it can be easily monitored and controlled in the monitor screen.

2.2 Pultrusion production process schematic diagram



Explained below the image how the resin and fibres forming the solid part through the heated die (Fig 1)

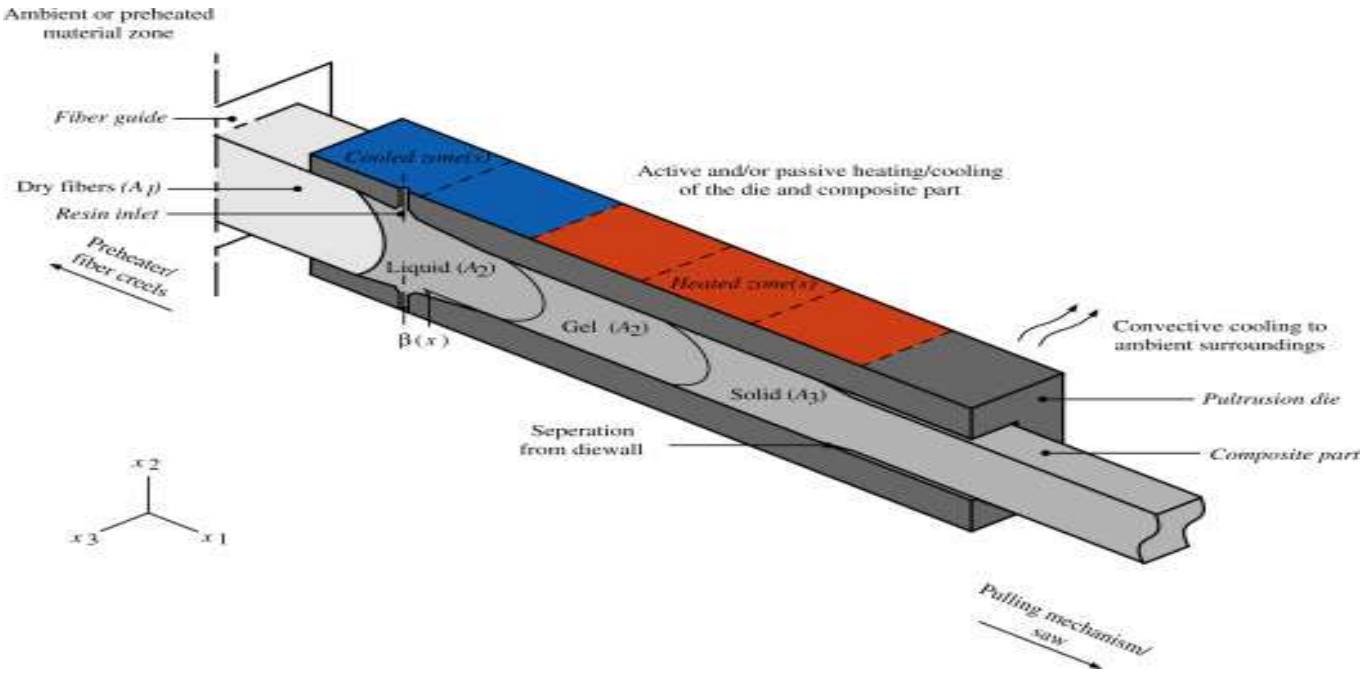


Fig. 1

2.3Pultruded part cross section

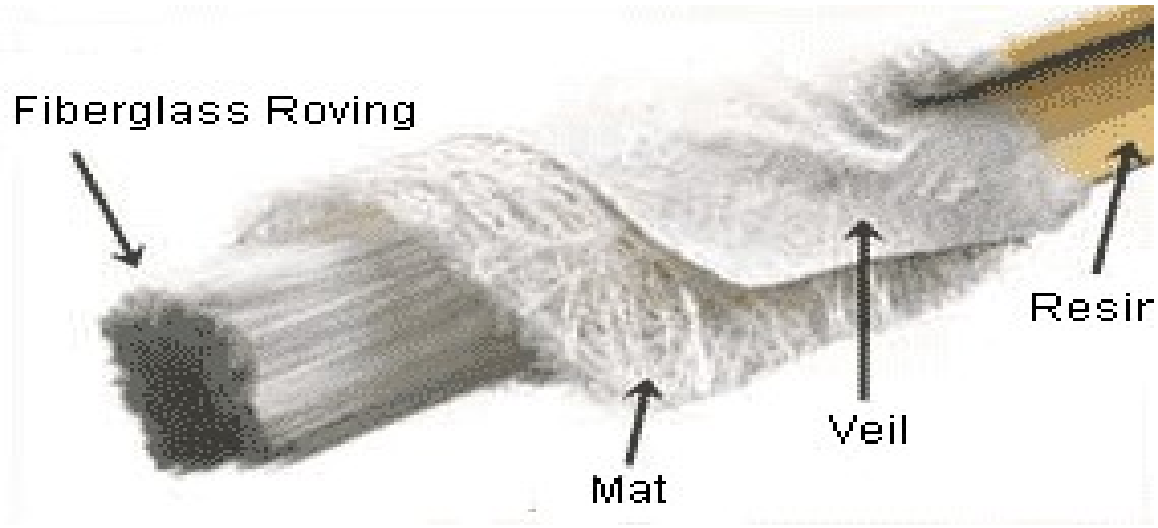


Fig. 2

Material options include generally any epoxy, polyester, vinyl ester or phenolic resin combined with any fiber type. Core materials are not generally used.

Pultrusion is a composite production method that results in low cost and high volume to medium volume ratios with good quality requirements and is used in the production of commercial and military products. Pultrude products are used in commercial applications where lightness, corrosion resistance, and/or low electrical conductivity are desired. There are some standards in the shape of the products in the markets where pultrusion products are sold; these can be in the form of a rod, angle, I-beams, panels, and plaques. The other uses of pultrude products are stair railings, fishing poles, tool handles, bus parts, etc. Today, S-glass, carbon, and kevlar reinforcement materials and epoxy, phenolic, and thermoplastic matrix materials can be used to produce by pultrusion method. The pultrusion method, thanks to its advantages can also be used in hardware areas such as aviation, transportation, sports equipment, and medical

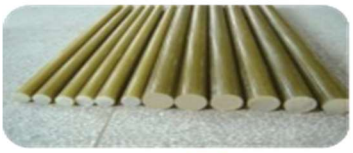
Advantages to pultrusion process include:

- This can be a very fast, and therefore economic, way of impregnating and curing materials.
- Resin content can be accurately controlled.
- Fiber cost is minimized since the majority is taken from a creel.
- Structural properties of laminates can be very good since the profiles have very straight fibers and high fiber volume fractions can be obtained.
- Resin impregnation area can be enclosed thus limiting volatile emissions.

2.4. Pultruded FRP Parts which is current production line

C-Channel

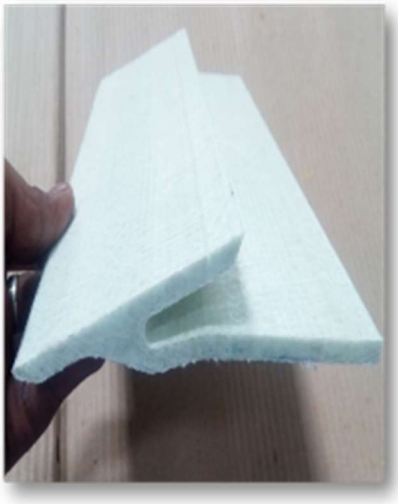
"I" Beam



FRP Rod

"L" Angle

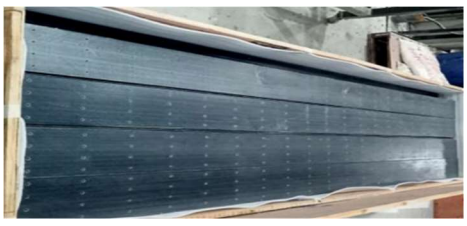
Y-PROFILE



FRP Handrail

FRP Cable Tray

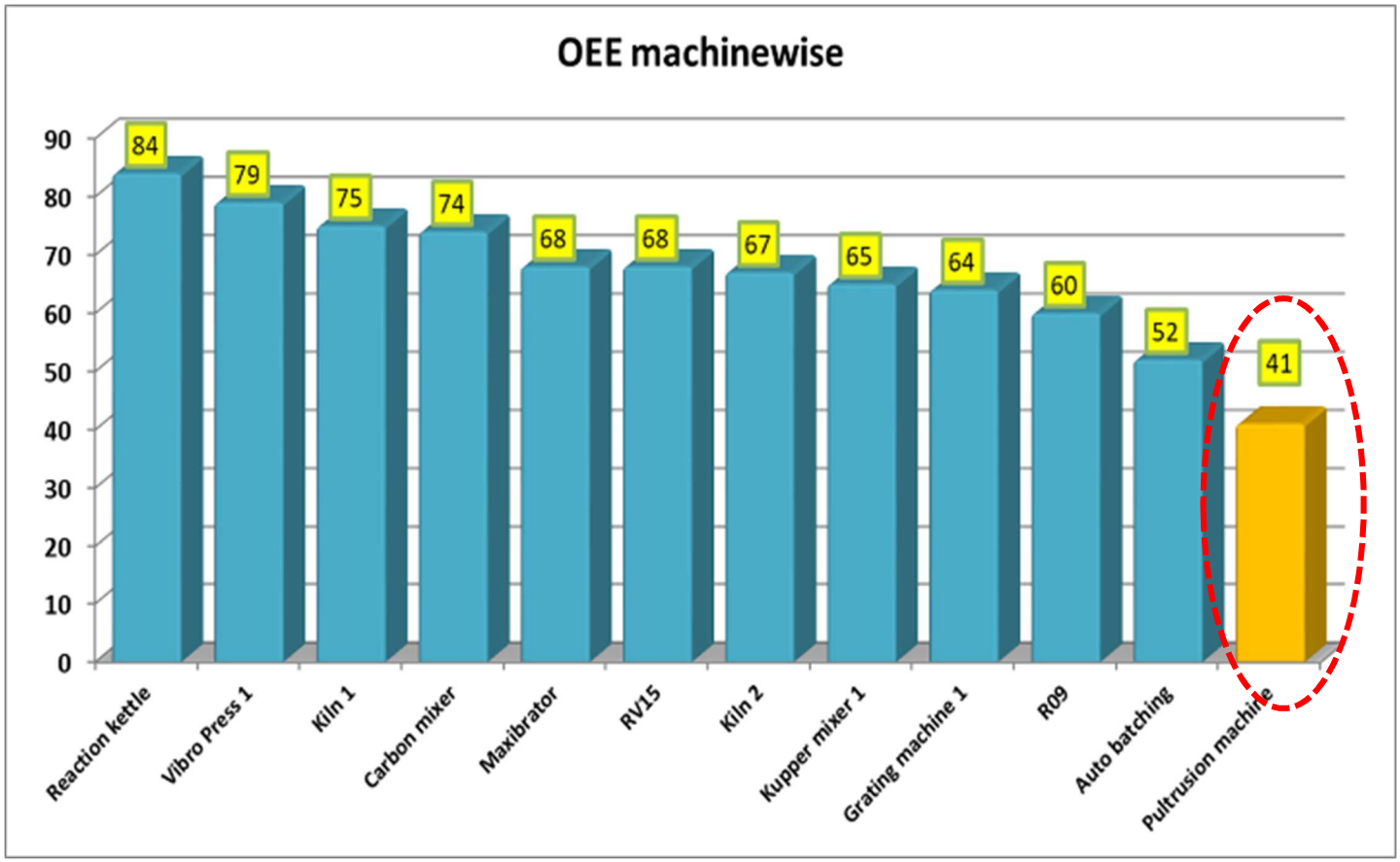
Ladder Type



Perforated Type

3. Problem Statement

Total we have in the company 12 types of the machines in the plant. In that Pultrusion machine production performance is very low compare to other machines. So Pultrusion machine was selected for improvement since OEE was very low - 41 %



Machine OEE low as factor of

Availability rate is 63.2%

Performance rate is 70%

Quality rate is 96%

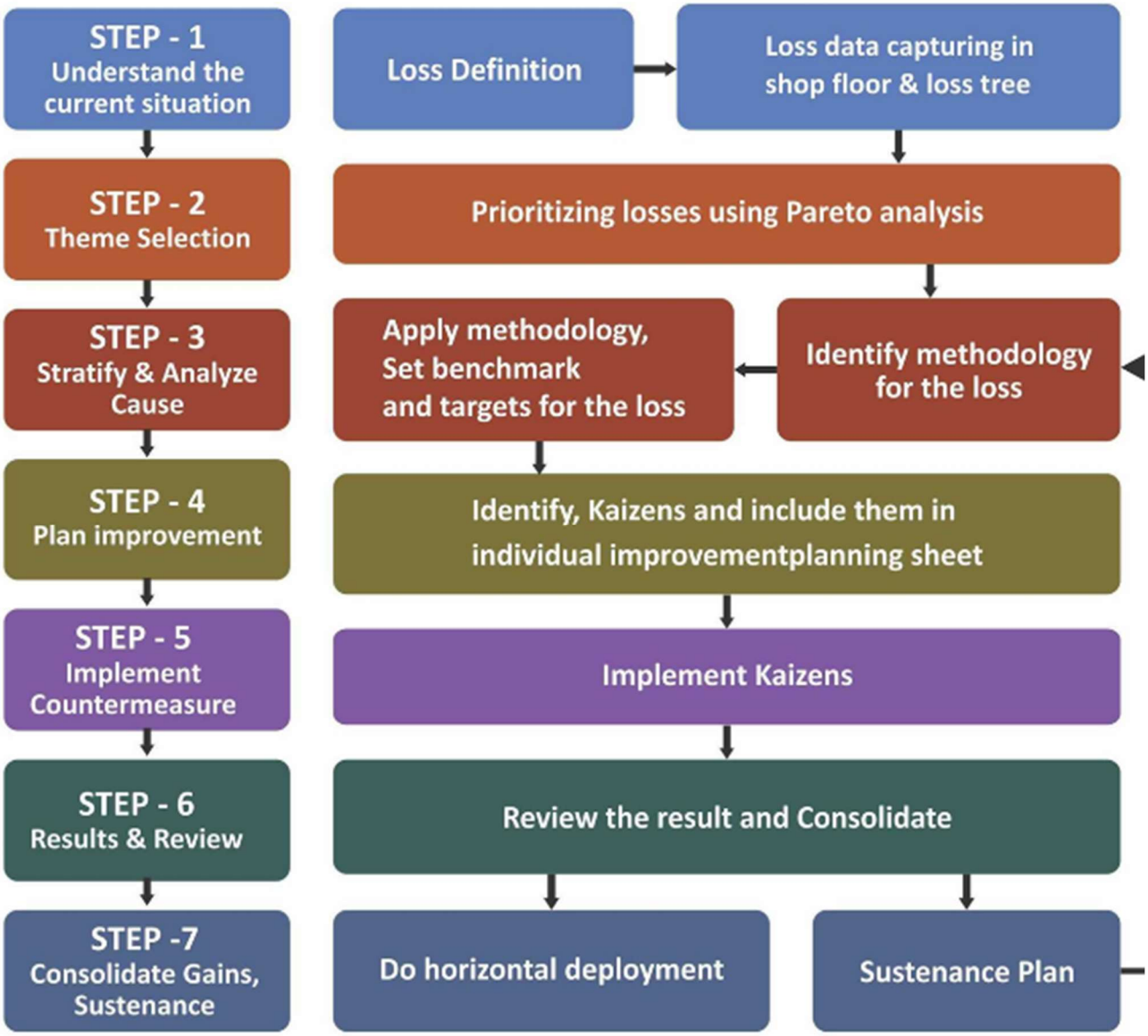
4. Team Formed for Improving OEE through TPM Methodology

Leader / Facilitator: Munusamy M – Production

Team Member:

1. **Prasanth K – Production**
2. **Sathishkumar V – QA**
3. **Harikirana – production**
4. **Sivashankar – Production**

Methodology followed - KK pillar 7 steps



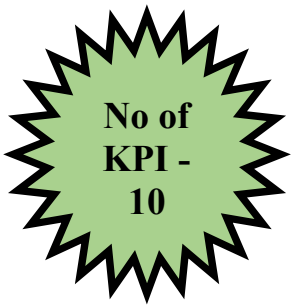
5.1. FRP Pultrusion { KMI – KPI – KAI }

KMI

KMI	Target
To increase sales volume	1000 L per annum
To improve of EBITDA	0.13
New product development	3 per annum
Nil Incidents / Accidents	Zero

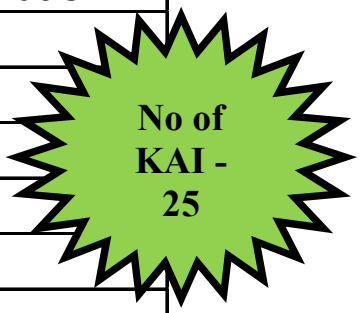
KPI

KPI
OEE Imrovement in filament winding
OEE improvement in pultrusion machine
Loss level reduction
Yield loss reduction
On Time Manufacturing
On Time Delivery
Reduction of specific power consumption
Manpower productivity improvement
Safety system implementation
Development of products for new application/market



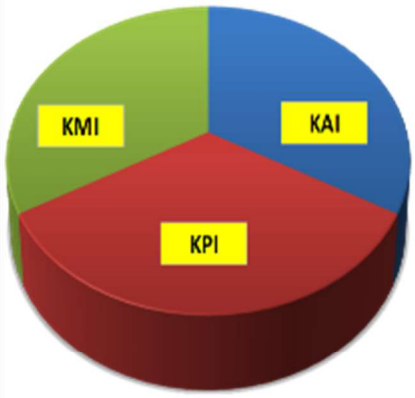
5.2.KEY ACTIVITIES INDICATOR

KAI
To identify & monitor losses (Loss 1 to Loss 7)
To do kaizens to reduce loss level
To implement energy related kaizens
To reduce rejection & rework level
To reduce lead time
To reduce grinding cost reduction
To reduce breakdown to increase AR
To reduce Setup & Adjustment loss in Pultrusion
To convert manual process into small scale automation & automation
Horizontal deployment
To conduct Market survey & take input
Alternate RM for reduction of product price
To conduct safety audit
Safety suggestion, Kaizens & mapping
To identify Unsafe condition & Unsafe act and eliminate them
To conduct training programs for Technical, Process, Safety & TPM
To reduce rework time (Trimming & Grinding) in gratting machine
To monitor near misses
To reduce start up loss in Pultrusion machine
VC reduction projects
Reuse/Recycle of scrap material
To reduce resin spillage
To develop environmental friendly products
To improve manpower productivity
To motivate people to give suggestions and do kaizens



5.3. KMI KPI KAI Matrix

FRP KMI - KPI - KAI



To increase sales volume - 100 L Per annum	To improve of EBITDA - 13%	New product development - 3 per annum	Nil Incidents/Accidents - Zero		To identify & monitor losses (Loss 1 to Loss 7)	To do kaizens to reduce loss level	To implement energy related kaizens	To reduce rejection & rework level	To reduce lead time	To reduce grinding cost reduction	To reduce breakdown to increase AR	To reduce Setup & Adjustment loss in Pultrusion	To convert manual process into small scale automation & autom	Horizontal deployment	To conduct Market survey & take input	Alternate RM for reduction of product price	To conduct safety audit	Safety suggestion, Kaizens & mapping	To identify Unsafe condition & Unsafe act and eliminate them	To conduct training programs for Technical, Process, Safety & TP	To reduce rework time (Trimming & Grinding) in gratting machin	To monitor near misses	To reduce start up loss in Pultrusion machine	VC reduction projects	Reuse/Recycle of scrap material	To reduce resin spillage	To develop environmental friendly products	To motivate people to give suggestions and do kaizens
★	★			OEE improvement in grating	★	★		★			★	★	★	★						★	★		★	★				
★	★			OEE improvement in Pultrusion machine	★	★		★			★	★	★	★						★	★		★	★				
	★	★		Loss level reduction				★					★			★									★			
				Yield loss reduction				★							★			★							★	★	★	
★			★	On Time Manufacturing					★							★					★		★					
★				On Time Delivery					★												★		★					★
	★			Reduction of Specific power consumption			★			★				★			★											
★	★			Manpower productivity improvement						★			★															
			★	Safety system implementation													★	★	★	★			★			★		
		★		Development of products for new Application/Market											★	★								★			★	

★ Strong relation

★ Moderate relation

☆ No/Weak relation

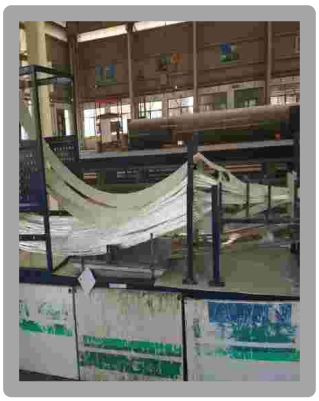
5.4. Pultrusion Machine Photos which selected for TPM Improvement

Machine Functions

1.Mat Cutting

2. Roving Stand

3. Resin Both



4. Heater die

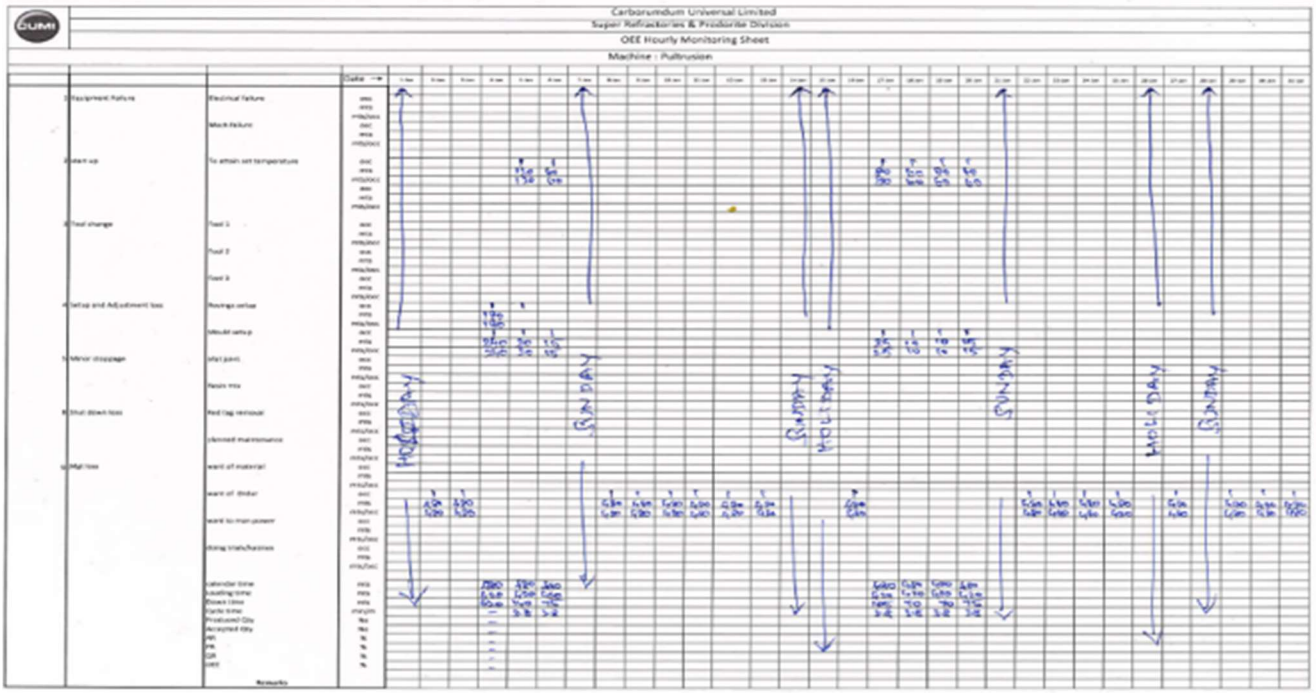
5. Puller

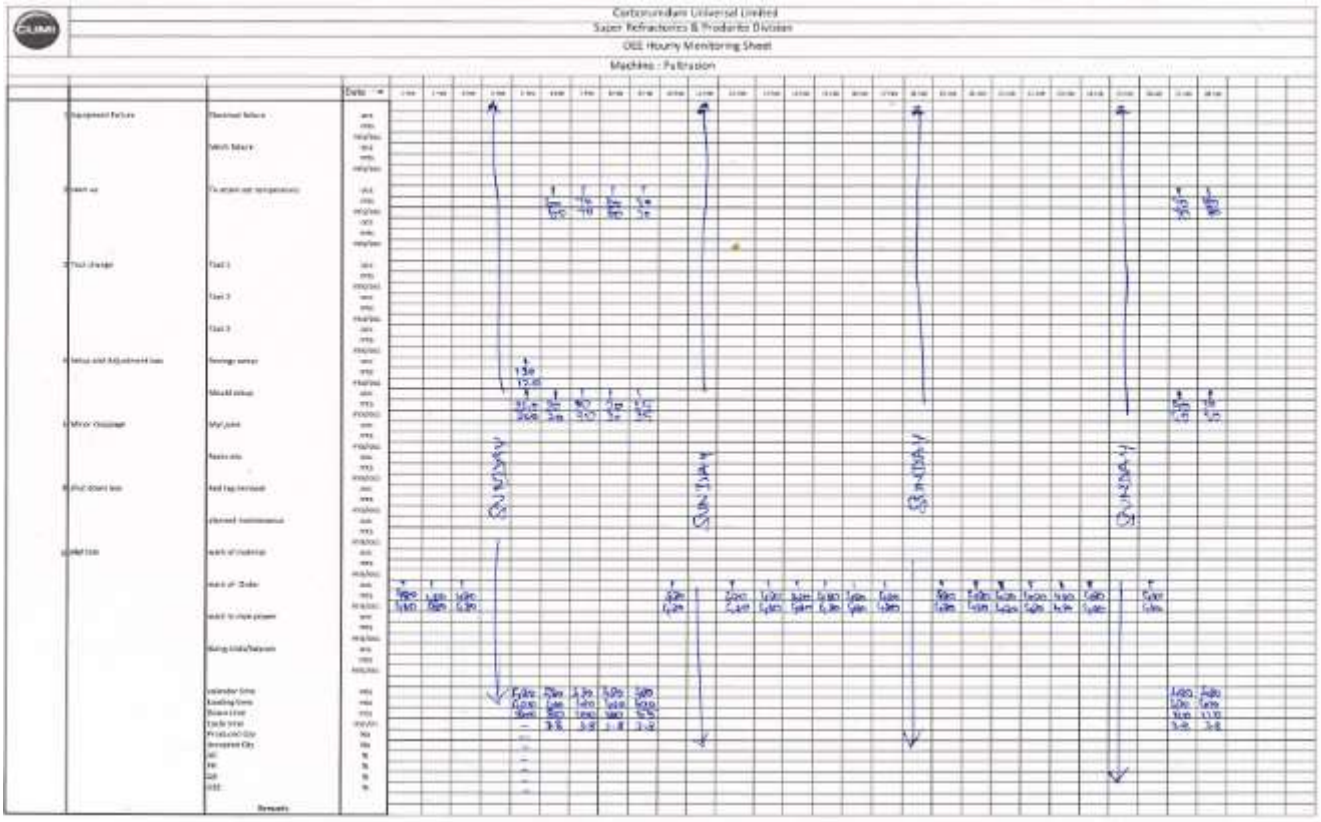
6. Control Unit

7. Product Cutting

5.5. Day to day Loss Data Collection in Shopfloor

Following Shopfloor data providing a concrete and manageable framework within which to categorize day to day losses. This makes it easier to see where your improvement efforts can have the greatest impact.





5.6. Down Time Analysis

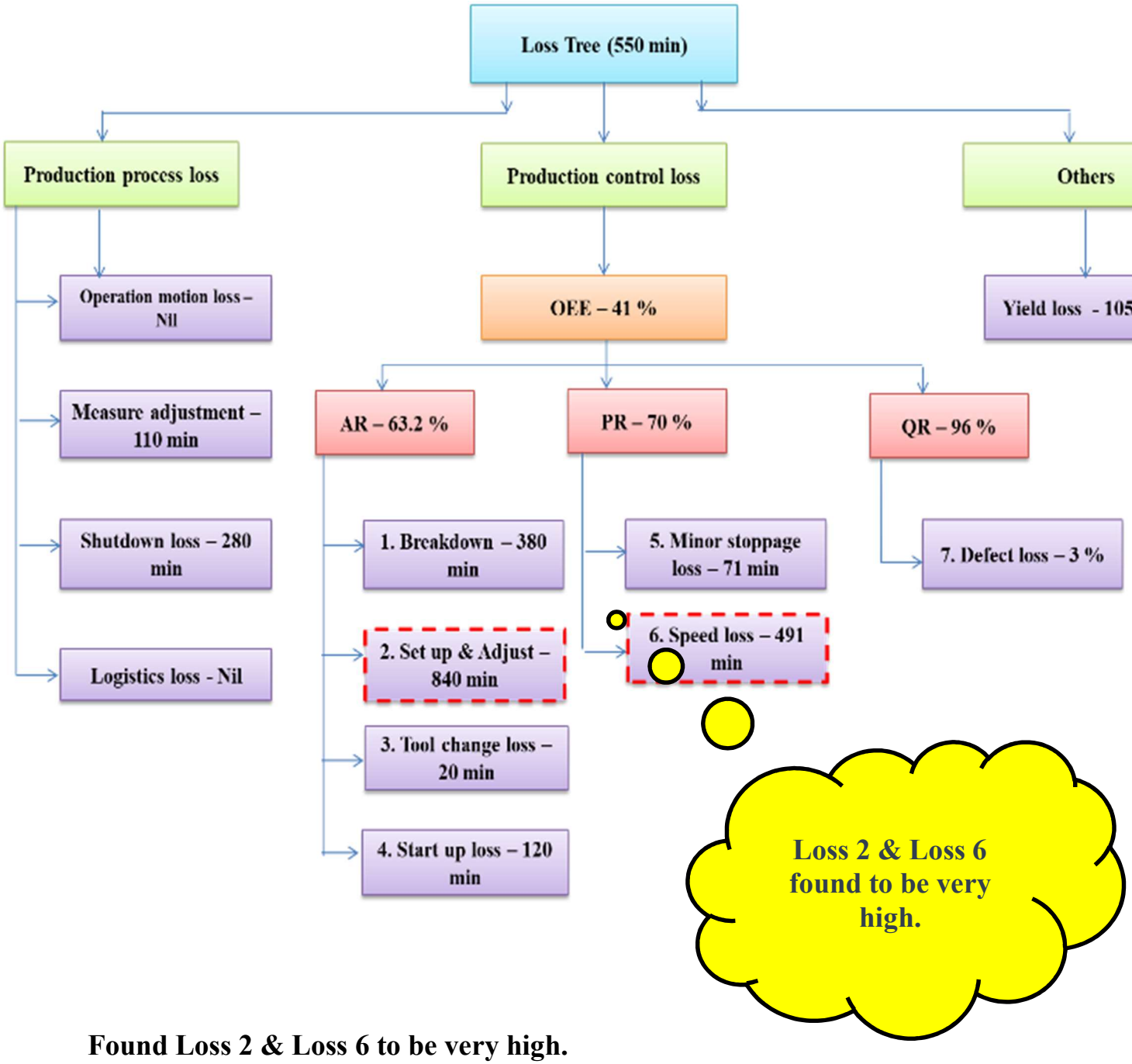
Machine downtime analysis is a process through which learn and understand exactly how often and why machines on the production line are not in use. As unplanned machine downtime is a huge challenge in production machines, this analysis is key to finding out what is causing downtime and how to prevent it.

Here I show the data collection of 5w1H format to find each area loss and sub losses.

CUMI	DOWNTIME ANALYSIS (KK PILLAR)										Carborumdum Universal Limited Super Refractories & Prodorite Division		
							Analysis for the month :						
Sl.No	What	When			Where	Which	Why	How	Loss	Sub Loss	Resp	Target	Status
	Reason for Stoppage	From	To	Duration	Area	Location	Root Cause	Counter Measure / Kaizen				Date of Completion / Planned	Completed / Under Progress
1	Mold Heater Ramping Time	9:00am	10:am	60 Mins	Mold	Heating Zone	To attain Set Temperature	1.Extra side heating provided in the mold 2. Watts to be increased 3. Insulation	Startup	Time for temperature to reach	Rajesh		
2	Roving Set up	10.00am	10.20 am	20 Mins	Preformer Plate	Roving Stand	Due to multiple end of rovings	Marking on the preformer	Setup loss	Excess Time for rovings preparation	Selva		
3	Mold Setup	10:30am	1:30pm	180Mins	Mold	Heating Zone	Manual Operation	Introducing Pneumatic Wrench	Tool change	Time for manually changing Mold	Selva		
4	Machine Operation	11.30	11.30.40	40 Sec	Clamping	Puller Zone	Travelling time more	Reduce the travlling time	Speed Loss	Time for gripping	Sathish		
5	Vaccum collection	12.00	12.05	5 Mins	Vaccum pump	Cutting zone	Due to separate switches of veccum pump and cutting Machine	Combine electrical Switch for both M/C	Speed Loss	Additional time	Sathish		
6	Puller clamping sheet	10.00	11.10	70 Mins	Puller	Puller Zone	Wear	New sheet to be procured	Speed Loss	Additional time	Munusamy		
7	Fixture broken	2.00	3.00	60 Mins	Puller	Puller Zone	Due to low strength material	New fixture with MS	Setup loss	Additional time	Sarfraz		
8	Mat shortage	1.00	2.30	90 Mins	Mat cutting	Mat cutting ZONE	Due to unavailability of cuted mat	Introducing Mat Storage stand with minimum stock level identification	Startup	Machine stop	Ram		
9	Product bend	11.00	12.30	91 Mins	Mould	Heating Zone	Misalligenment	Mould Stopper to be introduced	Tool change	Defectes	Pradeep		
10	Rovings cut inside the mould	11.30	2.30	180 Mins	Mould	Resin bath	No visual identification	Colour coding and visual indication to be provided for the material flow	Setup loss	Machine stop	Dhanapal		
11	Mat roll dislocate	6.30	6.40	10 Mins	Mat rolling stand	Roving Stand	Unavailability of stopper the roller position is changed freequently	Stopper to be introduced	Speed Loss	Excess Time for mat preparation	Ram		

6.1. Pultrusion machine Loss Tree

Loss tree is one of the effective continuous improvement tools used to drive productivity through Overall Equipment Efficiency losses elimination. Preliminary steps of measuring and analyzing will be followed with improvement plans and strategies.



Found Loss 2 & Loss 6 to be very high.

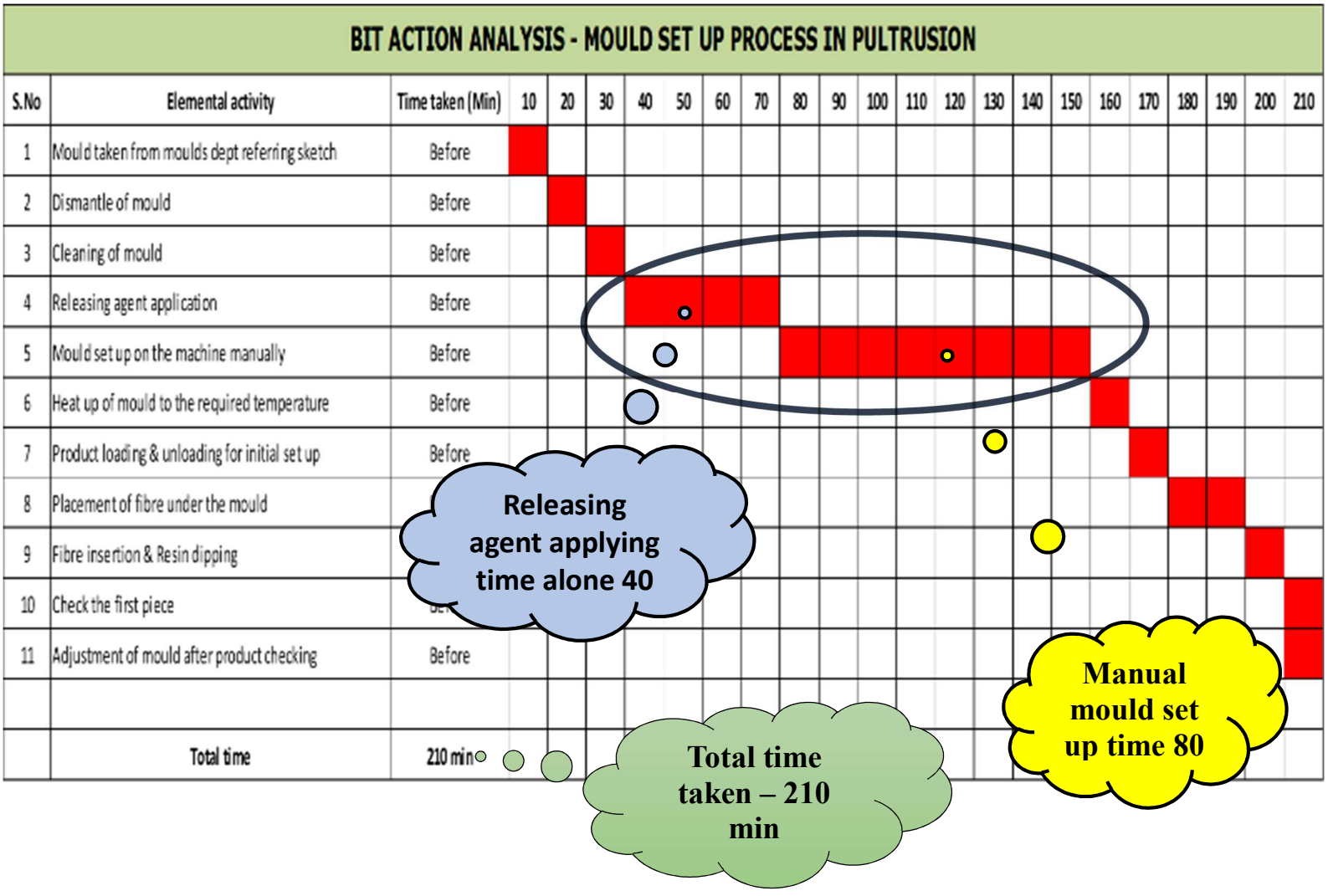
Loss 1 : Setup Adjustment – 840min

Loss 6: Speed loss- 491min

6.2. Loss 2. Set up & Adjustment loss reduction kaizens

Setup and Adjustments accounts for any significant periods of time in which equipment is scheduled for production but is not running due to a changeover or other equipment adjustment. A more generalized way to think of Setups & Adjustments is as any planned stop. Setup and Adjustments is an Availability Loss.

BIT action analysis for Mould setup process– Before

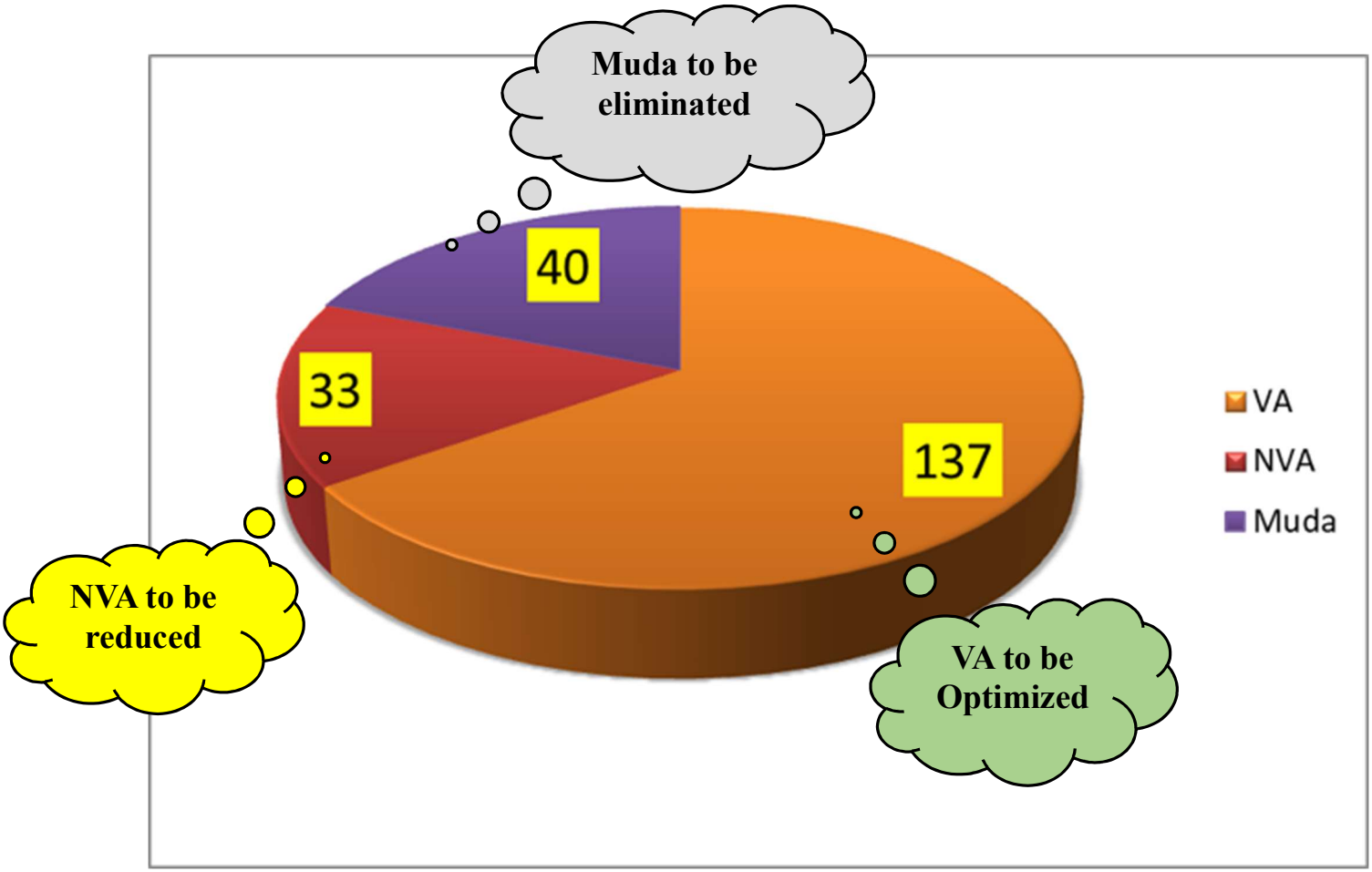


Total time taken for mould setup and adjustment 210 min

1. Releasing agent applying time alone 40 min
2. Manual mould set up time 80 min

6.3. Stratification of VA, NVA and waste

In order to reduce cost while keeping up with the competition, NVA activities might be eliminated, ENVA activities might be reduced, or simplified by becoming 'lean' (muda). Through Lean perspective, every activity is categorized as either a Value Added (VA) or Non-Value Added (NVA) activity. However, it should be noted that even some perceived NVA activities which may be necessary to comply with certain requirements. Such activities are termed as Essential Non-Value Added (ENVA) activities. Our goal is to reduce the waste or non-values added activity so as to maximize the value to our customer.



Action planned to increase the machine availability rate through finding non value activities.

Total 6 no's of Kaizen's completed for setup & Adjustment losses. In that 3 major kaizen's are shown here for ref.

7.1.1. Set up & Adjustment loss - Kaizen 1

The manual process is more time-consuming and expensive than an automated process. Manual processes involve one or more humans performing tasks, such as two person involved for bolt tightening with more effort, while automated processes involve one or more machines performing tasks, such as use proper tool to complete the task single hand without more efforts.

Observed manual working in mould assembly and dismantling. This cause to increase the working time and Operator fatigue issues.

Action taken for mechanised bolt tightening by providing pneumatic air gun.

KAIZEN

Theme : To reduce time taken for mold assembly & dismantling time.

Kaizen : To semi automate or automate manual works

Before	After
	
Existing : Manual	New : Semi automated & Self
Analysis	**Result**

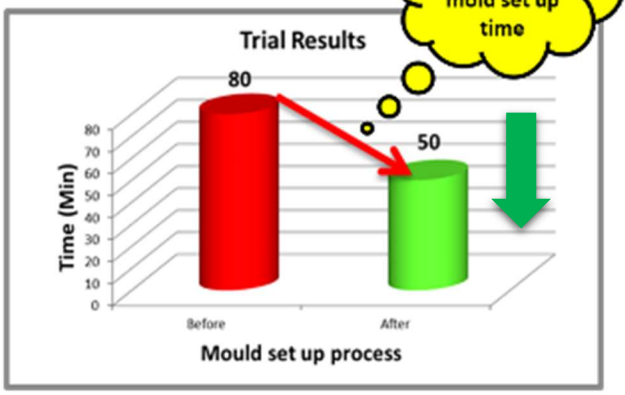
ANALYSIS:

More time spent in mold assy & dis assy
> manual tighten & loosen of bolts & Many set ups for mould assembly

Root Cause : Manual work

Kaizen Idea: To automate or semi automate

Counter measure: Air gun & Self locking moulds



Result

- Reduced mould setup time 80min to 50 min
- Operator morale improved

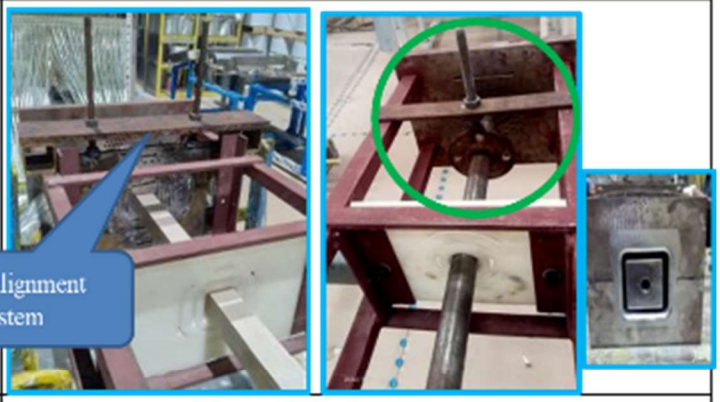
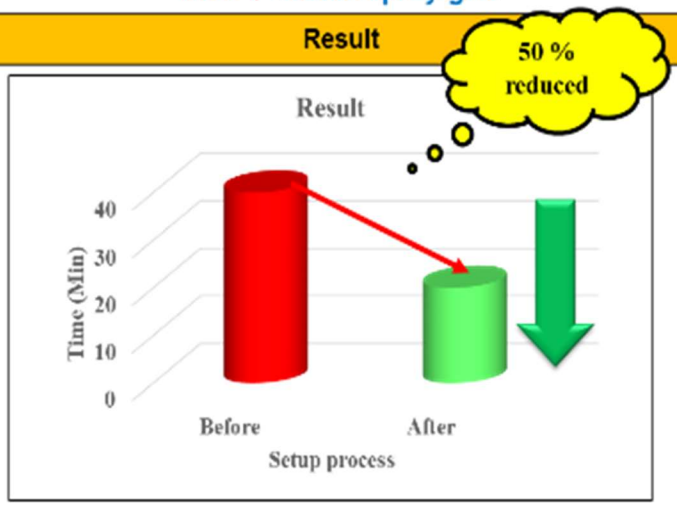
7.1.2. Set up & Adjustment loss - Kaizen 2

Observed problem in for roving pulling in bottom of the core. After assembly the core end always coming down and making centre of the core is difficult. Mostly operator pulling roving's in the bottom area, then they push the centre core. The total setup time of 40min.

KAIZEN

Theme : To reduce core assembly setup time

Kaizen : Core alignment time reduced by providing backend core alignment system

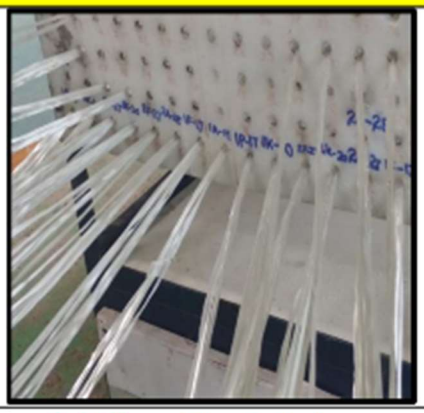
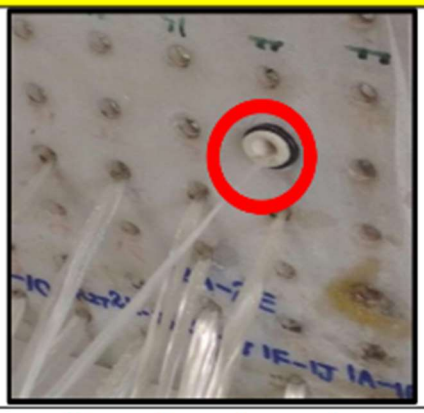
Before	After
	
Existing : Manual work	New : Nozzle spray gun
Analysis	**Result**
ANALYSIS: **Roving pulling difficulties > Core not align center > through tighten roving** Root Cause : falling down core end Kaizen Idea: providing backend core alignment system Counter measure: core alignment system	

Result

- Reduced mould setup time 40min to 20 min
- Operator morale improved

7.1.3. Set up & Adjustment loss - Kaizen 3

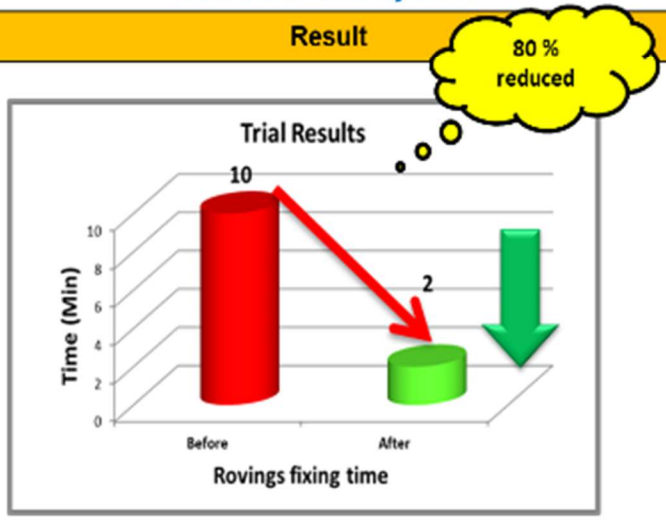
Roving fixing time high for worn out the PP sheets holes. Thus provided ceramic eye lets to avoided worn out issue.

<table>
<tr><th colspan="2">KAIZEN</th></tr>
<tr><td colspan="2">Theme : To reduce roving setup time through pre-former</td></tr>
<tr><td colspan="2">Kaizen : To providing ceramic eye lets to improve roving flow</td></tr>
<tr><th>Before</th><th>After</th></tr>
<tr><td>  </td><td>  </td></tr>
<tr><td>Existing : Plastic holes</td><td>New : Ceramic eye lets</td></tr>
<tr><th>Analysis</th><th>Result</th></tr>
<tr><td><u>ANALYSIS:</u>

Rovings fixing taking more time
➢ Getting struck in the holes
➢ Hole surface is not smooth
➢ Worn out

Root Cause : Hole surface not smooth because of worn out

Kaizen Idea: To make smoother surface

Counter measure: Ceramic eye lets</td><td> 
</td></tr>
</table>

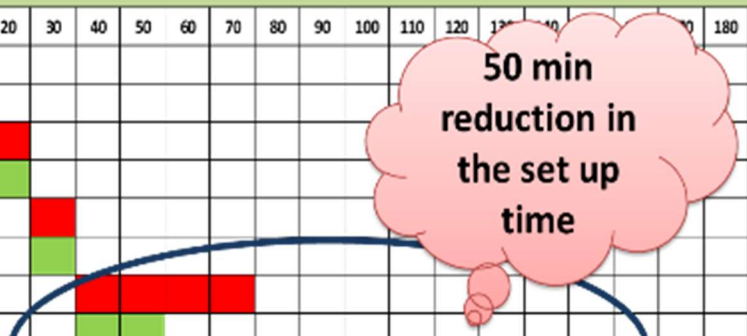
Result

- Reduced roving fixing time 10min to 2min
- Eliminated worn out issue
- For smooth surfaces roving fixing time reduced 10min to 2min.
- Operator morale improved

7.1.4. BIT action analysis for Mould setup process – After

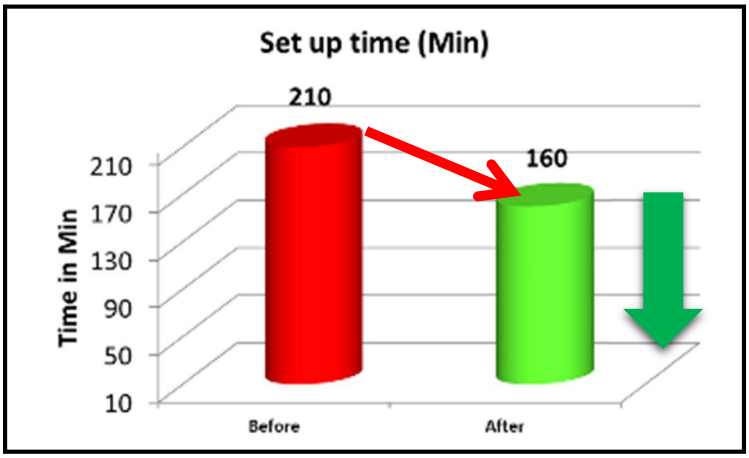
BIT ACTION ANALYSIS - MOULD SET UP PROCESS IN PULTRUSION

S.No	Elemental activity	Time taken (Min)
1	Mould taken from moulds dept referring sketch	Before
		After
2	Dismantle of mould	Before
		After
3	Cleaning of mould	Before
		After
4	Releasing agent application	Before
		After
5	Mould set up on the machine manually	Before
		After
6	Heat up of mould to the required temperature	Before
		After
7	Product loading & unloading for initial set up	Before
		After
8	Placement of fibre under the mould	Before
		After
9	Fibre insertion & Resin dipping	Before
		After
10	Check the first piece	Before
		After
11	Adjustment of mould after product checking	Before
		After
	Total time Before	210 min
	Total time After	170 min



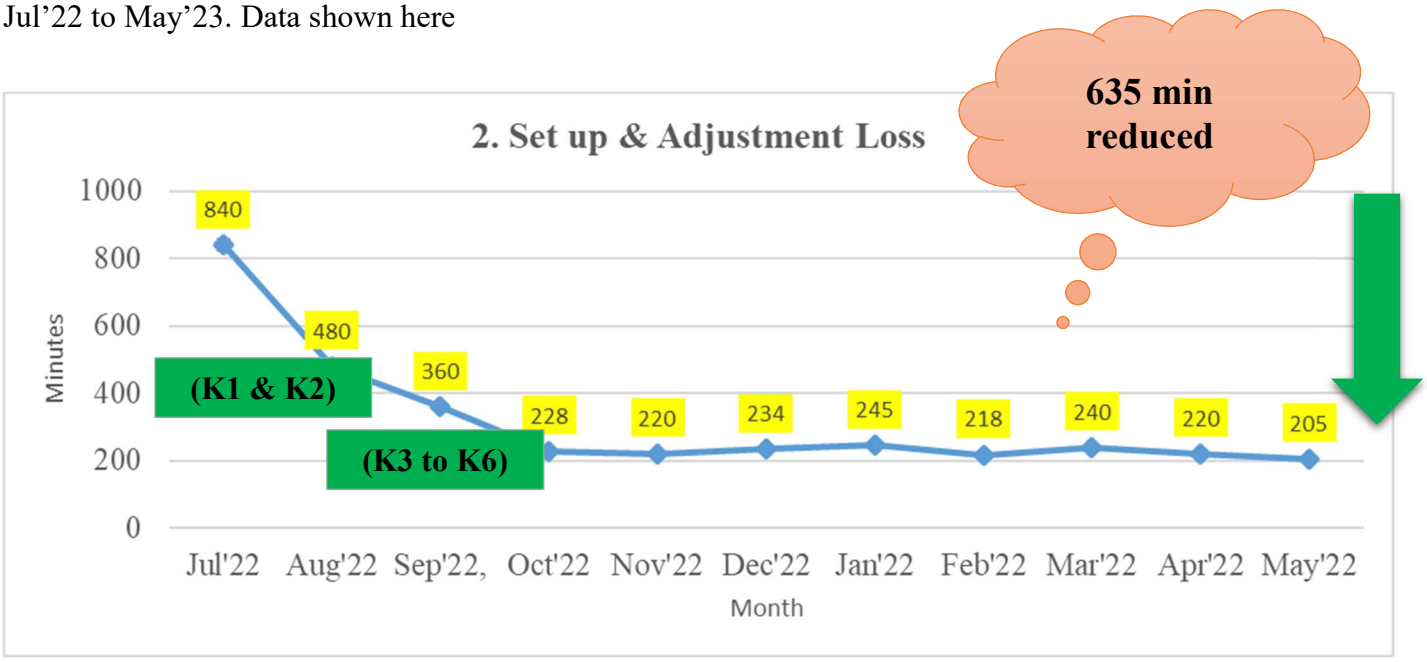
Before – 210 min After – 160 min

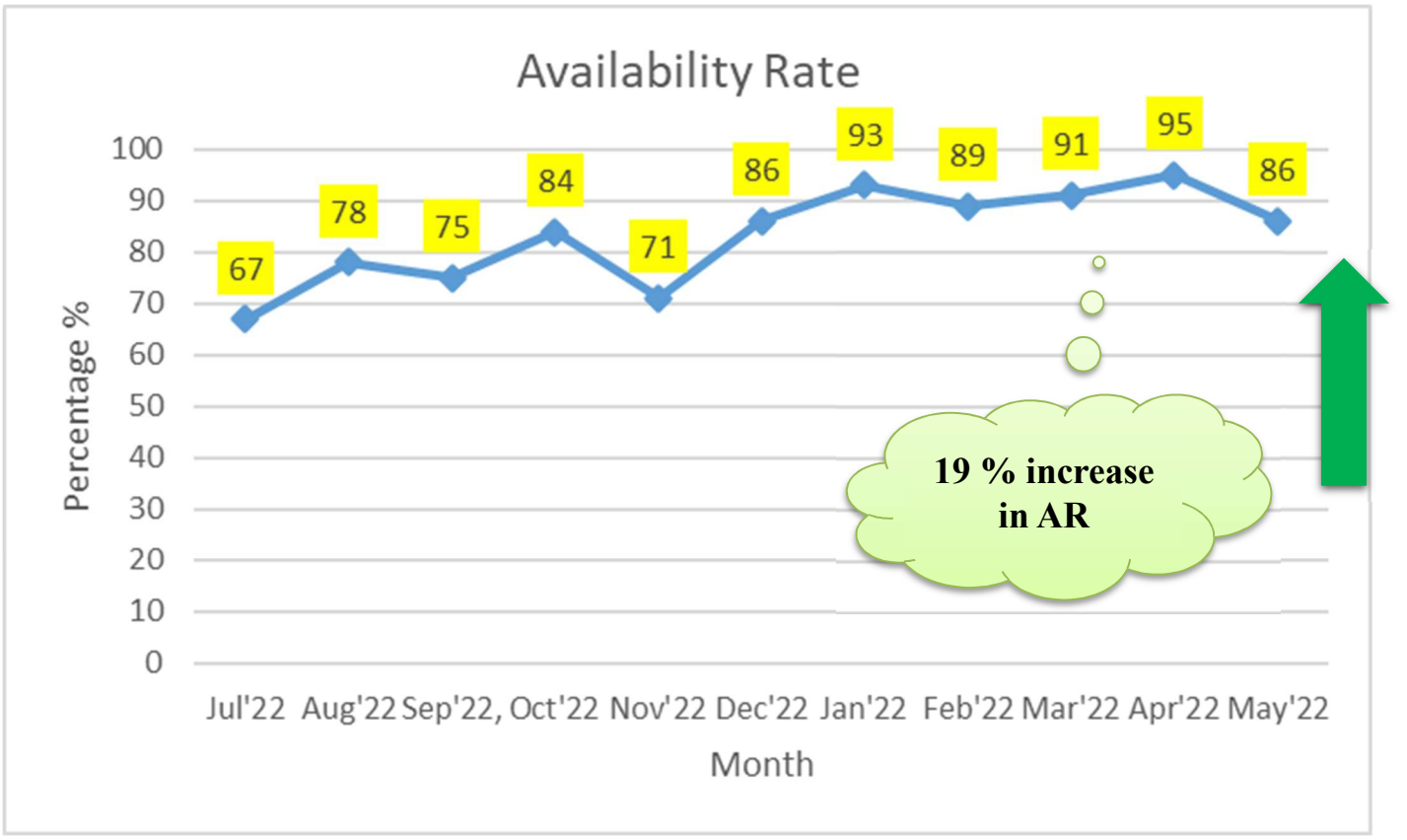
Result



7.1.5. Loss Trend

Based on kaizen's to reduced setup & adjustment losses and increased the availability rate from Jul'22 to May'23. Data shown here





7.2.1. Loss 6. Speed loss reduction kaizen's

Speed Loss is production time lost to equipment running below maximum rated speed. An alternative term for Reduced Speed in the Six Big Losses and affects OEE Performance. Examples of common reasons for Idling and Minor Stops include misfeeds, material jams, obstructed product flow, incorrect settings, misaligned or blocked sensors, equipment design issues, and periodic quick cleaning.

Action taken to improve the machine speed losses. Total 7 nos of kaizen's done for speed loss reduction. For reference major 4 kaizen's shown here,

7.2.2.1. Kaizen 1, Activity 1: Fibre glass & Roving aiding through performer / Guide Plate with new design. Thus improving the minor stoppages and roving stuck issues during the production process.

Before improvement

Fig : 1

After Improvement

Fig : 2 & 3

Before Improvement:

Preformer / Guide Plate without proper design

1.One manpower continuously aiding the fiber glass into mold Fig.1

2.Operator fatigue is High.

3.Machine speed control the man while manual operation

After Improvement:

Preformer/Guide Plate with new design.

1.Eliminated human intervention during the process Fig.2

2.Operator is free from the Fiber aiding process to control the machine speed

3.Operator fatigue is low.

7.2.1.2. Kaizen 1, Activity 2: Roving misaligned during process due to bulk roving pulling system.

Action taken for sequences of free roving guiding plate system through resin bath

Before improvement

After Improvement

Before Improvement: Resin bath without Guide plate

1.One manpower continuously allocated to check the Roving's Flow & Continuity.

2.Operator stressed to identify if any Roving's miss aligned or broken & difficulty to reconnect it.

After Improvement: Resin bath with guide plate

1. Created easy to roving's flow & without stuck during the process
2. Operator can easily reconnect the roving's without difficulty
3. Operator fatigue decreased

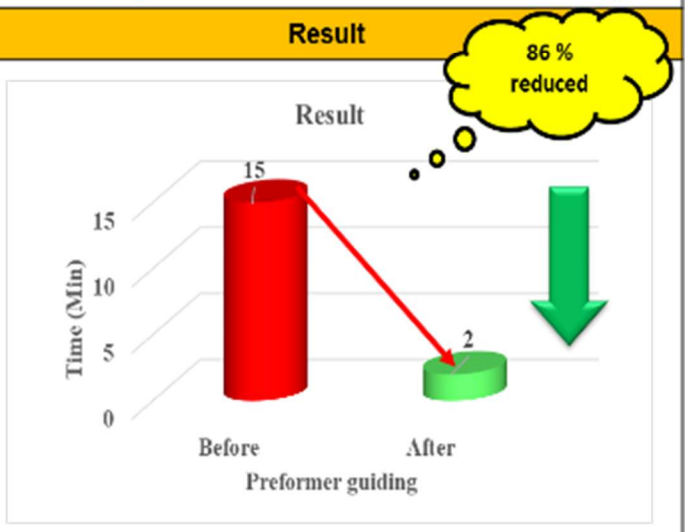
7.2.1.3Speed Loss Kaizen: 1

To increase the PR by reducing minor stoppages during the process. Kaizen idea of design the new performer guide tool to improve the roving flow without man intervention to operate the machine as per scheduled speed of the rate.

KAIZEN

Theme : To increase the PR by reducing minor stoppages

Kaizen : To provide proper performer guiding for free flow of the roving's

Before	After
	
Existing : Operator aiding roving	New : Operator is free from the Fiber aiding
Analysis	**Result**
ANALYSIS: Minor stoppages > Operator fatigue > existing method Root Cause : Improper performer guider Kaizen Idea: To provide proper performer guider Counter measure: design the new performer guide tool to improve the roving flow	

Result:

- Reduced minor stoppage during the process 15min to 2min.
- Reduced operator fatigue
- Reduced one operator in the process
- Morale improved

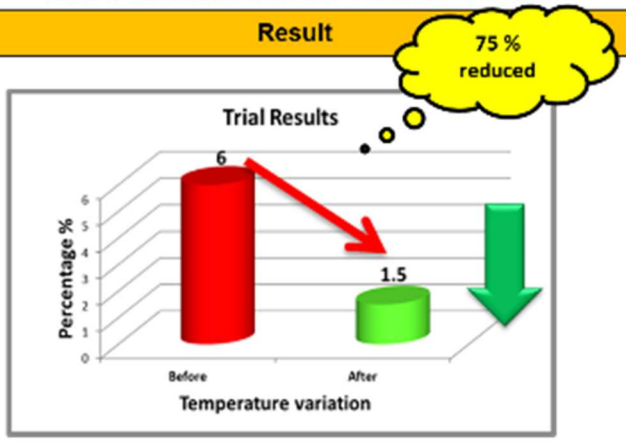
7.2.2. Speed Loss Kaizen 2:

Heat concentration is most common factor for pultrusion process. Due to heat losses part curing vary and reducing the machine operating speed. The pulling force occurs starting from fibre creel until the die inlet and mostly occurs when cross linking reaction between polymer molecules inside heated die.

To increase the PR by reducing the heat variation in the mold. By provide insulated cover over the die to arrest the heat losses.

<table>
<tr><th colspan="2">KAIZEN</th></tr>
<tr><td colspan="2">Theme : To increase the PR by reducing the heat variation in the mold.</td></tr>
<tr><td colspan="2">Kaizen : To provide insulated cover over the die to arrest the heat losses.</td></tr>
<tr><th>Before</th><th>After</th></tr>
<tr><td>  </td><td>  </td></tr>
<tr><td>Existing : No heat containment cover</td><td>New : Aluminum cover with insulation</td></tr>
<tr><th>Analysis</th><th>Result</th></tr>
<tr><td><u>ANALYSIS:</u>

Heat variation in the mold > Heat loss > Mould exposed to open atmosphere

Root Cause : No heat containment cover for mold
Kaizen Idea: To insulate
Counter measure: Fabricated aluminum cover lined with insulated ceramic fabric</td><td> 
</td></tr>
</table>

Result:

- Reduced temperature variation 6% to 1.5%
- Heaters & Mold are Enclosed by the Heat resistant shield – Eliminated Unsafe condition

7.2.3. Speed Loss Kaizen 3:

In composite resin curing is one of the main factor to define the product conversion. The exothermic reaction of the matrix begins when the composite reaches initiation temperature at which the gelation of the resin is also observed. Therefore, the thermosetting resin plays the important part in the degree of curing behaviour. Have to choose the correct curing agent for pultrusion process to stable the resin nature up to mould heat curing. To adding high reactive curing agent for improving resin setting time while heat die at recommended temperature. It will be sustenance to pull the part recommended speed of the process.

KAIZEN

Theme : To reduce the resin setting time there by improving the productivity.

Kaizen : To add high reactive material for improving resin setting time

Before	After
	
Existing : Low reactivity	New : Higher reactivity
Analysis	**Result**

ANALYSIS:

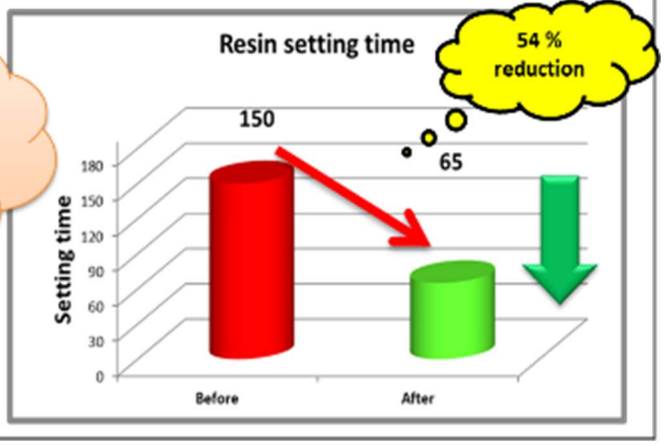
Product output is low
- **Cycle time is more**
- **Reaction was slow**

With support from R & D team

Root Cause : Reaction was slow

Kaizen Idea: To alter setting agent

Counter measure: Higher reactivity materials

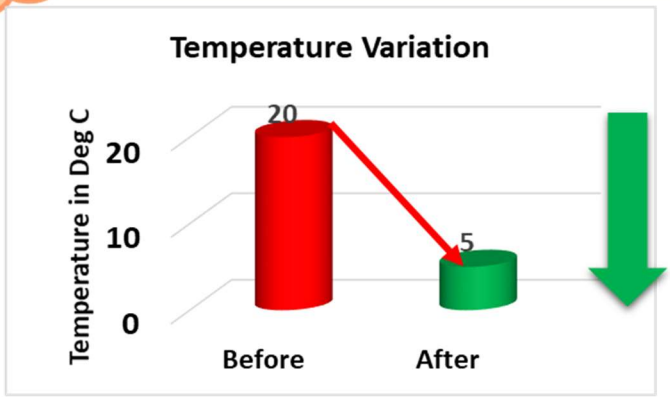


Result:

- Resin setting time reduced 150min to 65min by using alter curing agent
- Morale improved

7.2.4. Speed Loss Kaizen 4:

Mould curing is the one of the most important parameters in the pultrusion production process. This is the step where the fibers begin to solidify into their final shape, as the heat initiates the cross-linking process within the impregnated reinforcements. A key consideration during this step is the temperature. A low temperature can result in a weak composite profile, while a temperature that is too high can cause the composite to crack. Also the pulling speed must be controlled properly to reduce the pulling force through the pultrusion die. The pulling force occur starting from fibre creel until the die inlet and mostly occurs when cross linking reaction between polymer molecules inside heated die. The factors that influenced the pulling speed of the composites during pultrusion process is frictional force, viscous force and internal die pressure. When the velocity of the pulling speed reduces, the damage on the pultruded material can be reduced

KAIZEN	
Theme : To control the temperature variation	
Kaizen : Thermistor type temperature controller instead of contactor type	
Before	**After**
	
Existing : Contactor	**New : Thyristor**
Analysis	**Result**
ANALYSIS: Temperatur variation high > cut off temperature high > Contactor function **Root Cause :** Contactor cut off not happening **Kaizen Idea:** Changed to Thyristor **Counter measure:** Control the temperature variation through Thyristor	

Supported by Maintenance team

Result:

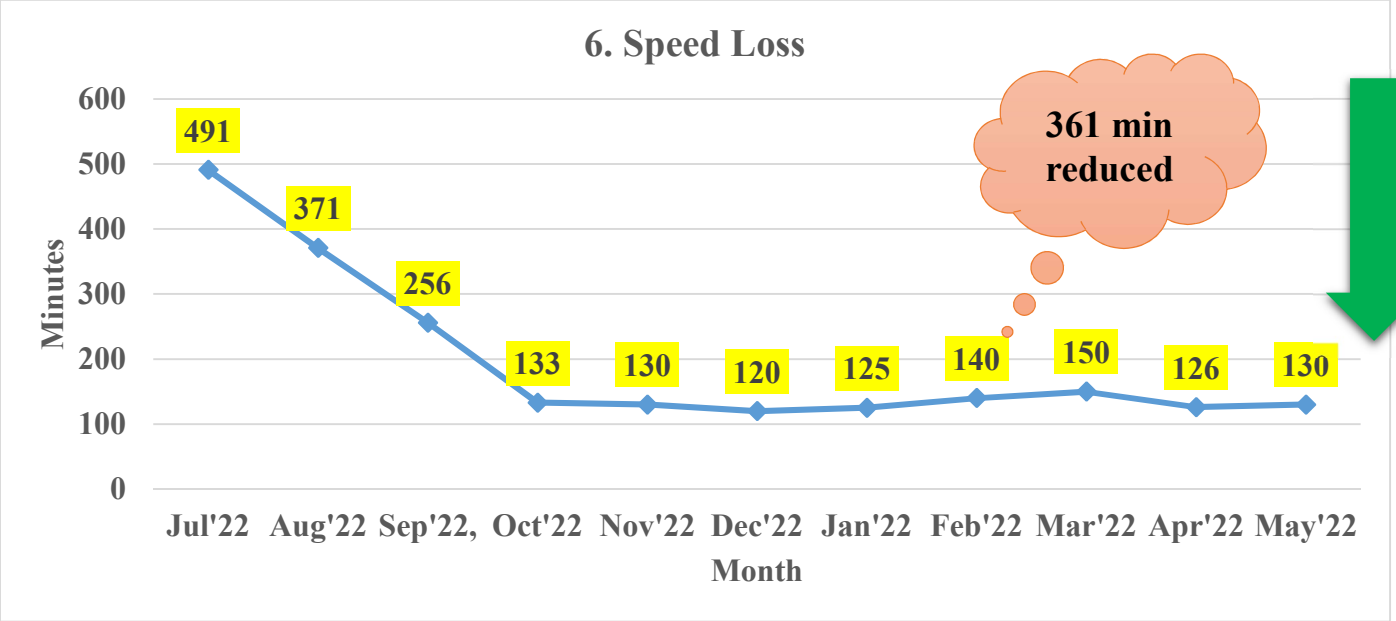
- Control the temperature ±5deg C
- Increased the pulling speed from 1.6mm/min to 1.8mm/min continuously.

7.3. Speed Loss Trend

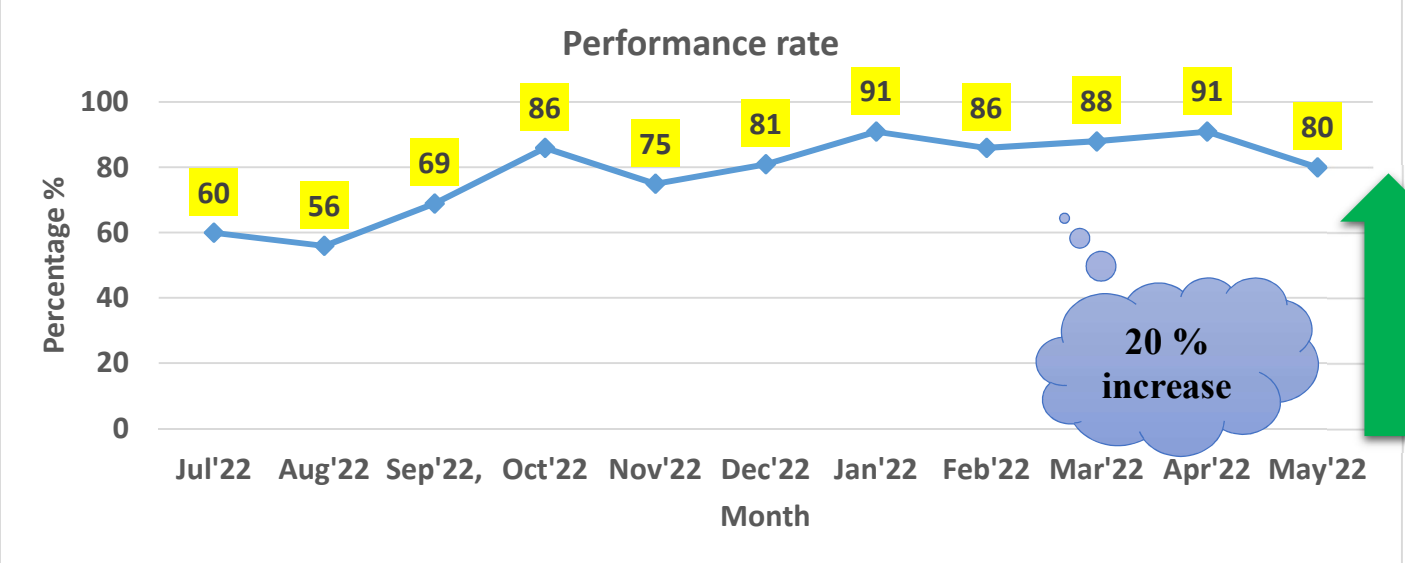
Based on kaizen's to reduced speed losses and increased the performance rate from Jul'22 to May'23.

Total reduction time of 361minutes and improved performance rate of 20%

Data shown here



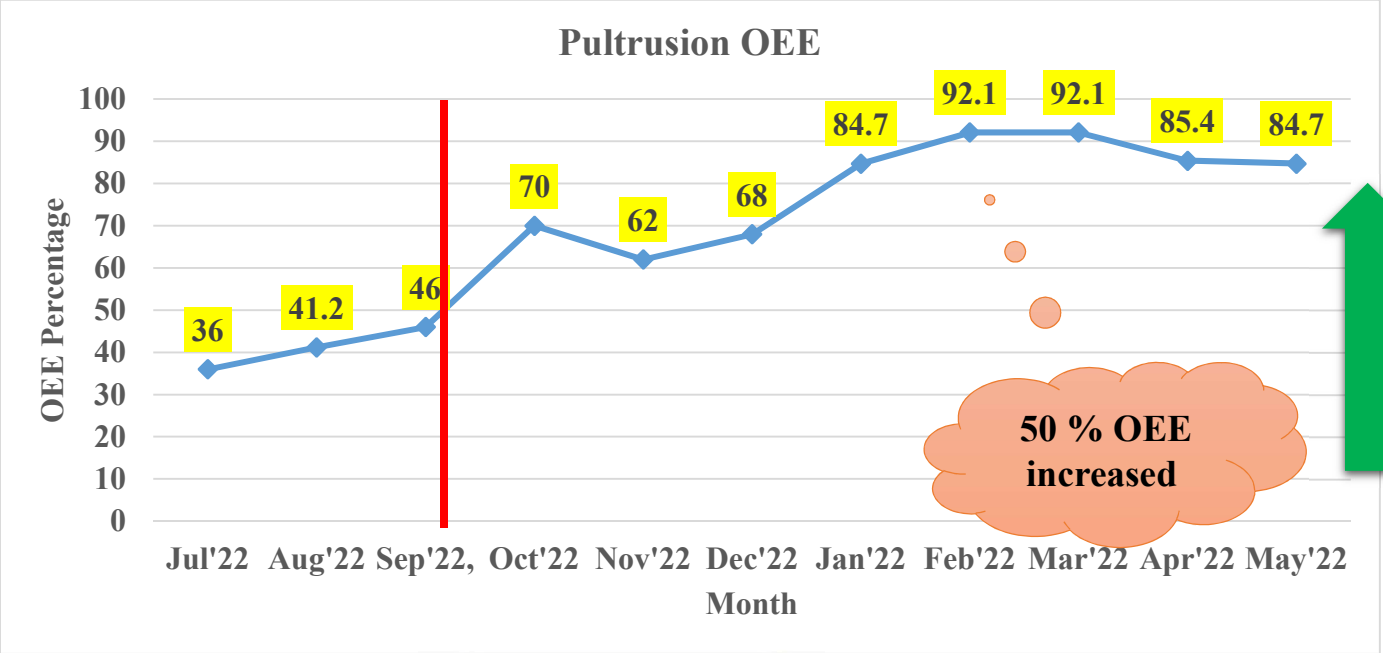
7.4. Performance Rate Trend



7.5. OEE Trend

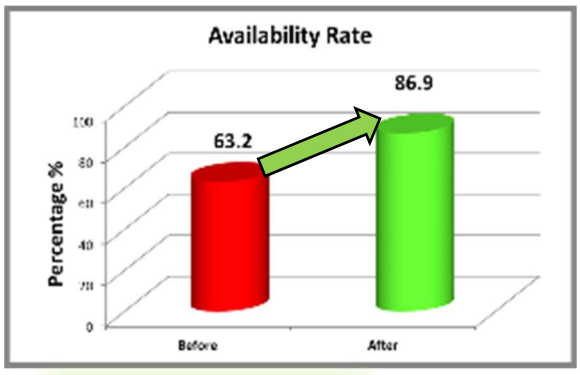
The preferred OEE calculation is based on the three OEE Factors: Availability, Performance, and Quality. OEE is calculated by multiplying the three OEE factors: Availability, Performance, and Quality.

Pultrusion machine OEE increased 50% based on kaizen's activities to increase the machine availability and performance rate.

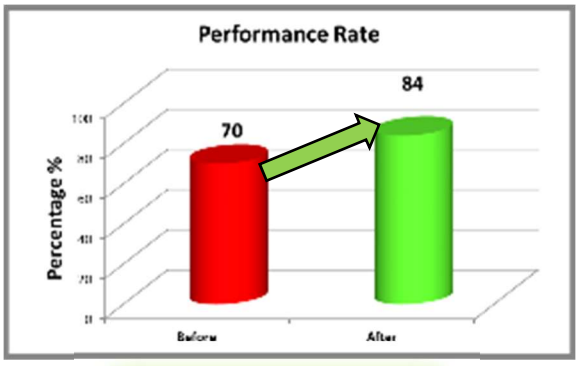


BEFORE **Target > 85** **AFTER**

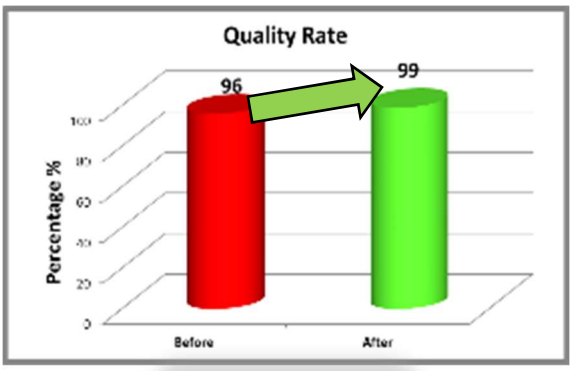
7.6. AR, PR, QR & OEE Target fixed



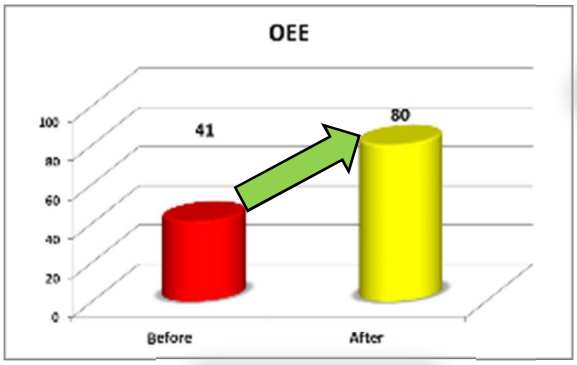
Target > 90



Target > 95



Target >



Target > 85

Avg 39 % increase in OEE

7.7.1. Improvement planning chart

Kobetsu Kaizen is a Japanese term which means 'targeted improvement' or 'Focused Improvement'. It is one of the 8 pillars of the TPM system. Kobetsu Kaizen approach is adopted to create a loss structure or loss tree for the equipment and its performance is improved through kaizen Initiative.

Implementing Kobetsu Kaizen requires the involvement of employees from different departments, including operations, maintenance, engineering, quality control, and management. Each department has a unique role to play in the improvement process, and collaboration among departments is critical to the success of the program.

Best Practices for Kobetsu Kaizen Implementation and Sustenance.

Some best practices for successful implementation and sustenance of Kobetsu Kaizen include:

- Providing training and resources to support improvement projects
- Encouraging open communication and collaboration among employees involved in improvement projects
- Establishing clear roles and responsibilities for employees involved in improvement projects
- Developing a system for measuring and monitoring the effectiveness of improvement projects
- Recognizing and rewarding employees for their contributions to improvement projects
- Standardizing improved processes
- Continuing to monitor and improve processes on an ongoing basis

Here I Given improvement planning chart which followed this project.

Total no of loss kaizen’s identified -23

Cost saving done this project – 21 lac

7.7.2. Individual Improvement planning chart which followed for this improvement activities

Individual Improvement Planning Chart.

LEGENDS

NEW THEME IDENTIFIED — KAIZEN DONE — C - Critical

Area	Major theme			Medium theme				Kaizen No	KZ no.	Minor theme / Kaizen Theme	Target for Completion / Status	UOM	BM	Target	Status [Actual]
	Case name	Target	Status	Case name (Loss wise)	BM	Target	Status								
Pultrusion	AR IN MINS														
	AR			Setup and Adjustment Losses	940	220		9	4	Manual resin mixing is converted into pneumatic stirrer mixing to increase the AR		Mins	15	3	Completed
								15	5	To increase the AR by modifying the mold design for easy access		Mins	90	35	Completed
								6	6	To reduce the cleaning time of the stored mold by using release agent		Mins	60	3	Completed
								14	7	Smooth flow of rovings in the preformer stand by marking on the preformer guiding plate		Mins	180	60	Completed
	PR IN MINS														
	PR			Speed Loss	401	132.5	NIL	11	8	Monitoring of mold temperature by increasing the thermo couple insert hole depth		Mins	45	10	Completed
								3	9	To reduce heat variation in the mold by covering insulated fiber blanket cover		%	6	1.5	Completed
									10	To increase the PR by run the machine in semi mode		Mins	4	2	Completed
									11	Introduce Aluminium coated heater with 1500watts for fast heating of the mold		Mins	120	60	In process
								19	12	Limit switch for cutting of different sizes of product		Mins	2	0.5	Completed
								5	13	To control the Temp variation during process by modifying the temperature controller		°C	8	2	Completed
								16	14	To increase the productivity by changing the resin mix formulation		Mins	320	60	Completed
				Minor stoppage	71	2.5		2	15	To avoid minor stoppages of machine by interconnecting of both Cutting & dust collector M/C switches		Secs	60	30	Completed
								12	16	Joining of Glass mat by adhesive spray instead of manual stiching		Mins	10	2	Completed
								4	17	To increase the PR by introducing the cut mat storage stand		Mins	60	0	Completed
	QR in Mtr														
	Quality Rate -			Defect & Rework	40	4		1	18	To prevent the roving's cut down issue		%	20	2	Completed
								7	19	To avoid product cross cutting defect by modifying the cutting table		%	10	1	Completed
								18	20	To reduce the bend defect in all pultruted profiles		%	10	1	Completed
					5	0.5		10	21	To reduce the wastage of excess Resin mix remains in the resin bath		Kg	5	0.5	Completed
				Mold loss	3	1		20	22	To avoid wear on the rovings by fixing of ceramic eyelet		%	3	1	Completed
					200	0		21	23	Reduction of material wastage by alteration in the existing mold		Kg	200	0	Completed

Total No of Loss Kaizens - 23

7.8.1. One Point Lesson

A One-point Lesson (OPL), also known as a single-point lesson, is a one-page procedure that uses images and short-form text to communicate the expectations of a process. It is intended to be a quick and precise way to learn about a complex process. Also more visual and lesser text representations i.e., 80 percent pictures and 20 percent words. In lean methodology the OPLs are often used in Kaizens, TPM, 5S, JIT, Safety, etc. as usage of machines, checking oil levels, performing autonomous maintenance, dos and don'ts, and many more.

In this project 46 nos of OPL visualized for enhanced the operations. In that I give two sample OPL for reference

8.1.1. OPL prepared for handling of roving bundles

TPM Club India

ONE POINT LESSON

CUMI

Theme	Needs at the Fiber glass storage area			No	OPL/FRP/PUL-006		
				Date of Preparation	22/11/2022		
Classification	Basic knowledge	Improvement cases	Trouble cases	TPM – Coordinator	HOD	Circle Leader	Prepared by
		✓					Sathish

X	Bottom side of the Glass rovings are direct contact with floor	✓	No direct contact with Glass rovings & the floor

Actual Results																	
	Date Executed	22/11	22/11	22/11	22/11	22/11											
	Teacher																
	Student																

Sample: OPL 1

.

7.8.1.2. OPL prepared for puller block rubber sheet proper fixing

TPM Club India

ONE POINT LESSON

CUMI

Theme	Change of puller block	No	OPL/FRP/PUL-010
		Date of Preparation	22/11/2022

Classification	Basic knowledge	Improvement cases	Trouble cases	TPM – Coordinator	HOD	Circle Leader	Prepared by
	✓						Rajesh

X	Operator not ensure the correct puller block was fixed correctly as per the mold
✓	Operator first ensure the correct puller block was fixed correctly as per the mold

Actual Results																
	Date Executed	22/11	22/11	22/11	25/11	25/11	25/11									
	Teacher															
	Student															

Sample: OPL 2

7.9.1. POKA YOKE

Poka-yoke is a powerful tool used within kaizen - a Japanese business philosophy for continuous improvement. It can be thought of as a continuous approach to reducing human errors that get in the way of processes. Error-proofing refers to the implementation of fail-safe mechanisms to prevent a process from producing defects. This activity is also known by the Japanese term poka-yoke, from poka (inadvertent errors) and yokeru (to avoid) - pronounced POH-kuh YOH-kay.

In this project 6 nos of Poka-yoke implemented for reducing the error during the operations. In that I give one sample Poka-yoke for reference

Poka-yoke prepared for to avoid mold position offset due to vibration

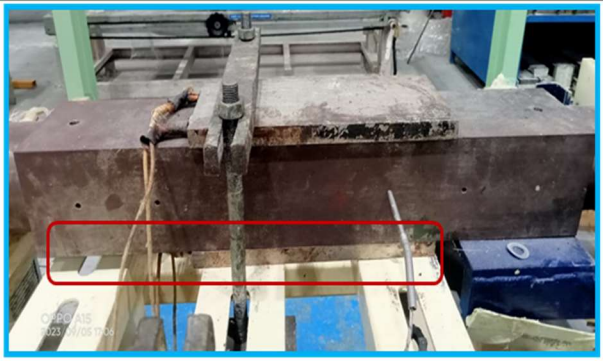
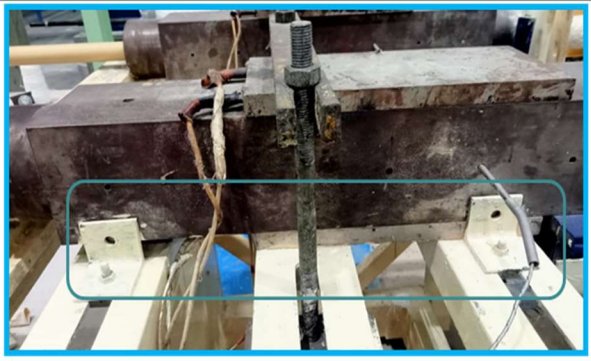
Project Title: Mold position offset due to vibration

Poka-Yoke Sheet	**Company Name : CUMI** **Location :**			
Problems: **1 Mold position offset** **2. Part stuck up** **3. Defects in part** **4. Existing method**	✓	**Prevent Error**	✓	**Control**
		Detect Error		**Alarm**
				Shutdown

Project start date: 14-12-2022

Project completion date: 20-12-2022

Tick any one category

Before	**After**
	

Benefits & Key results:	**Team:**
➢ Mold position fixed & Eliminated mold movement. ➢ Easy to ensure the Mold-Puller straightness. ➢ Cost saved Rs.2.5lac per year.	Harikirana U R Siva Shankar Ganesh Elumalai P

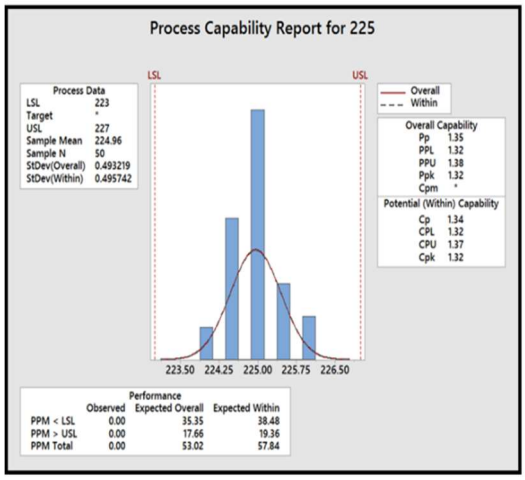
7.10. Process Capability study

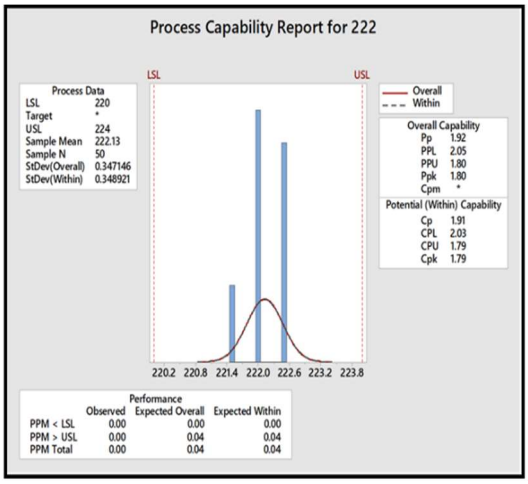
Process capability is defined as a statistical measure of the inherent process variability of a given characteristic. A process capability study uses data from an initial run of parts to predict whether a manufacturing process can repeatably produce parts that meet specifications. Think of it as being similar to a forecast.

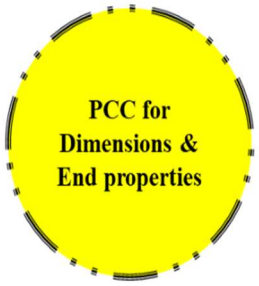
Based on data collections calculated process capability through Minitap.

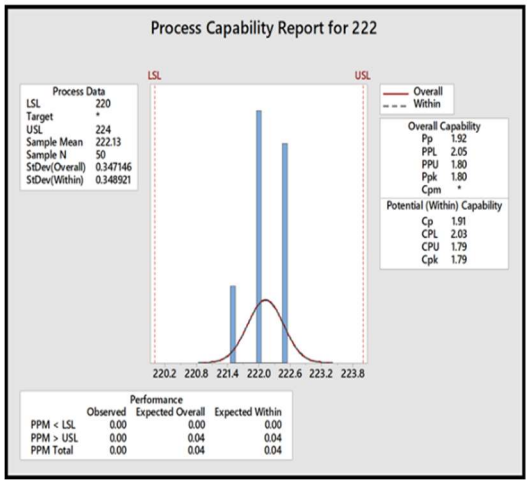
Values and capabilities details shown here.

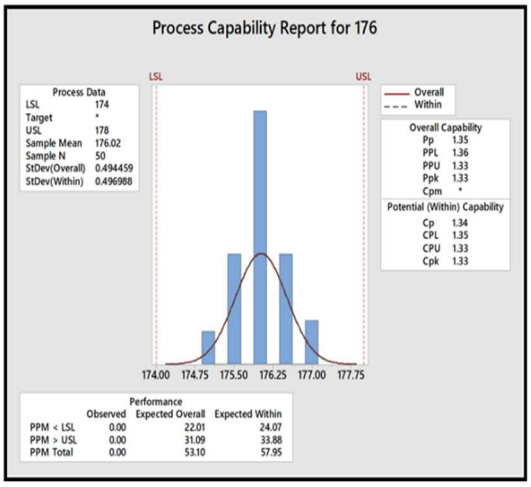
Process Capability Chart











7.11.Circle Meeting

Regular meetings are necessary to build strong interpersonal relationships, improve decision-making, increase productivity, encourage inclusion, promote team alignment, boost unity, and more.

I conducted weekly meeting for following the activities to meet the target and arranging the material requirements.

Here I shown weekly TPM Circle meeting sheet for ref.

Week 1 meeting sheet

TPM CIRCLE MEETING				
Circle No.	5			
Circle meeting conducted on	13-10-2022			
Circle meeting members present	5			
Munusamy M, Prasanth K, Sathishkumar V, Harikirana, Shivashankar				
Sl. No.	Discussion/Action points	Target date for completion of action points	Responsible person for completion	Status
1	Fabrication Materials for KK Kaizens pending from vendors	04-11-2022	Ram	Ongoing
2	Cleaning to be improved in machine, CLIT to be followed correctly	05-11-2022	Team members	Ongoing
3	Totally 13 kaizens identified, we completed 2 kaizens, weekly two to be completed, more kaizens required	05-11-2022	Prasanth K	Ongoing
4	Safety Kaizen discussion	06-11-2022	Harikirana	Ongoing
5	OPL Training & Discussion	26-10-2022	Sivashankar	Ongoing
Minuted By :		Sathishkumar V		

Week 5 meeting sheet

TPM CIRCLE MEETING				
Circle No.	5			
Circle meeting conducted on	10-11-2022			
Circle meeting members present	5			
Munusamy M, Prasanth K, Sathishkumar V, Harikirana, Shivashankar				
Sl. No.	Discussion/Action points	Target date for completion of action points	Responsible person for completion	Status
1	Fabrication Materials for KK Kaizens pending from vendors, Target date is 4-11-2022 but not yet closed	06-12-2022	Ram	Ongoing
2	Cleaning to be improved in machine, CLIT to be followed correctly	05-11-2022	Team members	Closed
3	Kaizens added Totally 27 kaizens identified, we completed 13 kaizens, weekly two to be completed, more kaizens required	06-12-2022	Prasanth K	Ongoing
4	Safety Kaizen discussion, 4 Kaizens received, one completed, Immediate action required	06-12-2022	Harikirana	Ongoing
5	OPL Training & Discussion, 12 OPL completed	06-12-2022	Sivashankar	Ongoing
Minuted By :		Sathishkumar V		

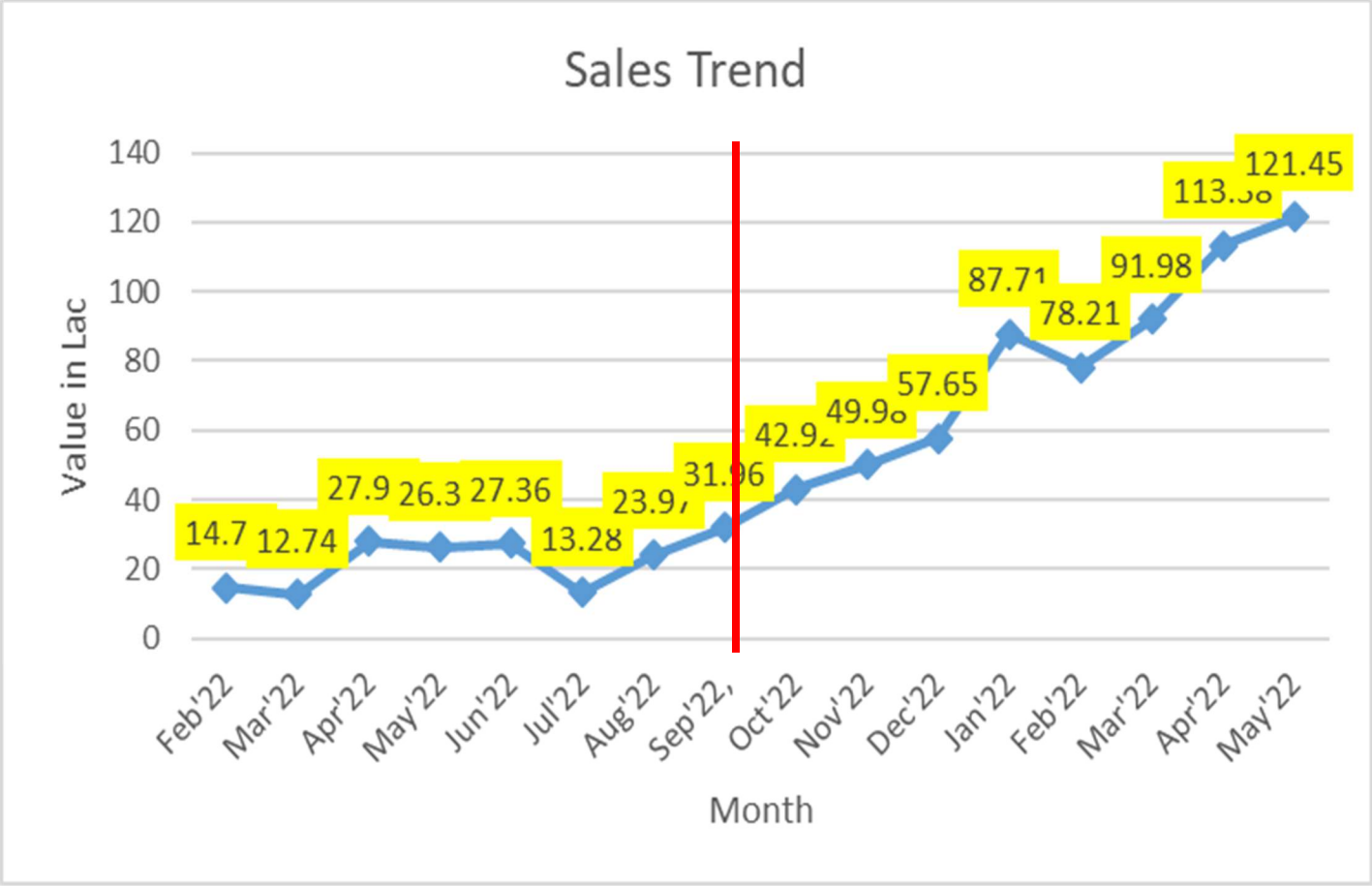
8.1. Sales Trend

Monthly sales value improved based on OEE improvement through TPM Methodology.

Sales trend data shown here.

Before Project avg, sale value of 22.2 lac

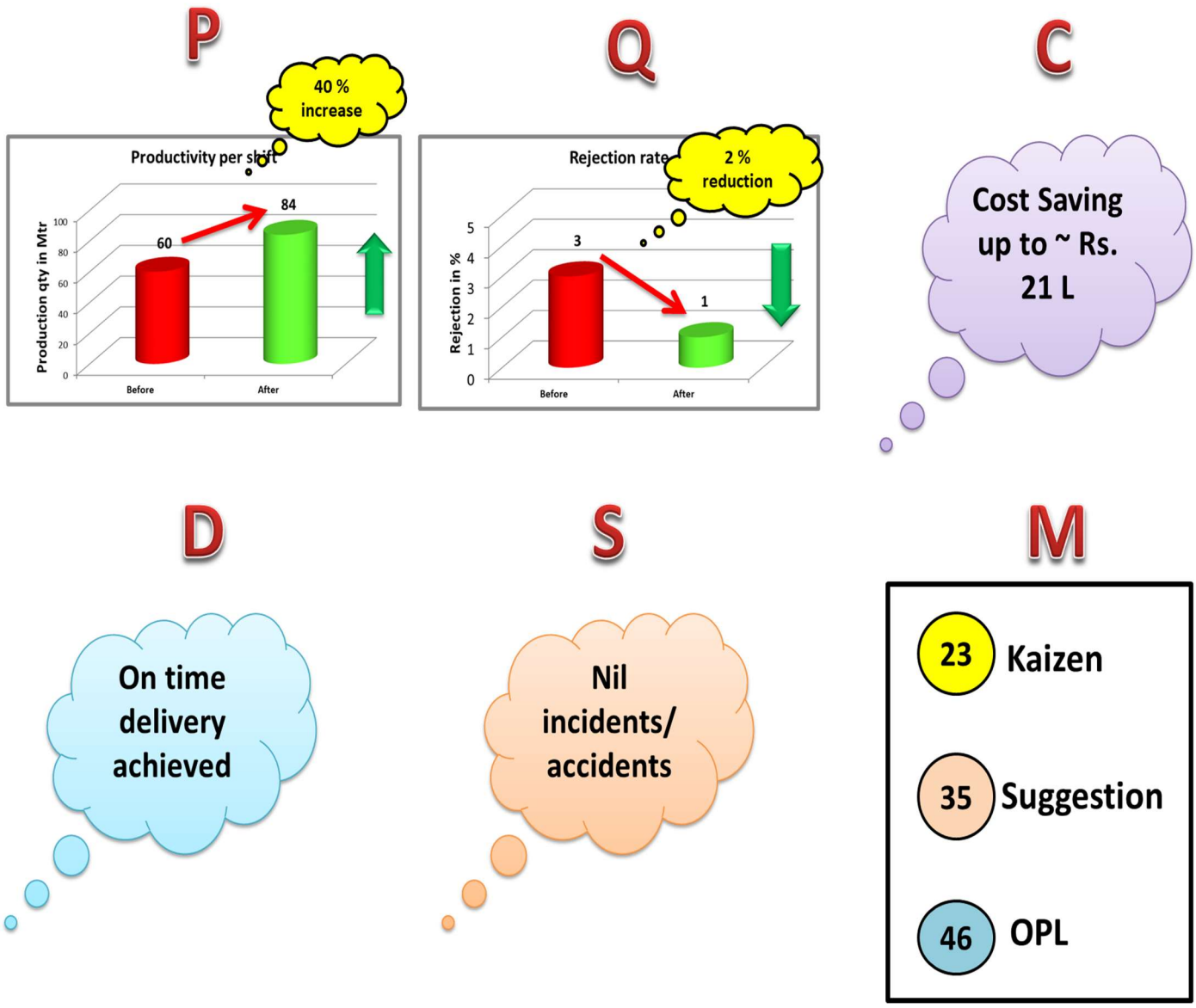
After Project avg. sale value of 80.41 lac



BEFORE **After**

8.2. Kaizen summary and benefits given in PQCDSM

PQCDSM is a vital tool in TPM implementation, with each word acting as an indicator of operational efficiency. Input consists of labor, machines, and materials, while output is composed of production (P), quality (Q), cost (C), delivery (D), safety, health and environment (S), and morale (M). Correlating these factors in terms of equipment maintenance demonstrates clearly that all aspects of PQCDSM are related to output.



8.3. Based on this project Business Impacts details given here

- **Increased sales growth of 82 %.**
- **On time delivery.**
- **Zero rejection.**
- **Reduced VC by 8 %.**
- **Got approval to put up a new line to cater customer requirement.**

9.1. References

Refered books - Total Productive Maintenance Training Textbook – Jaban Institute of Plant Maintenance (JIPM), Fifth Edition-2, Augest 2018.

Refered articles- Science Publications - Abd Manab, Mohd Fairuz and Salit, Mohd Sapuan and Zainudin, Edi Syams and Jaafar, Che Nor Aiza (2014) Polymer composite manufacturing using a pultrusion process: a review. American Journal of Applied Sciences, 11 (10). pp. 1798-1810. ISSN 1546-9239; ESSN: 1554-3641

Refered Articles – MDPI – Polymer science - Experimental and Simulative Analysis of the Pressure Development in a Closed Injection Pultrusion Process with Multiple Chamber Geometries by Sebastian Strauss.

Thank You.