Root Cause Analysis of the Major Equipment Breakdown Problems of the Tube Section of a FMCG Company as an Approach to Improve OEE

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Abstract *— Today's manufacturing scenario faces a great deal of competition since customers are becoming more and more quality centred and demands among customers are ever increasing. As such to meet the demands of different customers, the manufacturing industries must work with efficiency to become more and more productive. One of the most important ways to increase productivity is to increase the OEE (Overall Equipment Effectiveness) of the machines or equipment. OEE can be improved with the continuous implementation of TPM (Total Productive maintenance). The aim of this study is to focus on the most significant equipment breakdowns of the tube section of a FMCG (Fast Moving Consumer Goods) company and to suggest counter measures to reduce these breakdowns, which would as a result improve the OEE. For the analysis purpose, lean tool Root cause analysis have been used and necessary recommendations made to reduce the most significant equipment breakdowns. This research reveals the tremendous importance of Autonomous Maintenance and Education & Training pillars of TPM.*

Keywords *— TPM, OEE, Equipment Breakdown, Pareto Analysis, Fishbone Analysis, Root Cause Analysis.*

I. INTRODUCTION

Increasing market demand for larger varieties of products and customers' taste for quality has forced the manufacturing firms to produce and deliver good quality products to customers as and when required without fail. Thus manufacturing firms are working enthusiastically to hold their position firmly in the market against their competitors. As such with the increased level of competition, manufacturing firms are under constant pressure to enhance the performance of their firms. And for better performance, all the equipment of the firms should be in proper working condition. The equipment of the firm should be available whenever required, should perform efficiently to deliver good quality products. This becomes possible only when the six big losses of equipment as specified by Nakajima (1998) are under control.

Maintenance is a necessary process that allows the equipment to operate without failure from sudden unanticipated breakdowns. In regard to the importance of maintenance activities in the manufacturing scenario, the Japanese developed a strategy of overall maintenance of the plant and its equipment in 1971 named TPM (Total Productive Maintenance) as in [4].

Total Productive Maintenance (TPM) is a methodology whose aim is to increase the availability of existing equipment so that further capital investment is reduced as in [4]. OEE is a metric used for evaluating the success of TPM. OEE takes into account the six big losses of equipment and indicates the areas that can be improved by eliminating them. The six big losses of OEE are – Equipment breakdowns, Set-up and adjustments, Idling and minor stoppages, Reduced speed, Defects in the process and Reduced yield/Start-up losses as in [11]. OEE depends on three factors, namely, availability, performance and quality which take into account the six big losses. Equipment breakdowns reduce the availability factor of OEE.

Root cause analysis is a lean tool used to identify the root causes of problems so that the problems can be eliminated at their base. In this project, root causes of equipment breakdowns have been analysed and vital counter measures suggested to eliminate the root causes. If root causes are eliminated, breakdowns of equipment would reduce which would reduce the downtime of machine and ultimately increase the OEE.

II. PROBLEM STATEMENT

Inspite of producing for 24 hours-2 shifts, 12 hours each and even after the implementation of TPM since last few years, the OEE of the various manufacturing lines of the company is far below the world class OEE i.e. 85%. The reason for this low level of OEE are the sudden unwanted stoppages of production due to which the machines are not utilized effectively, hence the efficiency is affected. The major reasons for these unwanted stoppages are equipment breakdowns even though the company has been implementing TPM in all areas possible.

This project would focus on the most significant equipment breakdowns, as reduction of major equipment breakdowns is very important to make the equipment or machines produce without negatively affecting the productivity of the company. From literature study it is clear that equipment breakdowns are a major contributor to low OEE in many industries. Elimination of the major equipment breakdowns would certainly improve the OEE of the product lines.

III. OBJECTIVE OF THE STUDY

Improvement of OEE of tube section of a FMCG company by-

1. Identifying the root causes of major equipment breakdowns.
2. Suggesting counter measures to reduce or eliminate the root causes identified so as to reduce equipment breakdowns.

IV. CASE STUDY

This case study has been conducted in one of the most important FMCG (fast moving consumer goods) company located in Guwahati, Assam. The company has ISO 9001-2008, 14001 certification and products made by the company are different types of cosmetics that have a huge demand in the market in and outside India.

The study will be carried out in the tube section as because it is the section with the lowest OEE among all sections and production is interrupted very often in this section due to equipment breakdowns. There are total of nine product lines in the tube section and two product lines with the lowest OEE has been considered for the study and necessary suggestions have been recommended to eliminate the major reasons of equipment breakdowns. The study has been conducted for four months through constant reviewing on the shop floor, studying and understanding the machines under study, interviewing and brainstorming maintenance personnel and operators about the unwanted equipment stoppages.

V. RESEARCH METHODOLOGY

A. *OEE data collection*

The OEE data of the 9 product lines of the tube section have been collected for a period of six months (01/08/14 to 31/01/15) from the web portal of the company. Among the 9 product lines, 2 product lines having 4 machines, 2 machines per product line i.e 1 fillng machine and 1 packing machine having the lowest OEE have been selected for the analysis purpose of equipment breakdowns.

As seen from the OEE data analysis, "WIMCO-4+VP" and "PACMAC-6+HICART" machines had the lowest average OEE and hence these two product lines were taken up for the analysis purpose. WIMCO-4, PACMAC-6 are the filling machines. HICART, VP are the packing machines.

B. *Analyses of equipment breakdown reasons*

Equipment breakdown, a downtime loss is the sudden unwanted stoppage of the equipment due to failure or improper working of some parts of the equipment, in most cases due to improper maintenance of the equipment.

The various problems contributing to equipment breakdowns were reviewed from the log-sheets for a period of same six months as the OEE data collection period. Thereafter, Pareto were plotted to identify the reasons contributing to 80% of the breakdown time of the equipment.

As seen from Fig. 1, wrinkle problem, offcentre problem, filling problem, electrical problem and sealing problem constitute almost 80% of the total maintenance time for all the breakdown problems for WIMCO-4 machine.

As seen from Fig. 2, timing out, willet or coding problem and SPC timing out problem constitute 85.9% of the total maintenance time for all the breakdown problems for VP machine.

As seen from Fig. 3, offcentre problem, sealing problem, wrinkle problem, heater problem, batch number coding box problem and conveyor problem constitute 82.1% of the total maintenance time for all the breakdown problems for PACMAC-6 machine.

As seen from Fig. 4, coding problem, autocollator problem, timing out problem, linkup problem, carton chain timing out problem, drum & landing problem and closing setting problem constitute 80.9% of the total maintenance time for all the breakdown problems for HICART machine.

1) *Root Cause Analysis:* After identifying the major problems of equipment breakdown from the Pareto analyses, fishbone diagrams or Ishikawa diagrams were drawn for all the problems of equipment breakdown that accounts for 80% of the total maintenance time, for all the four machines under study to determine the root causes of the major problems, by conducting thorough interviews and brainstorming sessions with operators, maintenance personnel and experts from the company. Fishbone diagram is one of the seven basic Quality Control tools used for identifying the root causes of problems. In this project, Fishbone diagrams have been constructed mostly based on the categories of man, machine, method and material. After identification of the root causes, vital recommendations are made to eliminate the root causes.

VI. RESULTS AND RECOMMENDATIONS

After the root causes for various equipment breakdowns were identified and analysed, counter measure plans of breakdowns of the selected machines is constructed as shown in tables I, II, III, IV, V, VI, where counter measures are suggested to eliminate or reduce the root causes. The counter measure plans for the two filling machines have been shown in tables I, II, III and the counter measure plans for the two packing machines have been shown in tables IV, V, VI. The format of the counter measure tables has been formed in partial reference to [4].

The counter measure plans for the the two filling machines (WIMCO-4 and PACMAC-6) have been suggested in the same tables (table I, II, III) as because the root causes of breakdowns of these two machines are identical. Similar is the case with the two packing

machines (HICART and VP) whose counter measure plans are shown in tables IV, V, VI.

A. *Results*

From tables I, II, III, it is seen that 46% of the total root causes occurs due to improper CLIT (cleaning, inspection, lubrication, tightening) which is the most important phase of Autonomous Maintenance, 30% of total root causes occurs as a result of lack of training of operators, supplier problem accounts for 9.3% of the total root causes, another 9.3% of the total root causes occurs due to failure of some parts that are unavoidable and for the rest 4.6 % of the total root causes Kaizens have been suggested to eliminate them.

From tables IV, V, VI, it is seen that 55.55% of the total root causes occurs due to improper CLIT of packing machines under study, 19% of the total root causes occurs due to lack of training of operators, supplier problem accounts for 16% of the total root causes and the rest 8.3% of the total root causes needs direct replacement when failed.

B. *Recommendations*

The root cause analysis suggests that majority of root causes of equipment breakdown of the selected machines occurs due to poor Autonomous Maintenance (Jishu Hozen) of the equipment and due to lack of training of the operators as discussed in the results section. Hence following recommendations are made-

1. Operators should be informed about the tremendous importance of Autonomous Maintenance to keep their equipment in proper working condition. It is seen from shop floor visits that almost all operators tend to neglect the JH activities even though there are JH (Jishu Hozen) plans in the company and maintenance activities take place only when the equipment malfunctions. Hence it is of utmost importance to let the operators know about the benefits of Jishu Hozen pillar of TPM to reduce the downtime of machines due to equipment breakdowns.
2. Training and Education should be imparted to operators on a regular basis for proper handling of the equipment which would reduce the downtime due to improper setting of various parts of the equipment.

The root causes identified, problems caused by the root causes, reasons of the root causes, counter measurement plans, necessary Kaizens, time necessary for JH activities and method of JH activities are suggested in table (I, II, III, IV, V, VI) for the selected machines which will provide good benefit to the company if implemented. The counter measures, Kaizens, method and time of JH are suggested after interviewing and discussing with the operators, maintenance personnel and TPM group members from the company.

VII. CONCLUSIONS

As seen from the analysis Jishu Hozen (JH) or autonomous maintenance is a very important TPM pillar that keeps the equipment in a reliable condition and prevents forced deterioration of the equipment. Hence JH is a must to prevent the equipment from breaking down which would in turn increase the OEE of the equipment.

Training should be imparted to the operators for proper handling of the equipment and to take up JH in a more serious manner. Proper JH would uplift the condition of the equipment.

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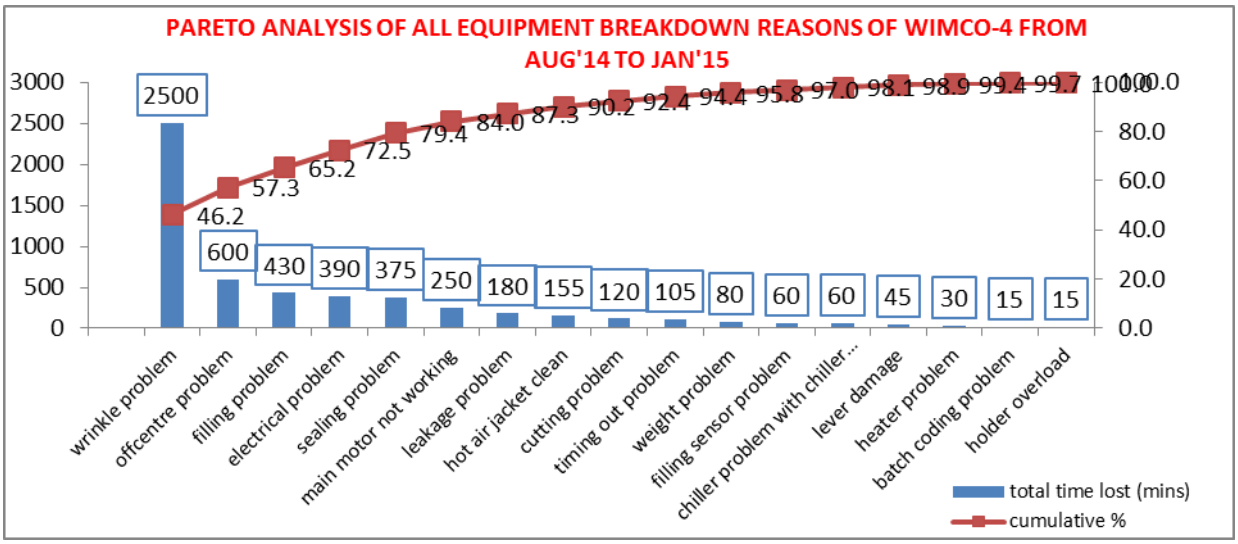

Fig. 1 Pareto Analysis of equipment breakdown problems of WIMCO-4 machine

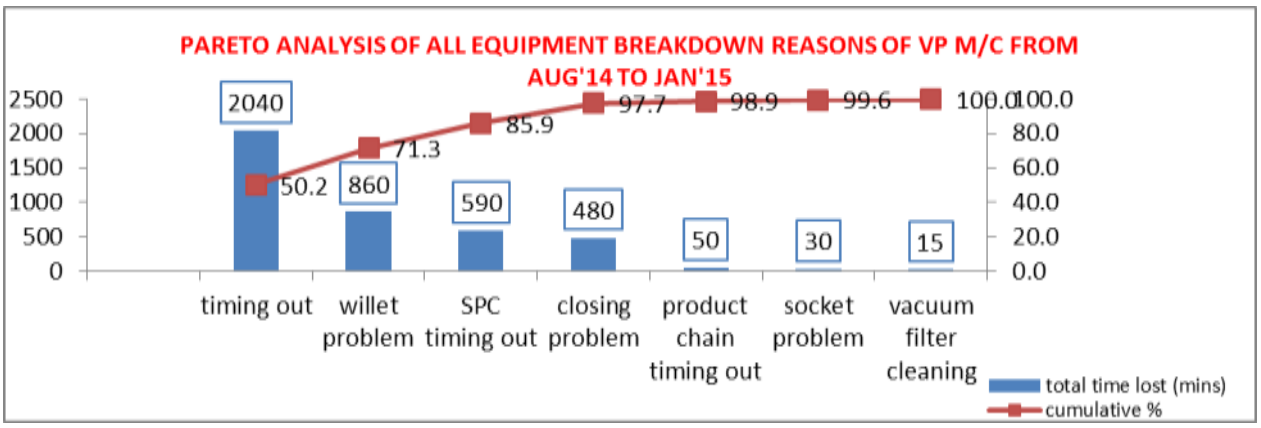

Fig.2 Pareto Analysis of equipment breakdown problems of VP machine

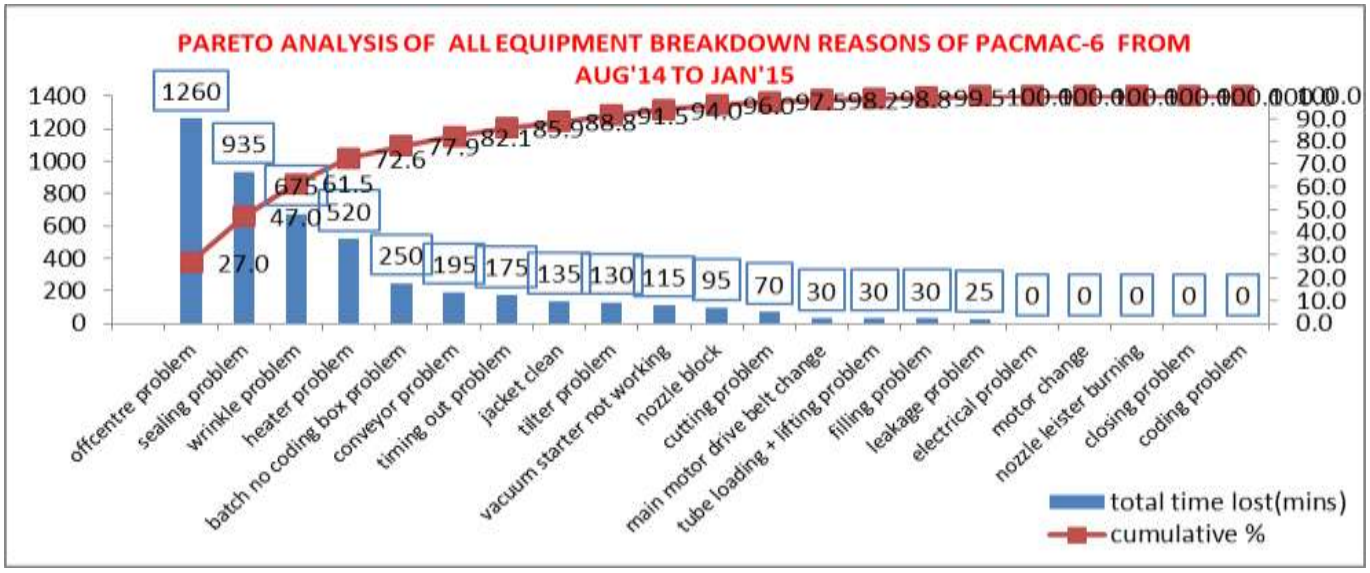

Fig. 3 Pareto Analysis of equipment breakdown problems of PACMAC-6 machine

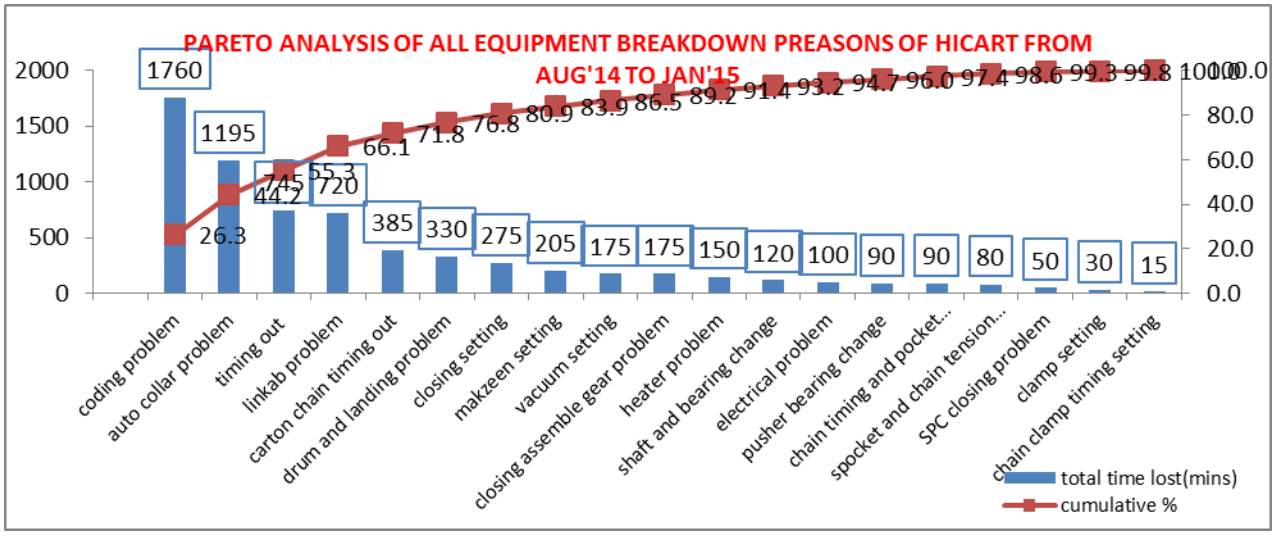

Fig. 4 Pareto Analysis of equipment breakdown problems of HICART machine

TABLE I
COUNTER MEASURE PLAN FOR POOR AUTONOMOUS MAINTENANCE OF WIMCO-4 and PACMAC-6

Category	Root causes identified from Fishbone Analysis	Problems caused by the root causes	Reason for the root causes	Recommended Counter measurement plan	Method of CLIT	Time suggested for CLIT (mins)	Recommended Kaizens
method	jacket water pipe line jam	wrinkle, sealing	untimely cleaning	daily cleaning	pressurized air	5	
	dirty particles in blower fan	wrinkle	untimely cleaning	monthly cleaning	diesel, dry cloth	45	
electrical	improper filtering of air by air filter	electrical	untimely cleaning	monthly cleaning	pressurized air	5	
machine	dust, cream in sensor face	offcentre, electrical	untimely cleaning	daily cleaning	dry cloth	2	
	holder gripper spring wear out	wrinkle	untimely inspection	weekly inspection	visual	5	
	connector of cylinder and air pipe damaged	sealing	untimely inspection	daily inspection	visual	10	use of metal connectors in place of rubber connectors
	improper knurling in coding box	batch number coding	untimely inspection & cleaning	daily inspection and cleaning	visual,copper brush	10	
	wear and tear of piston O-ring	wrinkle, filling, sealing	untimely inspection	monthly inspection	visual	15	
	cut up damage	wrinkle, sealing	untimely inspection & cleaning	weekly inspection & cleaning	visual,dry cloth	10	
machine	sealer shaft bushing loose due to wear and tear	wrinkle, sealing	untimely lubrication	weekly lubrication	oil	5	
	sealer bushing wear and tear	batch number coding box			grease	5	
	rack teeth damage	filling			oil	2	
machine	loose thermocouple connection	wrinkle, electrical, heater	irregular tightening of machine parts	monthly tightening	plier	2	
	sealer bushing loose	wrinkle, sealing			mallet hammer	20	
	loose bolt in stepper motor pulley	offcentre			alen key	2	
	connector of controller and stepper motor loose	offcentre			manual	5	
	loose connection of lifting cam	offcentre			alen key	10	
	magnet head loosens out of lifting rod thread	offcentre			manual	3	
	connector of cylinder and air pipe becomes loose	sealing			spanner	5	
electrical	heater contactor loose	electrical, heater			manual	8	

TABLE II
COUNTER MEASURE PLAN FOR IMPROPER TRAINING TO OPERATORS OF WIMCO-4 and PACMAC-6

Category	Root causes identified from Fishbone Analysis	Problems caused by the root causes	Reason for the root causes	Recommended Counter measurement plan
man	new operator	any problem being analysed	operators not properly trained	Training and Education- monthly training to operators on machine operation
	unskilled operator			
machine	improper rotometer setting	wrinkle, sealing, heater		
	wrong type of thermocouple	wrinkle, electrical, heater		
	improper handling of controller	wrinkle, electrical, heater		
	improper setting of wrinkle guard	wrinkle		
	bent tube stuck in heater	wrinkle, sealing		
	improper cut-up setting	wrinkle, sealing		
	improper O-ring dia of piston	wrinkle, filling, sealing		
	cable inside stepper motor wire tear out due to mishandling	offcentre		
	improper setting of photocell	offcentre		
	loose alen key bolt of coding box	wrinkle, sealing, batch no coding box		
electrical	improper adjustment of sensor	electrical		

TABLE III
COUNTER MEASURE PLAN FOR OTHER BREAKDOWN ROOT CAUSES FOR WIMCO-4 and PACMAC-6

Category	Root causes identified from Fishbone Analysis	Problems caused by the root causes	Reason for the root causes	Recommended Counter measurement plan	Recommended Kaizens
material	bent, oval tube	wrinkle, offcentre	packing material of bad quality	change supplier/vendor	
	eye mark height problem	offcentre			
	cap loose	offcentre			
machine	improper length of batch no coding digits	sealing, batch no coding box	purchased coding digits out of specification		
machine	metal sensor damage	offcentre	failed parts that cannot be repaired	direct replacement	
	photocell sensor damage	offcentre			
	controller card damage	offcentre, electrical			
method	blower bearing wear out	wrinkle			
machine	cap,tube etc present in rework cream that block the holes in hopper,wall and nozzle	wrinkle, filling, sealing	repeated use of same filter cloth for a long time		a) Use of good quality filter cloth b)change filter cloth after filtering 10 drums
machine	IC mother board damage due to overheat in electrical panel	filling	absence of cooling fans though there are provisions for it		Installation of cooling fans

TABLE IV
COUNTER MEASURE PLAN FOR POOR AUTONOMOUS MAINTENANCE OF HICART and VP

Category	Root causes identified from Fishbone Analysis	Problems caused	Reason for root causes	Recommended Counter measurement plan	Method of CLIT	Time suggested for CLIT (mins)	Recommended Kaizens
machine	untimely cleaning of vacuum filter	SPC landing, timing out	untimely cleaning	weekly cleaning	pressurized air	30	
method	vacuum filter jam						
	dust and oil accumulation on vacuum plates	SPC landing, timing out	untimely cleaning	monthly cleaning	dry cloth	30	
	dust and oil accumulation on motor shaft bearing						
machine	bevel gear shaft worn out	closing setting	untimely cleaning	weekly cleaning	dry cloth	5	
method	connector damage	autocollator	untimely inspection	daily inspection	visual	10	use of metal connectors in place of rubber connectors
machine	bearing breakage in closing assembly	closing setting	untimely lubrication	weekly lubrication	grease	2	
	bearing of drum wear out	drum, SPC landing, timing out	no lubrication		grease	30	
	gear of drum wear out						
machine	loose connection of sensor	coding	untimely tightening of machine parts	daily tightening	spanner	2	
	loose bolt in gear of closing assembly	closing setting		weekly tightening	alen key	2	
	loose bolt in closing cam					2	
	loose nut and bolt of suqr chain	SPC landing, timing out	untimely inspection and tightening of machine parts	daily inspection and tightening	visual, spanner/alen key	5	
	loose bolt in drum	drum, SPC landing, timing out		daily inspection and tightening	visual, spanner/alen key	5	
	loose chain of drum			weekly inspection and tightening	visual, spanner/alen key	5	
	loose bearing in pusher	timing out		weekly inspection and tightening	mallet hammer	10	
	loose bolt of pusher guard			weekly inspection and tightening	alen key	10	
	loose bolt of cams			monthly inspection and tightening	alen key	15	
	loose bolt in sprocket due to improper maintenance			monthly inspection and tightening	alen key	3	
method	loose connector of cylinder and air pipe	autocollator		daily inspection and tightening	spanner	2	

TABLE V
COUNTER MEASURE PLAN FOR IMPROPER TRAINING TO OPERATORS OF HICART and VP

Category	Root causes identified from Fishbone Analysis	Problems caused by the root causes	Reason for root causes	Recommended Counter measurement plan
man	new operator	any problem being analysed	operators not properly trained	Training and Education-monthly training to operators on machine operation
	unskilled operator			
machine	bad adjustment of sensor	SPC coding		
	improper setting of LML			
	improper shutdown of coding machine			
	improper setting of tuck-in -assembly	closing setting		
	improper setting of drum	drum, SPC landing, timing out		

TABLE VI
COUNTER MEASURE PLAN FOR OTHER BREAKDOWN ROOT CAUSES FOR HICART and VP

Category	`Root causes identified from Fishbone Analysis	Problems caused by the root causes	Reason for root causes	Recommended Counter measurement plan	Recommended Kaizens
machine	solenoid valve jam due to bad particles in ink	SPC coding	ink and make-up of bad quality	change supplier/vendor	
	ink filter getting jammed due to bad particles in ink				
	solenoid valve damaged due to bad quality of make-up				
	L-valve damaged due to bad quality of make-up				
method	gum in SPC, hard SPC	closing setting, SPC landing, timing out	packing material of bad quality		
machine	dust in SPC				
machine	sealing tape damage of autocollator	autocollator	failed parts that cannot be repaired	direct replacement	
	wear and tear of cutting blade				
	untimely change of ink filter	SPC coding	prolonged use of same ink filter		install new ink filter in every 3 months