TOTAL EMPLOYEES PARTICIPATION IN MAINTENANCE ACTIVITY: A CASE STUDY OF AUTONOMOUS MAINTENANCE APPROACH

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ABSTRACT

The purpose of this paper is to discuss the implementation of the 7-stage autonomous maintenance in a Malaysian automotive parts manufacturer, IESB. The study details the 7-stage autonomous maintenance implementation. A case-based approach is used to discuss 7-stage autonomous maintenance implementation and issues related to its implementation. It was found that the company not develop inspection and lubrication standards to improve the lubrication system effectiveness. Training in autonomous maintenance not only helps to prevent equipment deterioration but also restore equipment to its original condition. This paper offers suggestions to assist practitioners in the implementation of autonomous maintenance program. However, the study is conducted within a single organization and further research is needed in order to generalise to all manufacturing companies. The results of this study suggest potentially useful steps for autonomous maintenance program implementation.

Keywords: *Total productive maintenance, autonomous maintenance, skills, training, and productivity*

INTRODUCTION

Total Productive Maintenance (TPM) is an integrated approach towards maintenance functions in an organization. The objective of TPM is to create an active participation of all employees in maintenance and production functions, including the operators who operate the machines and equipments. The current business environment needs not only on time delivery but also high quality products as well. Therefore, in order to achieve this, there must be reliable machines and zero breakdowns and stoppages. Through TPM, zero defects and zero breakdowns can be achieved (Nakajima, 1988). However, TPM can be thought being integral to a World Class Manufacturing Strategy that also involves Just-In-Time (JIT), total quality management (TQM) and employee involvement (McKone, Schroeder & Cua, 2001). There were a few studies in the area of TPM to investigate the TPM relationship with manufacturing performance and business performance, for instance, McKone, Schroeder and Cua (1999); McKone, Schonberger, and Cua (1999); Brah and Chong (2004); and Seth and Tripathi (2005). Additionally, there were some studies of its implementation issues. These studies were related to the benchmarking of implementation practices to explore key areas (Ireland & Dale, 2001), identification of critical factors (Tsang, 2001), and strategies to support its implementation (Ben, 2000). The relationship of TPM with business performance has also been addressed in some studies (Bamber, Sharp and Hides, 1999; Cooke, 2000; Tsang and Chan, 2000). More importantly, Tsang and Chan (2000) revealed the importance of management leadership, employee involvement, education and training, strategic planning and communication for TPM in a high-precision machining company, located in Pearl River Delta, China. Cooke (2000) also identified top management support, alignment of management initiatives and change, employee training, autonomy to employees and communication as important factors for the success of TPM in a European context. Furthermore, there were also studies conducted in India for instance, Chandra and Krishna (1998); Narang (1992); and, Seth and Tripathi (2005) as well as in Malaysia for example, Ahmed, Masjuki and Taha (2004; 2005). In addition, Ahmed, Masjuki and Taha (2005) assert that there were a few rationale for TPM implementation which are based on 8 elements, i.e. autonomous maintenance, individual performance and improvement, planned maintenance, education and training, early equipment maintenance, quality of maintenance, TPM in office, and environment and health safety. Additionally, level of maintenance practices in Malaysian's SMI is still low priority due to lack of understanding of the importance of equipment in organizational performance, lack of technology and funding, training, etc. (Ahmed et al., 2004). In fact, in TPM, periodic maintenance is towards predictive maintenance, which can detect any equipment deterioration and failure more effectively using new embedded technology and condition-based inspection technology such as vibration analysis, fluorescence spectroscopy, infrared thermography, tribology and oil analysis, and others (Parida and Kumar, 2006).

LITERATURE REVIEW

The nature of maintenance work has changed in recent decades as a result of a huge increase in the number and variety of physical assets to be maintained, increasing automation and complexity, new maintenance techniques and changing views on maintenance organization and responsibilities (Moubray 1997). According to Murthy, Atrens, and Ecceleston (2002), up to about 1940, maintenance was considered an unavoidable cost, and the only maintenance done was corrective maintenance. Therefore, maintenance job was observed as fire fighting activity. Meanwhile, to Al-Najjar and Alsyouf (2003) state that maintenance functions has been more challenging in order to maintain and improve product quality, safety requirements and plant cost effectiveness. The new technologies and automation cannot be denied as they establish very efficient operations in manufacturing companies. However, in order to ensure all operations are smooth, therefore equipment breakdowns and stoppages must be avoided. The operators who operate the equipment and maintenance specialist should work closely to ensure any abnormalities can be detected as early as possible. Through TPM, the resources available at all levels work closely to achieve desired goals. More importantly, TPM helps equipment attain zero breakdowns, zero stoppage and increase availability and reliability as well (Nakajima, 1988). TPM integrates preventive maintenance, condition-based maintenance and predictive maintenance activities as well. In fact, in TPM, periodic maintenance is towards predictive maintenance, which can detect any equipment deterioration and failure more effectively using new embedded technology and condition-based inspection technology such as vibration analysis, fluorescence spectroscopy, infrared thermography, tribology and oil analysis, and others (Parida & Kumar 2006).

Basically, TPM operates through the 8 important pillars to support its implementation effectively, which:

- Increase overall equipment effectiveness
- Training and education
- Autonomous maintenance
- Early equipment management
- Planned maintenance

Quality maintenance
- Office TPM
- Safety, health and environment

All the 8 pillars put a strong emphasis on continuous process improvement through comprehensive and systematic maintenance management. The issue of ensuring uninterrupted daily operation, zero accidents and breakdowns, administrative, training and education etc are highlighted sufficiently. However, the most important thing to ensure successful TPM implementation relies on strong support and commitment from top management. Additionally, Hansson, Backlund, and Lycke (2003) put forward the importance of top management leadership to focus on strategic planning, training and education, monitoring and evaluation, empowerment, and information and communication in increasing the successful implementation of not only TPM but TQM and RCM (Reliability Centered Maintenance) also. More importantly, Tsang and Chan (2000) revealed the importance of management leadership, employee involvement, education and training, strategic planning and communication for TPM in a high-precision machining company, located in Pearl River Delta, China. Cooke (2000) also identified top management support, alignment of management initiatives and change, employee training, autonomy to employees and communication as important factors for the success of TPM in an European context.

TPM MEASUREMENT

Researchers, for instance, Sharma, Kumar, and Kumar (2005) and Ljungberg (1998) put definition of TPM in terms of overall equipment effectiveness (OEE) from a generic perspective. OEE also contributes to increased profit and reduced manufacturing cost using OEE calculation methodology (Kwon & Lee, 2004). Significant improvements have been recorded in manufacturing costs and profits of more than KRW357 millions or USD389 thousands (Kwon & Lee, 2004).
Generally, TPM puts emphasis on equipment losses elimination. These losses can be categorized into three main categories; namely downtime, speed losses and defects (Nakajima, 1988) and Table 1 illustrates the detailed description of losses.
"Take in Table I"

On the other hand, Venkatesh (2006) explores the six big losses and re-categorised them into 16 types of losses as highlighted in Table 2.
"Take in Table II"

Downtime and breakdown losses (time losses) will be used for calculating the availability of equipment. Meanwhile, speed losses are used to measure the equipment efficiency. Additionally, defect/rework losses are considered as quality losses and increasing number of defects and reworks reflect the quality of products produced.
Overall equipment effectiveness (OEE) is a function of availability (A), performance efficiency (P) and quality rate (Q). The OEE calculation can be simplified as, OEE = (A) x (P) x (Q).

$$OEE = A \times P \times Q$$

$$\text{Availability (A)} = \frac{\text{loading time} - \text{downtime}}{\text{Loading time}} \times 100\%$$

$$\text{Performance (P)} = \frac{\text{processed amount} \times \text{ideal cycle time}}{\text{Operating time}} \times 100\%$$

$$\text{Quality (Q)} = \frac{\text{processed amount} - \text{defect amount}}{\text{Processed amount}} \times 100\%$$

OEE will increase as equipment availability, equipment performance and quality rate increase accordingly. High equipment availability means that chronic and sporadic losses are very low. Adjustments of jigs and fixtures, for instance are done using the single minute exchange of die concept or SMED (Shirose, 1995). On the other hand, performance of equipment can be increased when idling and minor stoppages are tackled appropriately. However, reduced speed due to mechanical or quality problem can hinder performance of equipment as well. Long-period stoppages due to holidays, no materials supply, and periodic repairs are examples of start-up losses that can affect quality rate. Moreover, reworks and rejects also contribute to volume losses thus quality rate as well.

Autonomous Maintenance Implementation

This case study has been conducted at a manufacturing company categorised under the small and medium industry, IESB, located in Nilai Industrial Area, Malaysia. IESB produces automotive components such as beltline moulding part, weather strip, pillar drip moulding etc. Such components have been produced with the latest technology of roll-forming, co-extrusion, flocking and stretch-bending processes. Generally, all the components were supplied to PROTON and PERODUA and other car manufacturers as well such as Honda, Mitsubishi and Ford. Like many organizations, which continue searching for excellence programs to improve their competitiveness, the top management introduced TPM in April 2001 to IESB. Mainly, the following events have been initiated:

- TPM take-off for management
- TPM training for implementation
- Establish TPM management team
- Prepare and execute TPM implementation plan
- TPM training for production executives, supervisors and engineers
- Pilot TPM teams
- TPM training for operators, line leaders and technicians

However, in this paper, we would like to focus only on one of the TPM pillars, which is autonomous maintenance (AM) or “jishu hozen” in Japanese. According to Shirose (1995), an autonomous maintenance program is held with an objective of accomplishing three purposes. First, to bring the production and maintenance people together to accomplish a common goal, that is to stabilise equipment conditions and halt accelerated deterioration. Secondly, to help operators learn more about their equipment functions, what common problems can occur and why, and how those problems can be prevented by the early detection and treatment of abnormal conditions. Thirdly, AM helps to prepare operators to be active partners with maintenance and engineering personnel in improving overall performance and reliability of equipment. It must be recognized in developing fully autonomous maintenance systems that all relevant data pertaining to the state and

performance of the machine system should be recorded (Prickett, 1999). Clearly, from the objectives stated above, an autonomous maintenance program is mainly interested in improving human factors, i.e. attitude or behaviour of workers towards their work. Normally, in any organization, operators and maintenance personnel adopt the concept of "I operate, you fix"; whereby operators were used to devoting themselves full-time to manufacturing;
a similar situation at IESB. On the other hand, McKone and Weiss (1998) proposed five phases of TPM development. They focused on two major TPM programs, namely planned and autonomous maintenance. Additionally, they extended the 7-step of autonomous maintenance (Nakajima, 1988)) into 9-step with addition of two steps as follow:
Step 8: Process improvement
Step 9: Implement in all support area

The 7-step of autonomous maintenance will be discussed in the next section accordingly. Autonomous maintenance can help to change this by ensuring that individuals (operators) were responsible for their own equipment and they be trained in the skills necessary to perform autonomous maintenance activities, such as inspections, lubrications, cleaning, 5's etc. IESB slowly began to implement such system since its early production years. At being very immature especially in the whole TPM system, results have yet to be observed.

Process Flow at Line C: The Beltline Moulding Process

Basically, there are 24 main processes of beltline moulding. The processes involved including receiving parts from suppliers, inspections, storage of materials, cutting, flocking, work in progress assembly, injection, final inspection and delivery. Nevertheless, these processes can be categorised and simplified into nine main activities. Figure 1 outlines the processes involved in moulding manufacturing processes. "Take in Figure I".

On the other hand, incoming parts inspection by part quality assurance (PQA) personnel at material receiving bay is an important process as well. This process can eliminate any potential defect parts to pass through production line thus avoid stoppages in operations. For example, two important raw materials in moulding processes are polyvinyl chloride (PVC) and stainless steel (0.4mm x 45.5mm). In this paper, our main focus was processes involved at Production Line C only. Basically, there were eight processes at Line C as illustrated in Figure II. "Take in figure II".

Autonomous Maintenance Activities at Production Line C

Autonomous maintenance is geared towards developing operators to be able to take care of small maintenance jobs, thus freeing up the skilled maintenance staff to spend extra time on more value added activities and technical repairs. Steps have been taken at this line to develop an autonomous maintenance. There were five machines at Line C, namely metal saw cutting machines, press machines (capacity of 35 tonnes and 45 tonnes respectively) and injection machine (contributing the highest breakdown time). The operators were responsible to ensure their equipments are in good order and prevent from deteriorating. There are 7-step in Autonomous Maintenance implementation which are: conduct initial cleaning and inspection, eliminate sources of contamination and inaccessible areas; develop and test provisional cleaning, inspection, and lubrication standards; conduct general inspections autonomously; workplace organization and housekeeping; and fully implemented autonomous maintenance program. Each step will be discussed accordingly in the next section.

7- Step Autonomous Maintenance Implementation

Conduct initial cleaning and inspection

The first step was established to ensure operators develop an interest and concern of their equipment through frequent contact. Initial cleaning and inspection was a part of preventive maintenance. In any plant or work place, cleaning will reveal numerous abnormalities, which can lead to major breakdowns or other losses if detected early enough. Therefore, cleaning should be part of continuous production activity that will result in better equipment performance. The operators carried out the general cleaning and inspection of each equipment and machine at Line C at the beginning of each working day. A check sheet called the Daily Preventive Maintenance Check Sheet for each machine was prepared as part of the procedure. The daily checks carried out by the operators were part of the structured maintenance program. By carrying these checks, responsibility orientation, quality consciousness, and self-discipline were expected to develop. The procedure was also expected to:

- Encourage ownership of the machines by the production operators through carrying out some of the basic maintenance functions
- Observe the critical components for abnormalities
- Remove accumulated dusts from the machines
- Develop discipline among the operators by following systematic procedures
- Ensure that the process conditions and parameters are within the specified limit

Eliminate sources of contamination and inaccessible areas

Cleaning and inspection can be made a lot easier if the sources of contamination can be determined and controlled. At Line C, machines were placed in such a way that all parts of the machines were accessible. They were not installed too close to each other as well as to the floor. This way, dusts and dirt can be cleaned easily and without having to remove equipment or parts. Similarly, the operators easily did oil levels, air pressures, and other parameters checking due to no hidden areas. For example, when the oil level in the hydraulic tank was below minimum, operators will just have to top it up very easily since the locations of level indicators were just behind of each machine. Every team in all lines was responsible for their work place. The teams cleaned and improved their work place accordingly. Quality personnel will go around assessing the cleanliness of each line and team with the highest mark will be announced as the winner. Rewards in terms of monetary and certification will be given. Basically, operators were not permitted to do technical maintenance works especially dismantling machines in order to do overhauling. However, the maintenance technician was assigned this job once a month. As part of a scheduled maintenance program, a Monthly Preventive Maintenance Check Sheet was prepared.

Develop cleaning and lubrication standards

To date, IESB have not yet developed any cleaning or lubrication standards. Normally in this step, teams must decide which parts of the equipment needs cleaning and how often, which methods to use, what to inspect while cleaning, how to judge whether conditions were normal etc. These standards, which were developed through experience, were intended to help the operators do their cleaning tasks with more confidence and ability. What they have currently was just the standards for the type of lubricant used in each machine as well as the height of die for each part number. The machine maker however, produced these standards. Operators only have to follow what was stated in these standards and make changes wherever possible that substitutes the type of oil allowed. Periodically, operators carry out basic inspection and lubrication according to the daily checklist. However, technicians have not yet gone into every aspect of improving the lubrication system, such as having to measure the lubricant consumption rate, review the disposal method for used lubricant, establish a service station, or other improvements concerning lubrication system. Regarding service stations, a special separated area called the Maintenance Area was prepared not far from Line C for certain types of maintenance activities. Blades inside the Metal Saw Cutting machine were sharpen at this particular area by the maintenance department technicians after a certain number of parts being produced, based on the reading displayed on the Metal Saw Cutting machine counter.

Conduct general inspection training

Cleaning, lubricating and bolting were carried out to prevent deterioration and control the basic conditions of equipment maintenance. In fourth stage, operators were trained and provided with ample knowledge by the supervisors or team leaders in order to get better understanding of the equipments at their work place. This step was attempted to monitor deterioration through general inspection of equipment. It cannot be denied that human capital was a priceless asset and the workers have to be properly trained. Basically, new workers at IESB will be exposed a comprehensive induction training. Fundamental knowledge about safety procedures, daily operations standards, work place management, etc. was some of the contents in the training session. On the hand, on the job training also being carried out especially to understand the processes involved in the production of a beltline moulding. The operators will also be introduced to the machines and equipment required in order to produce a specific part. Moreover, the following were some of the training provided to operators:

At the end of each session of On Job Training, a team leader will assess the operator’s skills and knowledge according to the lists in the training material prepared and the operators were allocated to various production lines throughout the factory. Basically, the training provided showed an improvement in the production floor, particularly in Line C. On the other hand, breakdowns of die, bar materials, electrical and mechanical failures were the most frequent in this company. The failure causes however, showed that human related failures also need to be given special attention. For instance, Figure III encompassed the breakdowns in the production line in 2006. “Take in Figure III”.

It was discovered that through intensive training and education programs, the number of breakdowns frequency shows improvements in term of reduction in breakdowns. Moreover, Production Engineering that responsible in Autonomous Maintenance program planned a structured training program especially in ensuring basic equipment conditions. This activity involved cleaning, lubrication and bolting (Nakajima, 1988). Moreover, Nakajima (1989) also outlined 7 cleaning check points in order to detect any abnormalities and hidden defects. The cleaning check points are as in Table III. “Take in Table III”.

However, in Line C, attention only given to 3 aspects of cleaning check points as depicted by Figure 4.”Take in Figure IV”.

In addition, training for housekeeping particularly related to maintain equipment cleanliness was periodically conducted and external consultant was assigned to deliver the training program and assessment.

• Setting of die	• Bending pad insertion
• Setting of temperature	• Front end cutting
• Overload adjustment	• Front end lip cutting
• Safety repair	• Front end flange cutting
• Change of die	• Rear end cutting
• Mould adjustment	• Rear end lip cutting
• Adhesive applications	• Etc.

Conduct general inspections autonomously

This fifth step compares and re-evaluates the cleaning and lubricating standards established in Step 1 through Step 3. This step also tries to re-evaluate the tentative inspection standard to eliminate any inconsistencies and to ensure the maintenance activities fit within the established time frames and goals. An overall inspection process was formalised by combining the provisional standards created in step 3 with the additional check items for routine general inspection. This stage was formed with the purpose to prevent breakdowns from happening again in the future as well as to detect any inspection points that can be performed by operators themselves whenever breakdown occurs. These points should then be incorporated into the standards developed in step 3. Nevertheless, regular maintenance was still performed according to schedule. Upon discovery of breakdowns, the operators recorded into the Daily Downtime Monitoring sheet each day. However, technicians were responsible to repair any breakdowns. Downtime was divided into two categories, internal and external downtimes. Internal downtime consists of the time when machine or equipment was idle. External downtime was the time when other outside activities were carried out that needs the production to stop. These data were recorded according to car parts and done at the end of a working day. After three months, downtime data were gathered and recorded into the Predictive Maintenance Analysis sheet. Clearly, breakdowns or defects were almost impossible to be eliminated; therefore to avoid them from reoccurring was necessary. Data were then analysed based on the statistics calculated. Problems were identified and counter measured. Hence, recommendations will be made through deep discussions among team leaders, supervisors and managers. There were four types of breakdown in Line C, mechanical, electrical, bar material and die. Mechanical breakdown involved breakdown of machine in terms of its functionality. As for electrical breakdown, it involved electrical aspects such as wiring, loose connections, lightings, etc. Die breakdown was due to adjustment or setting of tools. Through analysis, a few problems were detected such as variation of parts; miss setting of parts, machine adjustments, and related errors due to human factors, etc. For instance, to investigate the causes of die breakdown, the cause and effect diagram was used. Table 3 summarised some causes of die breakdowns at Line C based on four categories, manpower, methods, material and machine. “Take in Table III”.

Workplace Organization

Nakajima (1989) argues that keys to workplace management were 'seiri' (organization) and seiton (tidiness). However, 'Seiton' (tidiness) refers to adherence to set standards. And, this was the operator's primary responsibility. In step 6, other aspects of work environment were considered in order to expand the shop floor team activities beyond the equipment itself. Workstations at IESB, particularly looking at Line C, were organized in such a manner that emphasis on work effectiveness and safe environment. The location of machines, die racks, work in progress, raw materials, dies, jigs, tools, etc. were all designed with ergonomics elements. The operators were easily accessed and handled them. The positions of equipment were arranged systematically so that enough space was allocated for operators to do their job. 'Seirie' (organization) involves the identification of objectives to manage and the setting of relevant standards. In IESB, managers and supervisors were responsible for guiding this activity. The yellow lines are used to show the boundaries of equipment being placed. Machines, trolleys, or racks wre positioned within these lines to ensure that everything was organised. Operators will have no trouble when looking for parts, jigs, or racks. The properly arranged parts can save time and increase productivity as well.

Fully Implement Autonomous Maintenance Programme

At this stage, operators were expected to continue to refine the inspection process and to generate improvements that increase equipment life span. Moreover, effectiveness in cooperation between the maintenance and production departments also can be improved. The operators will have to become more independent, skilled, and confident and work closely with maintenance staff. They were expected to monitor their own work and implement improvements autonomously. IESB is still behind in achieving the objectives of this step since there was many elements in each of the seven steps are lacking. Yet, a number of improvement activities were continuously implemented to create an ongoing autonomous management atmosphere. This was done through the quality control circle (QCC), 5'S activities, counter measuring downtimes and breakdowns, and others. More importantly, Nakajima (1989) has suggested that there were key implementation factors of autonomous maintenance such as progressive education and training; cooperation between departments; group activities; prompt equipments problems treatment by maintenance department, etc.

CONCLUSION

The 7-step of autonomous maintenance has been implemented successfully in IESB, particularly in Production line C. The benefits of TPM and autonomous maintenance have been addressed by many authors (Nakajima, 1988; Jantan, Jantan, Nasurdin, Ramayah, & Ghazali, 2003; Ahmaed, Masjuki & Taha, 2005; Bamber,Sharp & Hides, 1999; Brah & Chong, 2004; Cooke, 2000; Cua, McKone &Schroeder, 2001; Seng Jantan & Ramayah, 2005). However, one of the key success factors to autonomous maintenance in IESB was surely the top management commitment and support. The ongoing strong support from top management enhances the morale and motivation of IESB staff. Allocation of training and education provision also helps to upgrade the skill and technical capabilities of production and maintenance (Production Engineering) department staff. More experienced technical staff can be more focus on equipment improvements. Thus, the overall effectiveness of equipment can be improved significantly. Additionally, equipment deterioration can be eliminated as the equipment operated efficiently. Moreover, the positive attitudes towards autonomous maintenance enable other TPM's pillars to be implemented successfully as well.

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Table I: Description of Losses

Types of losses	Characteristics
Downtime/breakdown [a]	Equipment failure – from **breakdowns.** These failures are due to chronic/sporadic losses **Set-up and adjustment** – from exchange of die in injection moulding machines, etc
Speed losses [b]	**Idling and minor stoppages** – due to the abnormal operation of sensors, blockage of work on chutes, etc. **Reduced speed** – due to discrepancies between designed and actual speed of equipment
Defect:/rework [c]	**Process defects and rework** – due to scraps and quality defects to be repaired **Start-up loss** (reduced yield) – from machine start-up to stable production

Notes: [a] Equipment availability; [b] performance efficiency; [c] quality rate

Source: Nakajima (1988), p. 14.

Table II: Types of Losses

Losses	Category
1. Failures 2. Set-up/adjustment 3. Cutting blade loss 4. Start up losses 5. Minor stoppages 6. Speed losses 7. Defect/rework loss 8. Scheduled downtime loss	Equipment efficiency related losses
9. Management loss 10. Operating motion loss 11. Line organization loss 12. Logistic loss 13. Measurement and adjustment loss	Human work related efficiency
14. Energy loss 15. Die, jig, and tool breakage loss 16. Yield loss	Effective usage of production sources related losses

Source: Venkatesh (2006), p. 22.

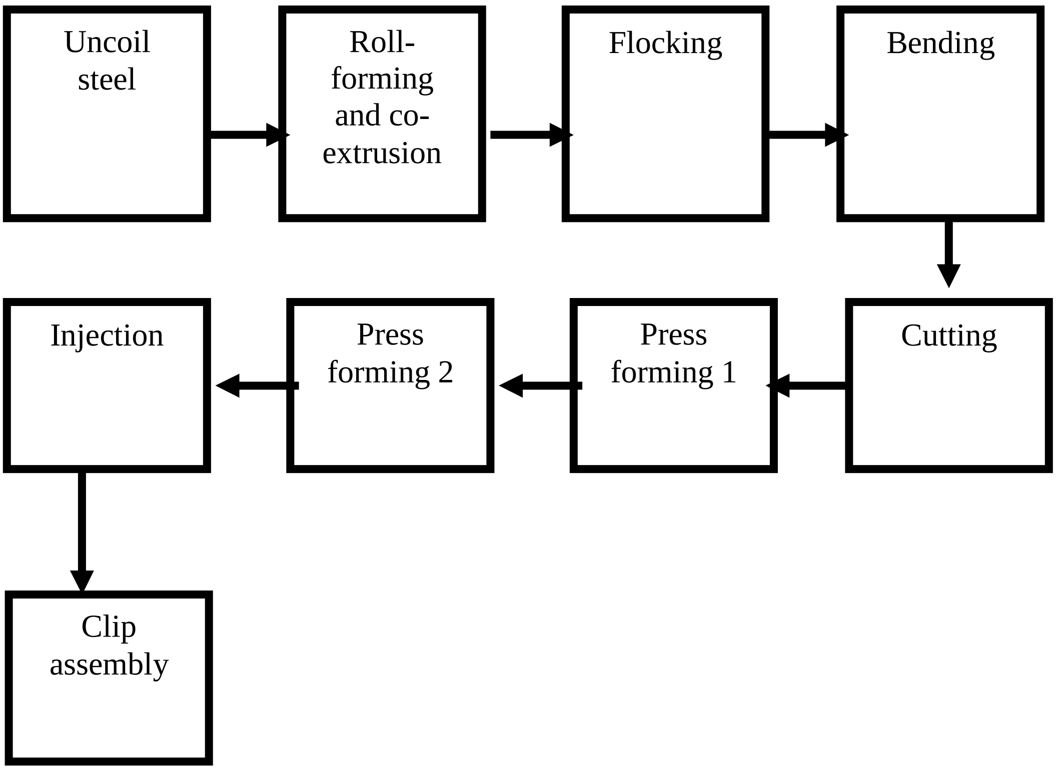

Figure 1: Moulding Manufacturing Processes

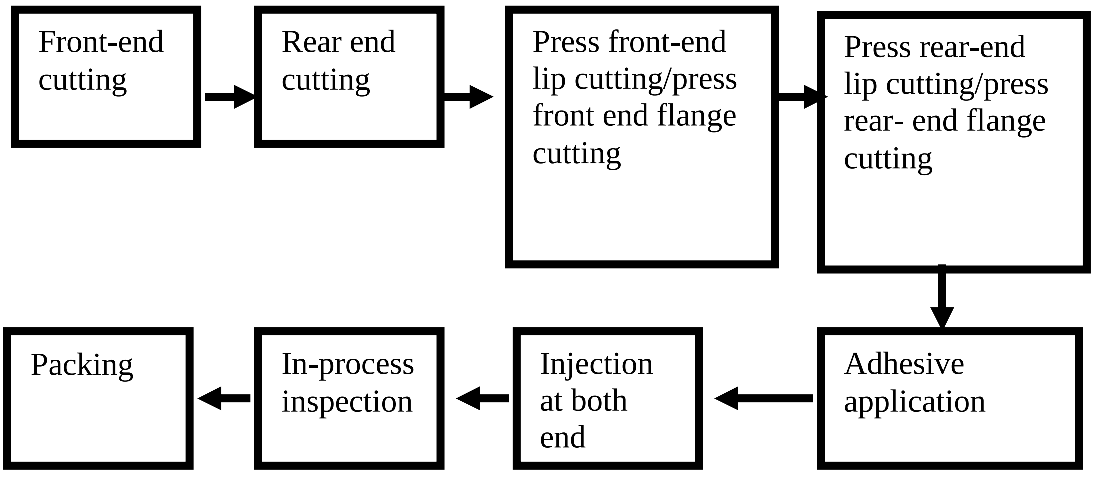

Figure II: Beltline Moulding Processes at Line C

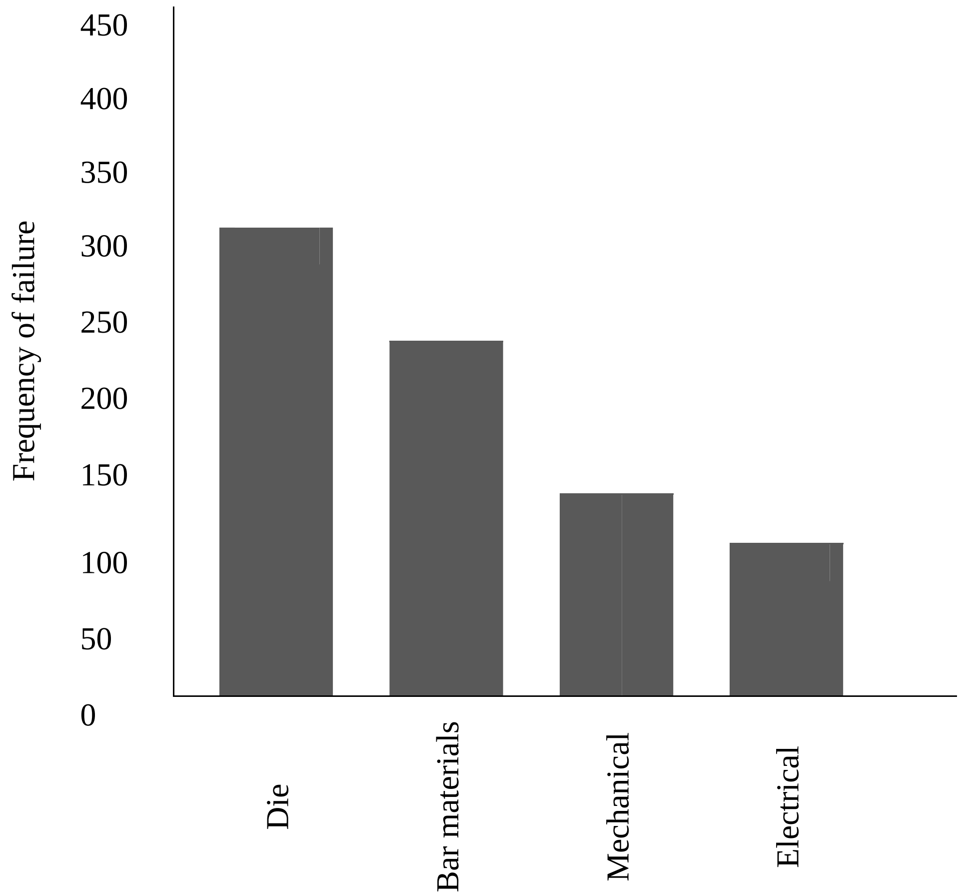

Figure III: Breakdown Frequency in 2006

Table III: The cleaning check points

Activity	Items to Check
1. Cleaning main body of equipment	• Check for dust, dirt, oil sludge, , scraps, other foreign matter adhering to equipment • Check for loose or missing nuts and bolts, etc. • Check for play in sliding parts, jigs fittings etc. • Etc.
2. Cleaning ancillary equipment	• Check for dust, grease, dirt, oil sludge, , scraps, other foreign matter adhering to equipment: e.g. micro switches, belts, motors, covers, control boxes, etc. • Check for loose or missing nuts and bolts, etc • Check for buzzing solenoids valves and motors • Etc.
3. Lubrications	• Check for dirt, dust, and sludge on lubrication, grease cups, lubrication devices • Check lubricant levels and drip levels • Make sure lubes pipes are clean and no leak • Etc.
4. Cleaning around equipment	• Ensure tools are properly placed and not missing • Check for bolts, nuts, etc. left on the machine • Check fro drop parts, work pieces, etc. • Make sure all pipes clean and no leak • Etc.
5. Treat causes of dirt, leaks, dust, etc.	• Ensure all information related to causes of dirt, dust, leaks etc. made available to all • Ensure action taken to prevent the occurrence of dust, dirt, leaks, etc. • Ensure sufficient effective plans to deal with longstanding problems • Etc.
6. Improving access to difficult to reach area	• Ensure inaccessible areas well documented • Ensure covers easily detachable to facilitate cleaning • Ensure tidiness and safe working environment • Etc.
7. Cleaning standards	• Ensure cleaning standards available for every piece of equipment or area • Ensure cleaning duties been clearly assigned • Ensure cleaning tools and methods clearly specified • Ensure cleaning time and interval clearly specified • Etc.

Source: Nakajima (1989), pp.174-175

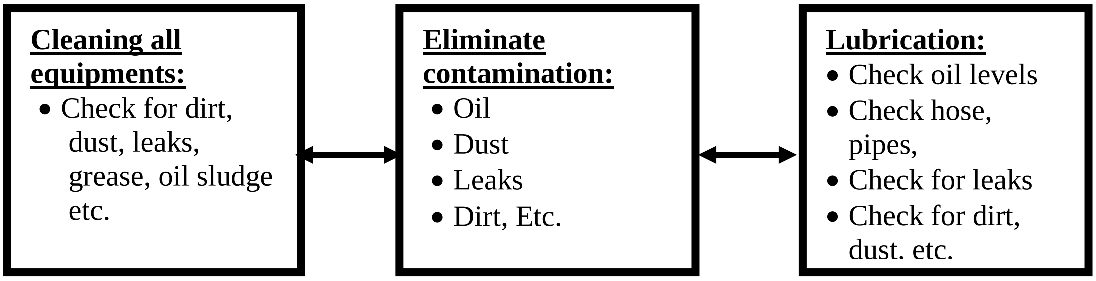

Figure IV: Cleaning check point in Line C

Table IV: Causes of Die Breakdowns

Manpower	Methods	Materials	Machines
Lack of training	Procedures not followed	Over specification	Life span
New operators	Not check procedures	Adjustments	Miss-setting of parts
Careless		Roll forming errors	
Handling		Parts defects	
Servicing			
Not follow standards			