Achieving Maintenance Excellence Using TPM Philosophy – ´´The ESFC Way´´

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ABSTRACT

ITC-PSPD(Paperboards and Specialty Paper Division) embarked on its Operations Excellence journey in 2006 and over the years significant business results have been achieved.Be it any manufacturing industry, typically the relationship between production and maintenance departments is often adversarial and the TPM philosophy challenges this basic premise and works towards establishing a harmonious relationship and establishing the fact that both Operations and Maintenance functions are inseparable. The early years of the initiative concentrated on bringing the equipment back to its basic condition (as supplied by the Original Equipment Manufacturer (OEM) and even to overcome the design weaknesses which were there during installation of the equipment) by attacking forced deterioration and putting in a strict regime of maintaining basic machine hygiene. Subsequent Steps concentrated on improving the Knowledge & Skill of the operators and engineering workforce which was a challenge in itself given the varying background of workforce in terms of education, technical skills and years of experience.ITC-PSPD has developed a novel way of training the workforce on maintenance and quality aspects and called it the “Equipment System Flow Charts (ESFC)” a hands on approach demanding active participation and involvement of the workforce. This resulted in maximum learning and skill development.

Introduction

ITC-PSPD(Paperboards and Specialty Paper Division) embarked on its Operations Excellence journey in 2006 and over the years significant business results have been achieved. Be it any manufacturing industry, typically the relationship between production and maintenance departments is often adversarial and the TPM philosophy challenges this basic premise and works towards establishing a harmonious relationship and establishing the fact that both Operations and Maintenance functions are inseparable.

ITC-PSPD adopted Operations Excellence Model involves all the people in the organization in improvement teams and brings in Daily Problem Solving & Kaizen, Best Practices in Maintenance, Quality, Operations, Safety, New Product Development, Skill Development and Service Improvements and sets up a Self-Assessment System to measure progress of different teams. The team structure followed ensures that both Cross functionality to solve problems and functionality to bring in best practices, coexist.

Tier 1 Daily Management Teams(DMTs):

As described in Fig. 2, the Daily Management Teams (DMTs) are supervisor level cross-functional teams which have the responsibility of the day-to-day operations of the plant. The plant is divided into logical areas like Paper Machines, Pulp Mill, Soda Recovery Plant etc. Daily Management Teams meet on a daily basis for 30-45 min. to conduct root cause analysis for deviations from plant performance targets, creation and implementation of action plans and implementation of pillar team roadmaps in the respective areas. Cross functionality (Presence of Engineering, Operations, Quality etc.) helps in faster resolution of problems, better root cause analysis and creation of a learning organization at the supervisor level.

Tier 2 JishuHozen Teams (JHs):

JishuHozen Teams (JHs) are operator level teams (Ref. Fig 2) which are focused on doing regular cleaning of equipment, 5S, identification and elimination of abnormalities in the equipment and performing routine checks so as to ensure superior performance of the equipment. Multiple JHs come under the purview of a single DMT. Each JH would be headed by a DMT member. This is to ensure removal of any roadblocks in the efficient functioning of the JH. Each JH is allocated an equipment or a set of Equipments and each operator will be allocated to an equipment to deploy the concept of Ownership.

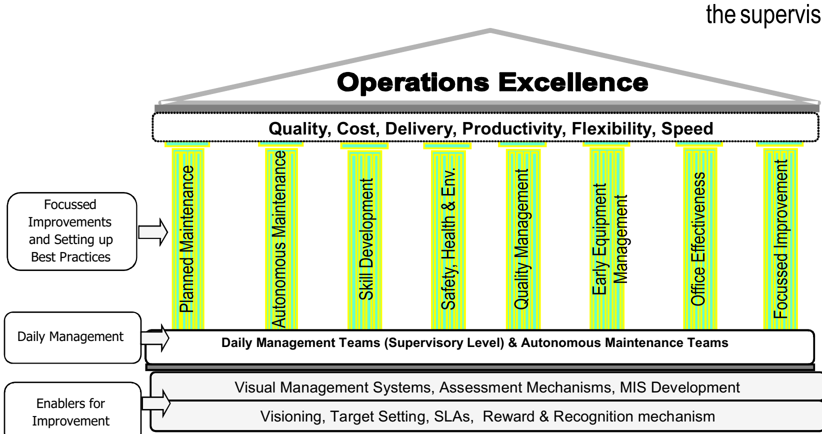

Fig 1- Eight pillar operation excellence structure

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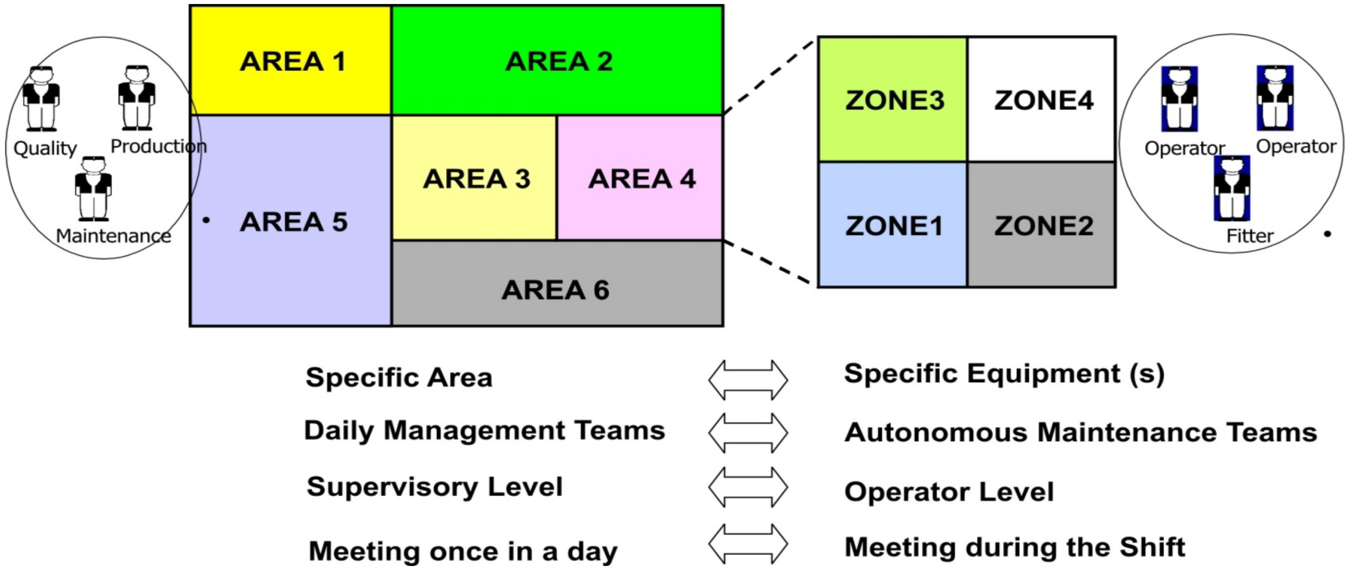


Fig. 2 TPM Team Structure

Tier 3 - Pillar teams:

Pillar teams bring in focused improvements and set up best practices in different areas of Maintenance, Quality, New Product Development etc. They implement a structured approach to realize business benefits. Each pillar team has a well-defined objective as stated below in Fig. 3:

Achieving Maintenance and Quality Excellence

The early years of the initiative concentrated on bringing the equipment back to its basic condition (as supplied by the Original Equipment Manufacturer (OEM) and even to overcome the design weaknesses which were there during installation of the equipment) by attacking forced deterioration and putting in a strict regime of maintaining basic machine hygiene. ***This was achieved by getting the Equipment Owners***(which included both Operators and Maintenance crew) into the discipline of carrying a checklist (called a Cleaning, Lubrication, Tightening and Inspection (CLTI) checklist) containing check points to assess the health of the equipment when it is in the running condition using the 3 basic human senses of seeing, hearing and touching. The Equipment owners in turn report deviations found if any. This has given enough inputs in-time to carry out the PM Schedules more effectively.

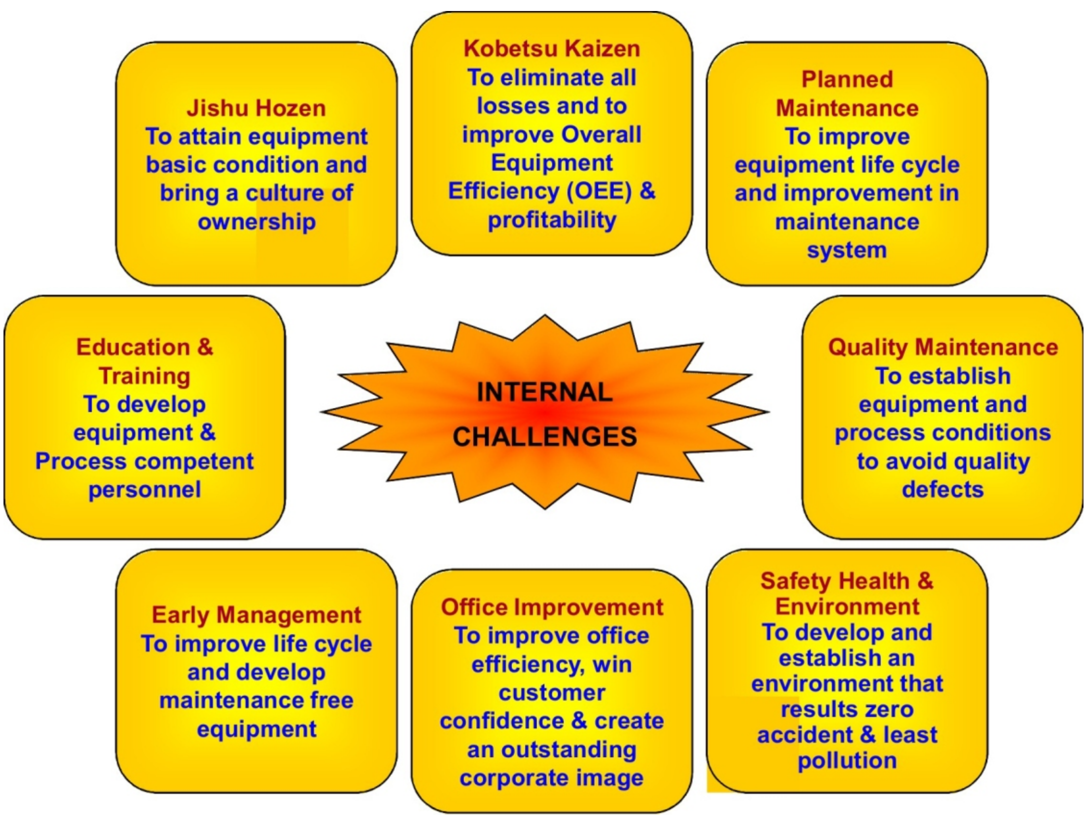


Fig. 3 Internal Challenges Vs Pillars' Objectives

But a need was felt to improve this further, which is possible by raising the knowledge and skills of the equipment owners. **Subsequent Steps** in the initiative concentrated on improving the **Knowledge & Skill** of the operators and engineering workforce which was a challenge in itself given the varying background of workforce in terms of education, technical skills and years of experience.

ITC-PSPD developed a novel way of training the workforce on maintenance and quality aspects and called it the ***"Equipment System Flow Charts (ESFC)"*** a hands on approach demanding active participation and involvement of the workforce. This resulted in maximum learning and skill development. ***This is a hands-on learning exercise and the JH members where involved at every step by getting support from DMT members and participate in live dismantling / assembly of equipments as far as practical.***

"The Equipment System Flow Chart (ESFC) Way"

A 10 Step Approach of implementing the "Equipment System Flow Charts (ESFC)" concept is illustrated below.

Purpose of Creating an Equipment System Flow Chart (ESFC)

- Knowledge enhancement of JH members who learn in detail about the function of their equipment in the entire process, equipment construction and working principles
- Skill enhancement of JH members
  - o To support JH members to carry out simple abnormality rectification on their own.
  - o Understanding the importance of their daily CLTI checks and identify the impact it has on the health of the equipment.
  - o To identify and correct quality related issues immediately
  - o Prediction of possible failures to avoid breakdowns
  - o Creation of trainers within the JH teams who can transfer knowledge.

To initiate this, team need to prepare the list of Processes and Sub Processes in their area and map them with respective equipment functions like mechanical, electrical and instrumentation. This is the preparatory step (Fig. 4) for proceeding on this exercise.

This exercise has 10 steps namely:

1. Identification of Basic Machine Elements
2. Preparation of Training Packs& On-Job Training Curriculum
3. Creation of Equipment System Flow Chart
   a) Process Flow Diagram
   b) Equipment System Flow Diagram
4. Creation of Schematic Diagram

JH Team/Process	Sub-Process	Equipments	Mech	Elec	Instrumentation		Lubrication
					Hydraulic	Field Instruments	
SFT Street C	Pulping	Conveyor	Fluid Coupling	LT Induction Motor Pull Card			Seno Mesh 225 Seno System 68 OKS Spray 451
			Helical Gear Box				
			Gear Coupling				
			Chain drive				
			Slate				
			Plummer Block				
			Bearing				
		Pulper	Rotor	HT Induction Motor		Level Transmitter Knife Gate Value	
			Helical Gear Box				
			Coupling				
		Poire		Local isolater		control value	
		Dump Chest	Contrifugal Pump agltator				
	High Density Cleaning	Constant Level Chest	Centrifugal pump				
		HD Cleaner					
			Knife gate value				
	Coarse Screening	Hole Screen				solenoid value	
		Slot Scree				pressure trasmitter	
			Horizontal split casing pump				
	Fine Screening						
	Thickening		worm & worm wheel gear box				
	Dispersion						
	Power Transmission			Switchgear Transformer PCC MCC Breaker			
	DCS & PLC control system						

Fig. 4 Step 0 of ESFC

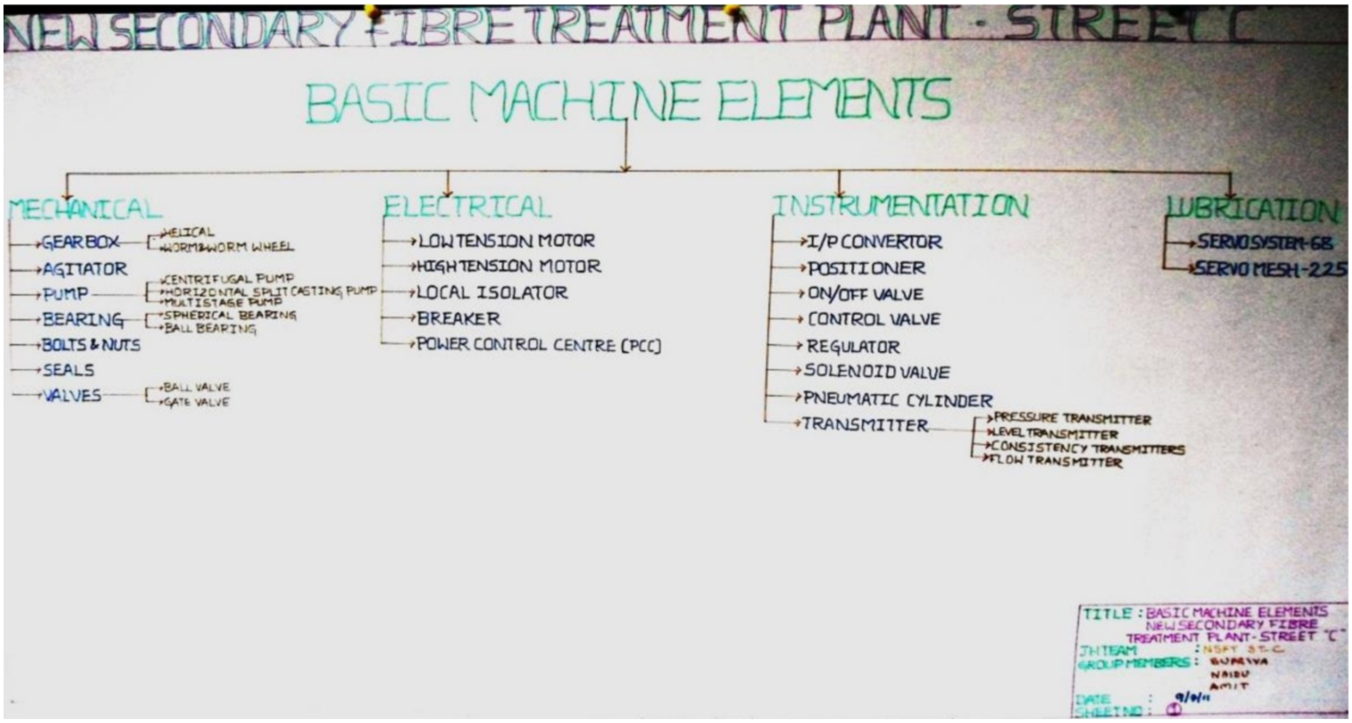


Fig. 5 Step 1 of ESFC

5. Identification of items for mapping problems
   a) Identification of Parts List
   b) Identification of Overall Inspection Items
6. Creation of Part-Problem Matrix
7. Creation of Inspection Checklist
8. Preparation of Know-Why Sheets
9. Creation of Inspection Manual
10. Training of Workforce

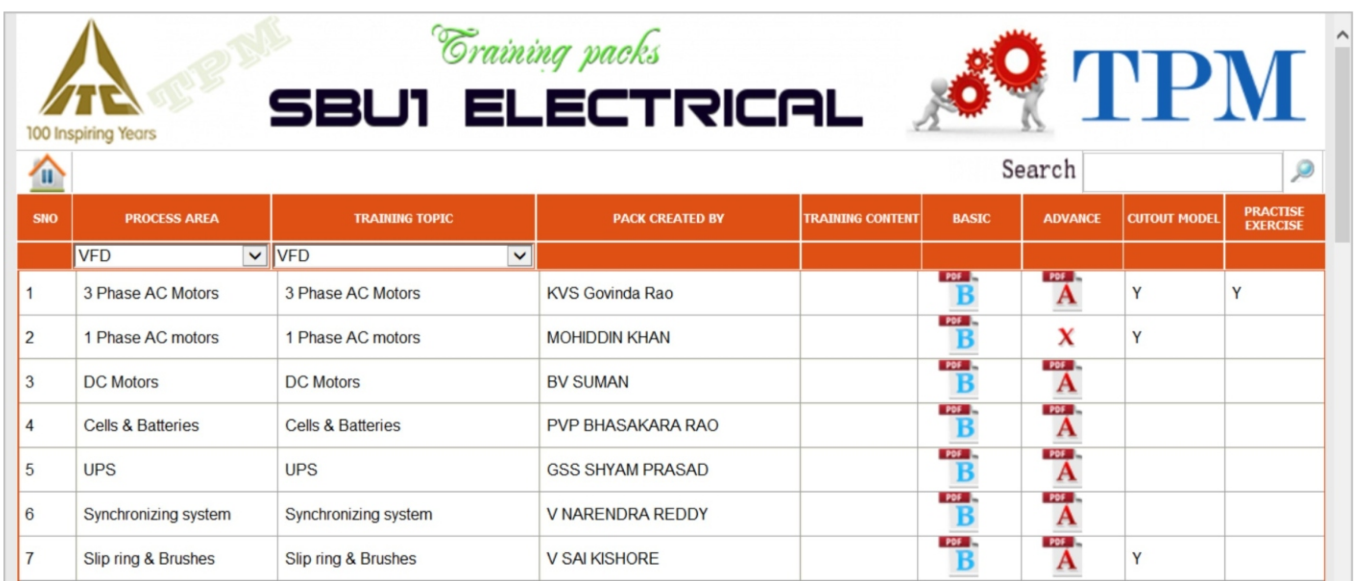
Step 1: Identification of Basic Machine Elements

It was used to identify the various machine elements that JH members will be trained on and also the major parts that will be depicted on the Process Flow diagram & Equipment system flow diagram respectively.(Fig 5)

Machine elements helped in identification of subjects for training packs and also helped the employees in understanding the various parts in their respective equipment.

Step 2: Preparation of Packs& On-Job Training Curriculum

Pack preparation and OJT curriculum designing was a step in which training materials/contentwere prepared in-house (based on our belief that internal faculty and training pack creators are better positioned to understand the needs and can customize training



SNO	PROCESS AREA	TRAINING TOPIC	PACK CREATED BY	TRAINING CONTENT	BASIC	ADVANCE	CUTOUT MODEL	PRACTISE EXERCISE
	VFD	VFD						
1	3 Phase AC Motors	3 Phase AC Motors	KVS Govinda Rao		B	A	Y	Y
2	1 Phase AC motors	1 Phase AC motors	MOHIDDIN KHAN		B	X	Y	
3	DC Motors	DC Motors	BV SUMAN		B	A		
4	Cells & Batteries	Cells & Batteries	PVP BHASAKARA RAO		B	A		
5	UPS	UPS	GSS SHYAM PRASAD		B	A		
6	Synchronizing system	Synchronizing system	V NARENDRA REDDY		B	A		
7	Slip ring & Brushes	Slip ring & Brushes	V SAI KISHORE		B	A	Y	

Fig. 6 Step 2 preparation of Preparation of Packs & On-Job Training Curriculum

contents to suit the technical needs of the in-house recipients)based on the machine elements identified in Step 1. These packs were prepared for training the JH members on basic machine concepts. (Fig 6)

Step 3: Creation of Equipment System Flow Chart

A) Process Flow Diagram

Creation of Process Flow diagram involved logically interlinking all the processes in a particular JH to facilitate easy understanding of the Overall Process.(Fig. 7)

Step 3: Creation of Equipment System Flow Chart

B) Equipment System Flow Diagram

This step firstly involved splitting the Process Flow diagram into logical sub-processes. Each sub-process was then depicted on a separate chart interlinking all the equipment. The energy flow in the sub-process was depicted here and therefore the internals of the equipment were shown in this case.(Fig. 8)

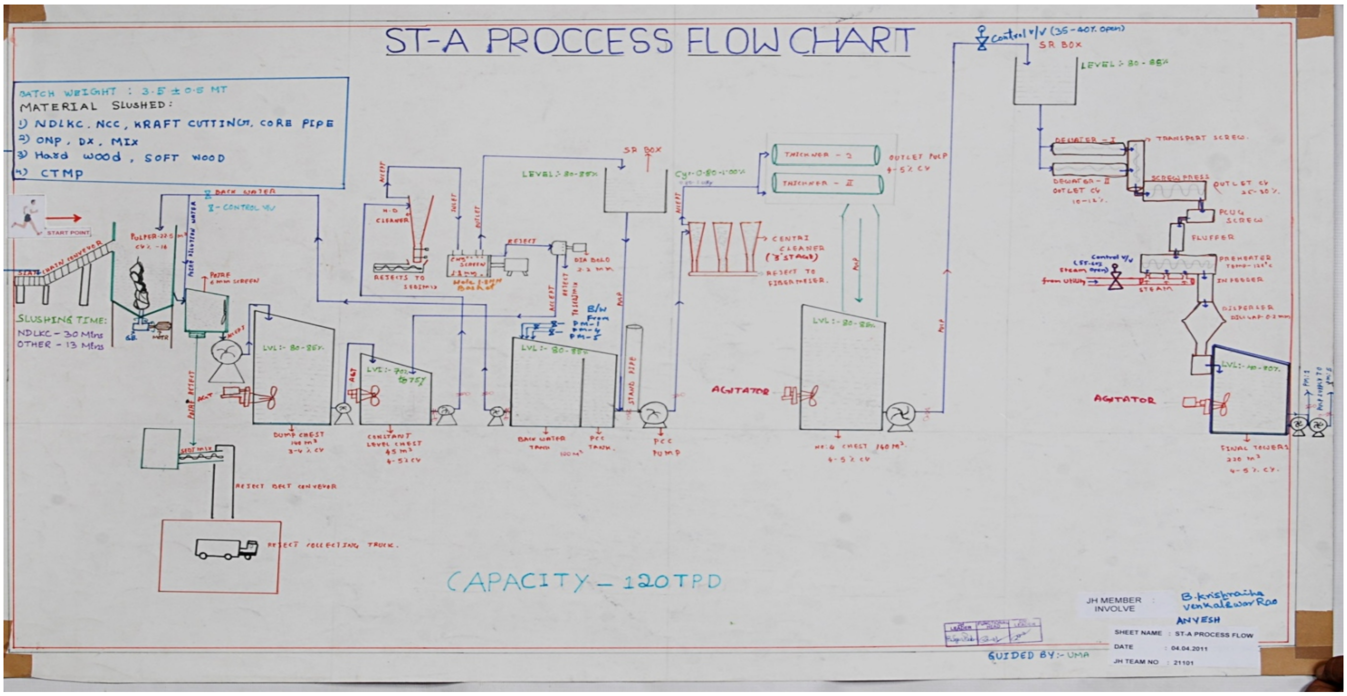


Fig. 7 Step 3 (a) of ESFC

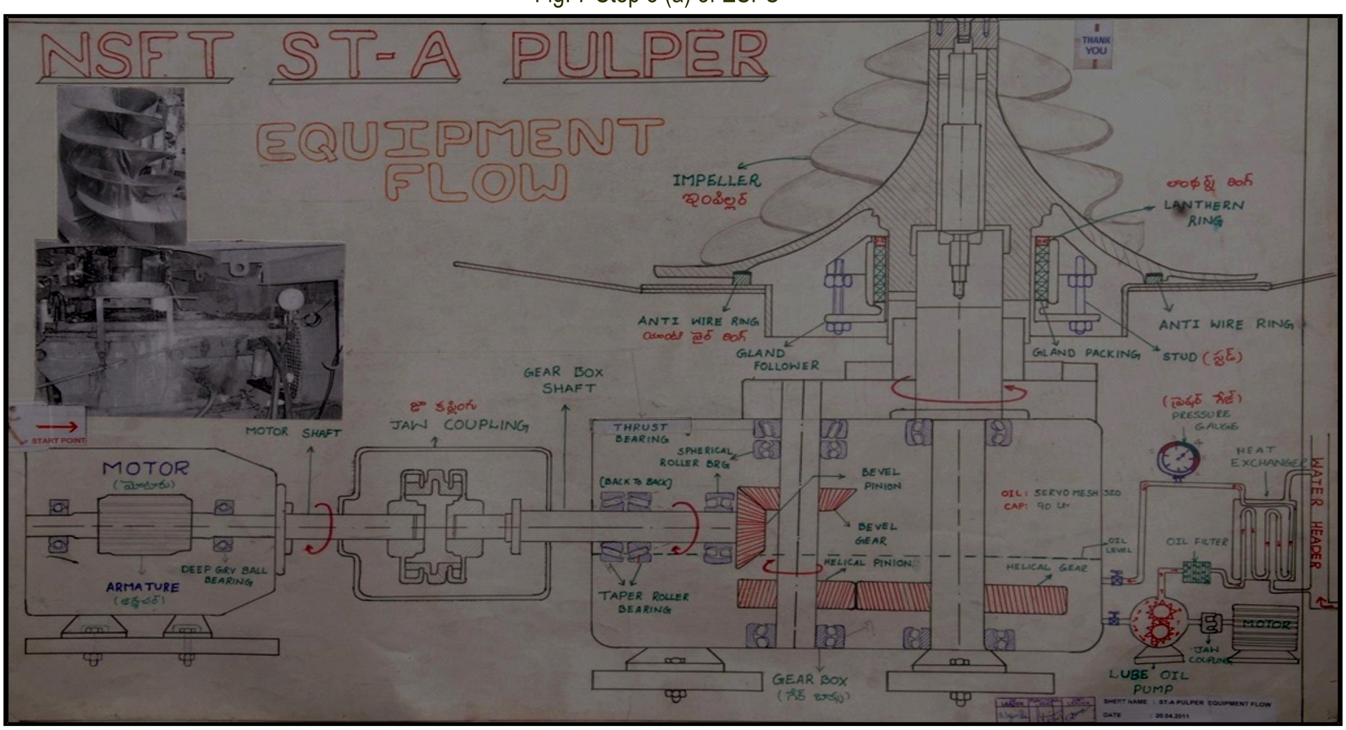


Fig. 8 Step 3 (b) of ESFC

Step 4: Creation of Schematic Diagram

The step intended to give a detailed knowledge of parts of the equipment to JH members. This involved dismantling the equipment where ever possible or creating detailed internal construction of the same.(Fig. 9)

Step 5 A: Identification of Parts List

Identification of Parts list helped the JH team members to understand the various components that constitute the whole equipment.(Fig. 10)

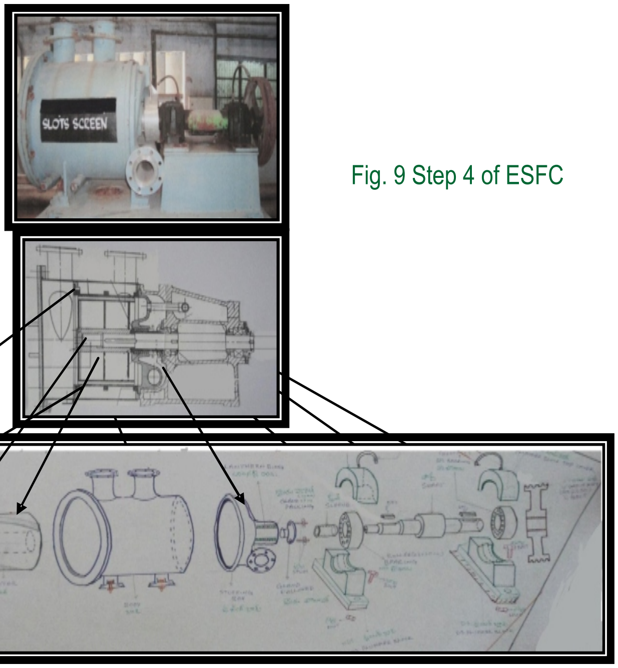


Fig. 9 Step 4 of ESFC

Equipment Name		SLOT SCREEN			
Sub-Equipment	**Sub-Equipment**	**Sr. No.**	**Part Name**	**Part Specification**	**Part Quantity**
1	Screen Body Assembly	1.1	Screen Body		1
		1.2	End cover lock bolts	M24" 90mm (as per screen Size)	8
		1.3	End cover O ring	8 mm dia " 2mt length (as per screen size)	1
2	Basket Assembly	2.1	basket and ring		1
		2.2	basket and ring lock bolts		6
		2.3	basket		1
		2.4	basket key		1
		2.5	basket key screws	M10 & 25 mm (as per screen Size)	2
		2.6	Basket O rings	5 mm " 600 die (as per screen Size)	2
3	Rotor Assembly	3.1	Rotor		1
		3.2	Rotor dummy plate		1
		3.3	Rotor dummy plate locking bolts		4
		3.4	Rotor key	14 mm " 7 mm (as per screen Size)	1
4	Sheft	4.1	Sheft		1
5	Stuffing	5.1	glend bolts	16 mm " 150 mm stud (as per screen Size)	2
		5.2	glend packing	14 mm (as per screen Size)	1
		5.3	Throat Bush		1
6	Bearing Assembly	6.1	bearing housing	SPA 518	2
		6.2	bearing	22218K	2
		6.3	bearing sleave		2
		6.4	lock nut	KB 18	2
		6.5	lock wesher	MB 18	2
7	Drive System	7.1	screen pulley		1
		7.2	taper lock bus		1
		7.3	bush lock screws (screen pulley)		3
		7.4	belts	SPC 2500	4
		7.5	motor pulley		1
		7.6	motor pulley taper lock bush		1
		7.7	bush lock screws (motor pulley)		3

Fig. 10 Step 5A of ESFC

Step 5 B: Identification of Overall Inspection Items

Fig. 11 Step 5B of ESFC

ITC Limited	Condition Appraisal and Refurbishment Plan.								
	Dimension	Checking Tool	Type of Check	Ideal Condition	Actual Condition	Action Required	Resp.	Traget Date	Status
	Check the Dia of Screen Rotor	Outside caliper	Stop Check	Dia 693 mm					
Component	Check the Rotor Vane height	Vernier caliper	Stop Check	16mm					
ROTOR	Check the rotor Vane width	Vernier caliper	Stop Check	55mm					
	Check the Lock bolt Condition	Spanner	Stop Check	Tight position					
	Check the Dia of Basket	Outside caliper	Stop Check	Dia 700 mm					
	Check The O-ring condition for any damage	Eye	Stop Check	No damage					

EQUIPMENT : ST-C SLOT - CH 5 SCREEN						283M010										
NO	Item	What / Standard	How	Sched	TIME (SEC)	1	2	3	4	5	6	7	8	9	10	11
1	Screen gland area	No pulp	Water	D	60	O	O	O		O	O	O	O	O	O	
2	Screen motor area	No dust	Cotton waste	D	60	O	O	O		O	O	O	O	O	O	
3	Screen Motor	No abnormal sound	Ear	D	10	O	O	O		O	O	O	O	O	O	
4	Dilution water pressure guage	As per visual control	Ear	D	5	O	O	O		O	O	O	O	O	O	
Signature of Employee																
Signature of Verifier																

Sub-Equipment Number	Sub Equipment	Inspection Point	Type of Inspection (Run/Stop/ Workshop)	Whether in CLTI/PM/C ondition Monitoring	If in CLTI, how to Inspect	Frequency of Inspection
6	Bearing Assembly					
		Temperature Of Bearing Housing	RUN	CLTI		Daily
		Inspection of Bearing Housing For Worn-Out And Crack	RUN	CLTI		
		Vibration Monitoring Of The Bearing Housing	RUN	CM		
		Bearing Housing Locking Bolts Looseness	STOP	PM		
		Inspection Of Bearing Clearance	STOP	PM		
		Inspection Of Bearing Physical Condition	STOP	PM		
		Inspection Of Bearing Sleeve Condition	STOP	PM		
		Inpection Of Bearing Sleeve Thread Condition	STOP	PM		
		Condition Of Threading On Lock Nut	STOP	PM		
		Condition Of Lock Washer	STOP	PM		

Step 6 :Creation of Part-Problem Matrix

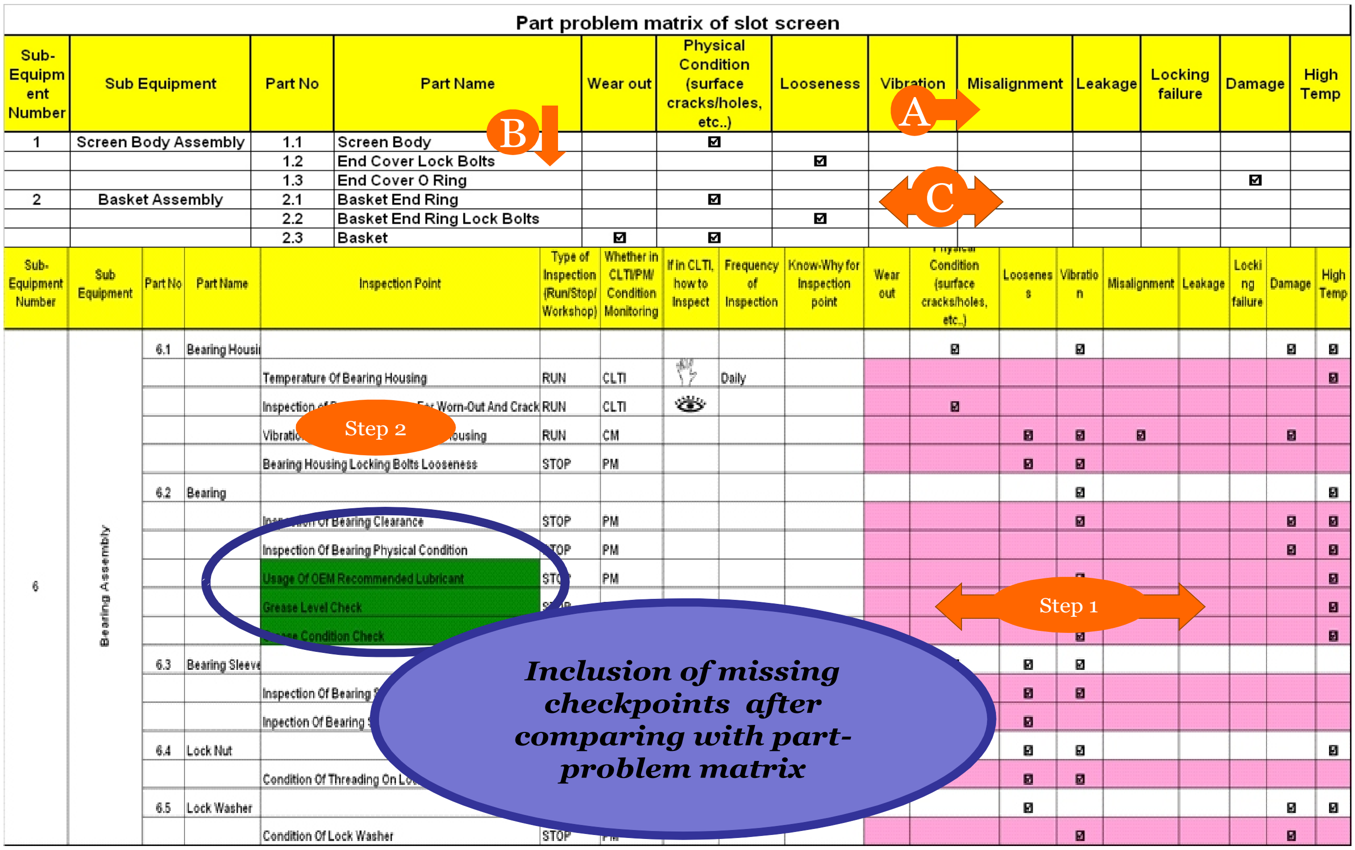
Fig. 12 Step 6 of ESFC

Part problem matrix of slot screen

Sub-Equipment Number	Sub Equipment	Part No	Part Name	Wear out	Physical Condition (surface cracks/holes, etc.)	Looseness	Vibration	Misalignment	Leakage	Locking failure	Damage	High Temp
1	Screen Body Assembly	1.1	Screen Body		☑							
		1.2	End Cover Lock Bolts			☑						
		1.3	End Cover O Ring								☑	
2	Basket Assembly	2.1	Basket End Ring		☑							
		2.2	Basket End Ring Lock Bolts			☑						
		2.3	Basket	☑	☑							
		2.4	Basket Key			☑						
		2.5	Basket Key Screws			☑						
		2.6	Basket O Rings								☑	
3	Rotor Assembly	3.1	Rotor	☑	☑							
		3.2	Rotor Dummy Plate		☑							
		3.3	Rotor Dummy Plate Locking Bolts			☑						
		3.4	Rotor Key			☑					☑	
4	Shaft	4.1	Shaft	☑								

Step 7 :Creation of Inspection Checklist

Fig. 13 Step 7 of ESFC



Part problem matrix of slot screen

Sub-Equipment Number	Sub Equipment	Part No	Part Name	Wear out	Physical Condition (surface cracks/holes, etc..)	Looseness	Vibration	Misalignment	Leakage	Locking failure	Damage	High Temp
1	Screen Body Assembly	1.1	Screen Body		☑							
		1.2	End Cover Lock Bolts			☑						
		1.3	End Cover O Ring								☑	
2	Basket Assembly	2.1	Basket End Ring		☑							
		2.2	Basket End Ring Lock Bolts			☑						
		2.3	Basket	☑	☑							

Sub-Equipment Number	Sub Equipment	Part No	Part Name	Inspection Point	Type of Inspection (Run/Stop/ Workshop)	Whether in CLTI/PM/ Condition Monitoring	If in CLTI, how to Inspect	Frequency of Inspection	Know-Why for Inspection point	Wear out	Physical Condition (surface cracks/holes, etc..)	Looseness	Vibration	Misalignment	Leakage	Locking failure	Damage	High Temp
6	Bearing Assembly	6.1	Bearing Housi								☑		☑				☑	☑
				Temperature Of Bearing Housing	RUN	CLTI		Daily										☑
				Inspection of B... For Worn-Out And Crack	RUN	CLTI					☑							
				Vibratio... ousing	RUN	CM						☑	☑	☑			☑	
				Bearing Housing Locking Bolts Looseness	STOP	PM						☑	☑					
		6.2	Bearing										☑					☑
				Inspection Of Bearing Clearance	STOP	PM							☑				☑	☑
				Inspection Of Bearing Physical Condition	STOP	PM											☑	☑
				Usage Of OEM Recommended Lubricant	STO	PM							☑					☑
				Grease Level Check														☑
				...se Condition Check									☑					☑
		6.3	Bearing Sleeve									☑	☑					
				Inspection Of Bearing S...								☑	☑					
				Inpection Of Bearing S...								☑						
		6.4	Lock Nut									☑	☑					☑
				Condition Of Threading On Lo...								☑	☑					
		6.5	Lock Washer									☑					☑	☑
				Condition Of Lock Washer	STOP	PM							☑				☑	

Step 8 :Creation of Know-Why Sheets

Fig. 14 Step 8 of ESFC

Sub Equipment	Part No	Part Name	Inspection Point	Type of Inspection (Run/Stop/Workshop)	Whether in CLTI/PM/Condition Monitoring	If in CLTI, how to Inspect	Frequency of Inspection	Know-Why for Inspection point	Wear out	Physical Condition (surface cracks/holes, etc..)	Looseness	Vibration
Bearing Assembly	6.1	Bearing Housing								☑		☑
			Temperature Of Bearing Housing	RUN	CLTI		Daily	Increase in temperature of bearing housing >> failure of lubricant film >> Damage to bearing internals >> equi[ment stoppage				
			Inspection of Bearing Housing For Worn-Out And Cracks	RUN	CLTI			a) Worn-out/crack in the bearing housing >> Incorrect seating of bearing >> increase in vibration >> damage to bearing housing >> uprooting of bearing housing >> equipment stoppage		☑		
			Vibration Monitoring Of The Bearing Housing	RUN	CM			Increase in vibration > Damage/ uprooting of Bearing housing > machine stoppage			☑	☑
			Bearing Housing Locking Bolts Looseness	STOP	PM			Increase in vibration > Damage/ uprooting of Bearing housing > machine stoppage			☑	☑
	6.2	Bearing										☑
			Inspection Of Bearing Clearance	STOP	PM			Reduction in Bearing clearance > wear and tear of bearing > increase in bearing Temp > bearing seizure > Machine stoppage				☑
			Inspection Of Bearing Physical Condition	STOP	PM			Wear and tear of bearing > Increase in Vibration / Temp > Bearing seizure > Machine stoppage				
			Usage Of OEM Recommended Lubricant	STOP	PM			Usage of inappropriate lubricant > increase in bearing Temp > bearing seizure > Machine stoppage				☑
			Grease Level Check	STOP	PM			Low/High quantity of Grease > insufficient/ over lubrication > increase in Temp > bearing seizure > Machine stoppage				☑
			Grease Condition Check	STOP	PM			Early symptoms of bearing failure goes undetected> increasing in bearing temp/ vibration > bearing seizure > Machine				☑
	6.3	Bearing Sleeve								☑	☑	☑

Step 5 B: Identification of Overall Inspection Items

This step involved collation of all checklists pertaining to the equipment (i.e. Condition Appraisal/PM task list/Condition Monitoring/CLTI) into a single consolidated sheet. (Fig. 11)
This list was compared later with a part-problem matrix (post Step 6) to know the missing checkpoints and JH members wouldsubsequently update it at a later stage (Step 7).

Step 6: Creation of Part-Problem Matrix

This step involved mapping of equipment parts to the possible failure modes (problems) of the sub-equipment.
The output of this exercise was a part-problem matrix (mentioned in Step 5 B) which was used by JH teams to compare and update their current checklists.(Fig. 12)
This also ensured standardization of checklists for similar equipment across the mill.

Step 7: Creation of Inspection Checklist

This step involved mapping of existing checkpoints (as collated by the team in Step 5 B) with the part-problem matrix (created in Step 6) and inclusion of missing checkpoints for the respective equipment in the teams.(Fig. 13)

Step 8: Creation of Know-Why Sheets

This step involved the creation of Know-Why for inspection points (Knowing Why timely checking of a particular checkpoint was critical and how non-conformance would be detrimental for the respective equipment/process/ quality.(Fig.14)
This helped the JH members to understand the relevance of the inspection points.

Step 9: Creation of Inspection Manual

This step involved the collation of the outputs of Step 1-8 into a single manual at the equipment level. It is a live document with Why-Whys and OPLs (One Point Lessons) being added as and when they are made.
It helped in the training the JH member (existing Equipment owner) on a particular equipment and also acted as a ready reckoner for his successor in the event that the ownership was transferred. Also, unlike an OEM equipment manual which is cumbersome to refer to especially by the employees who may not be having a formal background, as this entire ESFC is done as a hands on exercise by the employees, ease of accessing and connecting to the field equipment is far more easier.

Step 10:Training of Workforce

This step involved training of the JH member on his specific using the Inspection Manual.

Results:

Post mill-wide training using the ESFC concepts substantial benefits where observed in terms of Maintenance and Quality KPI improvement. Also, the entire experience of the exercise was appreciated by the workforce especially the ones who did not have any formal training in the past. Some of the results are depicted below.

Conclusion:

After involving shop floor person (JH member) who is owner of the equipment, from Step-1 to Step-10,the person is able to understand …

- the importance of each part
- its working condition
- And ways it can fail.

This knowledge has enabled the process operator to operate the equipment under standard condition, resulting in …

- less wear and tear of parts
- Improved understanding of engineering crew member on the importance of the equipment health condition for good quality product.
- The results were witnessed in way of downtime reduction to the tune of 70% on breakdown front (Fig. 15 (a)) and to the tune of 20-25 % on NCP-rejections front (15 (b)).

Acknowledgement:

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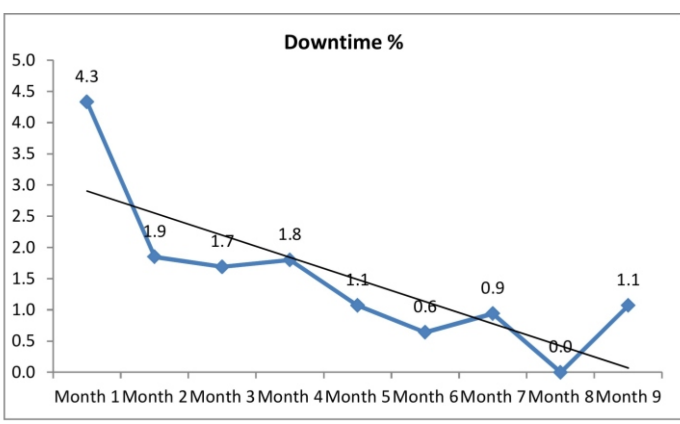

Fig. 15 (a) Results Downtime Reduction

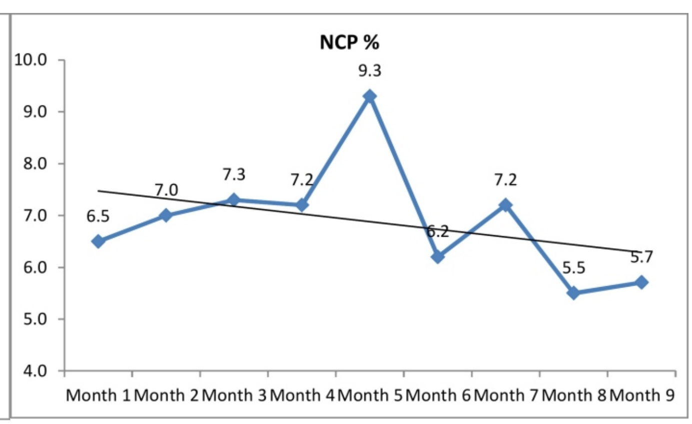

Fig. 15 (b) Results NC Products Reduction

Annexure:

Some Pictures from our in-house Technical Training facility "Vidyalaya"for Knowledge and Skill Enhancement of Managers & Employees.