CHAPTER 6

MAINTENANCE QUALITY TARGETING

6.0. INTRODUCTION

An effective SMQE model requires the continuous quality improvement of maintenance activities. The conventional statistical process control techniques do not result in continuous improvement of quality. Hence Taguchi’s on-line quality control (TOLQC) methods are required to be adopted. Fundamentally “TOLQC” methods envisage the attainments of target by evaluating quality in terms of financial loss. Hence “TOLQC” methods should be modified and improved, so that they are adaptable in SMQE model. This research involves the design of modified and improved TOLQC models. Further, the steps required for implementing TOLQC models are designed with the primary objective of improving the quality of maintenance in the manufacturing enterprises. The maintenance function of a foundry is considered to implement the modified TOLQC models.

The quality in maintenance engineering in today’s context envisages the error free operation of both process and products at an economical cost. Hence conventional statistical techniques are becoming obsolete to fulfilling the requirement of improving quality in maintenance. At this juncture, TOLQC methods are found to provide feasible solution to overcome this situation.

6.1. OVERVIEW OF TAGUCHI'S METHODS

Taguchi started to publish his methods from early nineteen sixties. During his work in various capacities he noted the three phases of evolution of any product. They are:
1. System design

2. Parameter design

3. Tolerance design

Out of the above, Taguchi's exhaustive study revealed that the parameter design stage is the one, which decides the criticality of quality levels. The important features of Taguchi's methods are narrated below:

1. Starting quality engineering from design stage itself, since statistical process Control or Statistical quality control can never fully compensate for bad design.

2. Initiating systematic procedures and policies to optimize the product and Process design before going for manufacturing.

3. Imparting more thrust on design rather than inspection.

4. Aiming for producing products whose outputs don't vary with external disturbances and such designed products are called as robust products.

5. Use of limiting the statistics in design stage and eliminating them during the production stage.

6. Depending upon the models developed based on the philosophy 'Loss to the Society' rather than statistical techniques during production.

In a nutshell to say, Taguchi's approach is based on his way of describing an intuitively agreed philosophy that he puts under the term quality loss that is defined as "the loss a product costs society from the time it is released for shipment".

The careful study of the above points hints that the quality is required to be infused during two stages that are before production and during production. The quality engineering method proposed by Taguchi for applying before the production is known as off-line control.
method and the method proposed for implementing during production are called as on-line quality control methods.

6.1.1. Taguchi's Off-Line Quality Control Methods

As hinted earlier, the quality control activities employed during product planning, design and product development stages are referred to as off-line quality control. This basically envisages the process known as "design of experiments" in which matrices called as orthogonal arrays with numbers are suggested. This is required for conducting reduced number of prototype experiments to determine the optimum parameters before the actual production. Today Taguchi's off-line quality control methods are approved as a step towards the installation of prevention based quality system, which is prerequisite for the implementation of TQM and thereby TPM.

6.1.2. Taguchi's On-Line Quality Control Methods

As already mentioned, the quality engineering activities that are required to be carried out during production are referred to as on line quality control. The methods suggested by Taguchi for on line quality control is totally different from the existing statistical techniques used in traditional manufacturing system, rather it solely rests on the concept of quality loss that results as a result of deviation from the target.

The following subsections brief various features of on-line quality control systems from Taguchi's point of view.

6.1.3. On Line Feedback Quality Control Variable Characteristics

This introduces the concept of on-line feedback quality control system and discussed the effect of mean square drift of measurement on the parameters of the feedback quality control system. Two types are:

1. Feedback control system that require measurements on every piece of production and
2. Feedback control system that requires measurements after the production of number of products. In both cases total quality cost, including the loss function, is used as a criterion for design evaluation.

6.1.4. On Line Process Parameter Control Variable Characteristics

In this he discussed the effect of variations in process parameter on the quality characteristics of the product, and reviewed the methods for determining the optimal values of those process parameters. These methods were also used to determine the optimal parameters of measurement system in order to minimize the effects or measurement error and the calibration cost of measurement systems. Two types of on-line feedback quality control are:

1. Repairing or discarding of defective products found in inspection.
2. Adjusting or recovering process found out-of-control by checking either quality characteristics or process condition.

There is a third type of action for controlling product quality, which is used on Processes in which predicted quality differs from the target or targets.

6.1.5. On Line Quality Control: Attribute Characteristics

Here he explains on-line quality control for attribute characteristics. It also examined methodologies similar to those used in the on-line quality control for variable characteristics. They permit to estimate the optimal diagnosis interval and the loss per unit for production processes when operating under normal conditions or when large number of defective items are produced. This also discusses the frequency of production process diagnosis as a function of the production rate of a process.
6.1.6. On Line Quality Control Methods for Process Improvements

Here he discusses methods for improving product quality during production. Methods for improvement of production process included periodic tool changes, automatic diagnosis and recovery of the production process, process diagnosis improvement, and the scrap and disposition of defective products. Employing any of these methods separately, or combination, causes significant improvement in the quality of products. Obviously, the cost of employing any of the methods presented must be considered economically in terms of the increased improvement in product quality.

6.2. TAGUCHI'S MODEL FOR PREVENTIVE MAINTENANCE

Taguchi introduced the concept of employing preventive maintenance schedules to improve the quality of products and production machinery. The production machine's accuracy and break down rate directly affect the product quality. He also introduced optimal preventive maintenance schedules that minimize quality loss per hour of products and machinery. Relationships were developed between the tolerance of product and machinery's characteristics and optimal preventive maintenance schedules. Finally, optimal checking schedules for large-scale systems are to help in minimizing total quality loss.

The excessive preventive maintenance results in unnecessary maintenance costs. Therefore an optimal preventive maintenance schedules exists that minimize the total cost of repair and down time of equipment.
Preventive maintenance as it affects on-line quality control systems involves the quality control of characteristics of products and the reduction of the expected failure of the machine during the production operation.

A machine may fail and it is not able to produce products to the requirements. A machine failure may also be a sudden break down during the operation. Employing preventive maintenance schedules can reduce the failure of either type.

These schedules can be applied when a product experiences deviation caused by extended use of the operations. The schedules also apply when the parameters of a production machine deviate from their target values. Thus causing deviations in quality characteristics of the products being produced.

The following parameters are defined

\[ B = \text{Checking cost} \]
\[ n_0 = \text{Current (or initial) checking interval} \]
\[ C = \text{Preventive maintenance interval} \]
\[ u = \text{Average preventive maintenance interval} \]
\[ u_0 = \text{Current average preventive maintenance interval} \]
\[ C^* = \text{Loss per failure due to deviations greater than } \Delta^* \]
\[ u^* = \text{Average time between product (or machine) failure when no preventive maintenance is performed} \]
\[ n = \text{Checking interval (To check the amount of deviation)} \]
\[ \Delta^* = \text{Functional limit of product or of a parameter of the production Machine} \]
\( \Delta \) = Preventive maintenance limit

\( \Delta_0 \) = Current (or initial) maintenance limit

\( f \) = Time lag (in unit)

The diagnosis cost per component of machine = \( B/n_0 \) ........(1.1)

The adjustment cost per component of machine = \( C/u_0 \) ........(1.2)

Assume that the time required for the parameter of the production process to reach \( \Delta \) is proportional to the squared distance from the target value, and that the limit required to reach the maintenance limit is

\[
\frac{\Delta^2}{\Delta_0^2}
\]

We also assume that the parameter of the production machine being measured follows a uniform distribution within the range \( \pm \Delta \). No preventive maintenance is done as long as the value of the parameter is within this range. The mean squared(m) of the parameter of the production machine within \( \pm \Delta \) is derived from the following equation.

\[
\frac{[(m+\Delta)-(m-\Delta)]^2}{12} = \frac{\Delta^2}{3}
\]

Since the parameter of the production machine is checked at intervals of ‘n’ units of time when the average time the parameters is outside the control limit \( \Delta \) is ‘n/2’. When the time lag ‘f’ is considered (not negligible), then the average time the parameter is outside the maintenance limit \( \Delta \) is \((n/2+f)\). So the mean squared deviation becomes
When $\Delta$ in Eqn.1.5 becomes $\Delta^*$, failures will occur at intervals of $u^*$, causing a loss $C^*$. Thus, the expected loss as a result of preventive maintenance (using a checking interval ‘$n$’ and a preventive maintenance limit $\Delta$) is

$$C^* \frac{1}{u^*} \left[ \frac{\Delta^2}{(\Delta^*)^2} \right] \frac{n}{3} \frac{\Delta^2}{u}$$

The total quality cost under current preventive maintenance schedule ($L$) is obtained by adding Eq.No.1.1,1.2,1.3,1.4,1.5 and 1.6

$$L = \frac{B}{n_0} + \frac{C}{u_0} + \frac{C^*}{u^*} \left[ \frac{\Delta_0^2}{(\Delta^*)^2} \right] \frac{n}{3} \frac{\Delta_0^2}{u_0}$$

The optimal checking interval and preventive maintenance control limit are obtained as follows:

Following Eq: 1.7 the expression is rewritten as

$$L = \frac{B}{n} + \frac{\Delta_0^2 C}{n u_0 \Delta^2} \frac{C^*}{u^*} \left[ \frac{\Delta_0^2}{(\Delta^*)^2} \right] \frac{n}{3} \frac{\Delta_0^2}{u_0}$$

The optimal checking interval ‘$n$’ and preventive maintenance control limit $\Delta$ can be obtained by partial derivatives of Eq No: 1.8 with respect to ‘$n$’ and $\Delta$ and equating the results to zero.

Thus,

$$\frac{\partial L}{\partial n} = \frac{B}{n^2} + \frac{C^*}{n^2} \frac{1}{(\Delta^*)^2} \frac{\Delta^2}{2u^*} = 0$$
The optimal checking interval,

\[ n = u^* \sqrt{\frac{2B}{C^*}} \]  
\[ \text{-------(1.9)} \]

And

\[ \frac{\partial L}{\partial \Delta} = \frac{2 (\Delta^*)^2 C^*}{u^* (\Delta)^3} + \frac{C^*}{u^* (\Delta^*)^2} \frac{1}{3} \frac{2\Delta}{x} \frac{x}{=0} \]
\[ \text{-----x -----x} \]

Optimal preventive maintenance control limit.

\[ \Delta = \Delta^* \left[ \frac{3C}{C^*} \right] \]  
\[ \text{-------(1.10)} \]

The average preventive maintenance interval will get by using optimal preventive maintenance control limit. Thus

\[ \frac{\Delta^2}{u = u_0} \]  
\[ \Delta_0^2 \]  
\[ \text{-------(1.11)} \]

The total quality cost under optimal preventive maintenance schedule is

\[ L = \frac{B}{n} + \frac{C}{u} + \frac{C^*}{u^*} \times \frac{1}{(\Delta^*)^2} \left\{ \frac{\Delta^2}{3} + \left[ \frac{\Delta^2}{2} \right] \right\} \frac{n}{u} \]  
\[ \text{-------(1.12)} \]
But there are two cases of product deviation from the target value. First, the deviations (drifts) can be on both sides of the target value. Second, the deviations can only be on one side of the target value such as the wear of mechanical parts.

In the first case, we can use a random walk model as an approximation to determine the average time to reach the upper or lower limit of a product characteristic, at which point failure will occur. When using the random walk model, the average time \( u^* \) is assumed to be proportional to the square of distance between the target value and the upper or lower limits (the functional units \( \Delta^* \) is equal for both upper and lower limits of the target value). Thus, \( u^* \) is

\[
u^* = \lambda (\Delta^*)^2 \tag{1.13}
\]

Where \( \lambda \) is the constant of proportionality, determined by observing the average time \( u_0 \) to reach a predetermined deviation \( \Delta_0 \). Thus the value of \( u^* \) can be obtained as follows

\[
u^* = \frac{u_0 (\Delta^*)^2}{\Delta_0^2} \tag{1.14}
\]

In the second case, where the average time to reach the fundamental limit \( \Delta^* \) is proportional to the amount of deviation from the target value, \( u^* \) is

\[
u^* = \frac{\Delta^*}{\Delta_0} \tag{1.15}
\]

The loss per failure when the deviation greater than \( \Delta^* - C^* \) is

\[C^* = Pt + c\]

Where,

\[t = \text{Average amount of down time}\]
6.4. STATE OF ART OF ON-LINE QUALITY CONTROL METHODS AND BREAKTHROUGH SEQUENCE

Dr. Genuchi Taguchi contributed his work both in on-line and off-line quality controls. There was limited amount of research work has done in the area of on-line quality control. The most of the work was done by Taguchi and he published the same.

Presently no manufacturing enterprise is implementing Taguchi’s off-line quality control methods fully and very few manufacturing enterprises are implementing TOLQC techniques in the world. Though some of the manufacturing enterprises are interested to implement TOLQC methods, they are not able to implement this because of difficulties in calculations, maintaining of records and the lack of sufficient information.

6.4.1. Breakthrough Sequence

Considering the various factors a breakthrough sequence was evolved to successfully implement Taguchi’s On-line quality control methods in typical manufacturing systems. This breakthrough sequence is explained below.
6.4.2. Select the Manufacturing Enterprise

Select the manufacturing enterprise (PSGII is selected for the purpose) and the implementation begins by obtaining the management permission and support. Since the process of applying Taguchi's methods has to pass through various critical activities such as major change in quality policies, data collection, study of present system, etc., the management permission and support are vital and it is obtained.

6.4.3. Enlist the Machinery and Equipment

After obtaining management permission and support, the tedious task of carrying out the identification of machinery and equipment problems with the hectic consultation of managerial personnel and operating personnel is to be carried out.

6.4.4. Brainstorming to identify Critical Machinery & Equipment from Maintenance view Point

After listing maintenance problem, several brainstorming sessions are to be conducted at different levels of organization to identify machines and levels, which need immediate and meaningful attention. The phase is quite important in the sense that this reduces the chances of considering non-economical problems, which will not improve the profitability of the company.

6.4.5. Design Experiment

After identification of critical factors, the experiment to be conducted is design considering the various interacting factors such as non-disturbance to maintenance, cooperation of employee's etc.
6.4.6. Experiment, Record Results and Analysis using TOLQC Methods

Now, the experiment is to be conducted and the results are to be carefully collected and recorded. During this process, care has to be taken to see that the experiment is conducted in the same condition to that of the actual.

After conducting the experiment and recording the results, the quality losses for machines and equipment identified are to be computed for assessing the quality levels using the recorded data.

6.4.7. Suggest Modified Parameters

Using computed results, if the quality of machines is not improved, then suggests changing the modified parameters.

6.4.8. Re-Design the Experiment

After changing the modified parameters than re-design the experiment to improve the quality cost.

6.4.9. Analyse the Result (Quality Cost) and Record the Data

The results of confirmation experiments are analyzed and recorded the quality cost. If the quality loss is decreased compared to the previous computation, then, the findings are reported to the management through convincing reports by using statistical tools.

6.4.10. Design the System

By using the TOLQC preventive maintenance schedule, if the quality system is improved, then design the system by using new parameters.

6.4.11. Obtaining Management Approval

After getting the approval of the management, the quality system encompassing modified quality policy and procedures are to be evolved. Since the continued pressure is placed upon the
industrial world towards QS 9000 compatible quality systems, it is to be ensured that the modified system is compatible to any one of the QS 9000 series quality standards.

6.4.12. Check for Missed Factors

However if the preventive maintenance quality loss is not reduced, then the factors, which missed are to be incorporated and the confirmation experiment is to be repeated. The process is repeated until the quality loss is reduced to a significant level and it is advisable again to go for conducting brainstorming sessions to identify the factors and levels which are of economically important for the consideration and the whole procedure is to be repeated.

6.4.13. Quality System for On-Line Quality Control

Since the ultimate goal of Taguchi's On-line quality control method is itself continuous quality improvement, it is firmly emphasized that, in order to ensure perpetual application of these methods, a quality system encompassing quality policy, procedures, manuals, records and work instructions is an imperative. As a matter of fact the research work on Taguchi's On-line quality control methods becomes meaningful and useful only when the quality system pertaining to these methods are developed and implemented.

6.5. IMPROVEMENT OF PREVENTIVE MAINTENANCE QUALITY FOR JOLT-SQUEEZE MOULDING MACHINE (A case study)

P.S.G Industrial institute was established by the P.S.G and sons charities in 1926. The institute manufactures a variety of industrial products like CNC machine tools, conventional

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machine tools, presses and several other products. The scope of foundry division encompasses a major segment of the P.S.G. industrial institute economy, employing directly and indirectly 300 people and produce about 7200 tons of ferrous production annually and feeds castings into 90% of all machine shops, produce about 6500 tons of salable castings annually and undertaking job order from Ashok Leyland Autoluc, NGEF Hubli, Crompton Greaves Ltd., for the production of different components.

6.5.1. PSG Quality Policy

1. Manufacture goods and offer service with consistent quality.
2. Increase the customer satisfaction.
3. Aim to achieve global recognition as champion for quality.
4. Identify, communicate and promote quality principles and technology.
5. Reorient, train and motivate human resources to meet technological challenge.

6.5.2. Human Resources and availability in Maintenance Department

The maintenance dept is sub divided into two divisions viz.

- Mechanical Engineering Dept

<table>
<thead>
<tr>
<th>Position</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assistant engineer</td>
<td>1</td>
</tr>
<tr>
<td>Junior Engineer</td>
<td>1</td>
</tr>
<tr>
<td>Junior Engineer (Trainee)</td>
<td>1</td>
</tr>
<tr>
<td>Supervisor</td>
<td>2</td>
</tr>
<tr>
<td>Fitters</td>
<td>2</td>
</tr>
<tr>
<td>Trainees</td>
<td>4</td>
</tr>
<tr>
<td>Machine operators</td>
<td>2</td>
</tr>
</tbody>
</table>
Trainees 2
Others (Oilers and welders) 4

- Electrical Engineering Dept
  Junior Engineer 1
  Electrician 2

6.5.3. Machinery and Equipment

1. Simultaneous Jolt_Squeez molding machines 6 no
   ARPA 300 –2 (Automatic or manual operation)
   SMFA 200 – 2 (Automatic or manual operation)
   WBQ3 - (Automatic or manual operation)

2. Induction Furnace 4 no
   450 kW 2
   750 kW 2

3. Crane 3 no
   5T capacity 2
   2T capacity 1

4. Sand bucket elevator 1 no

5. Electric oven 2 no

6. Coke fired oven 1 no

7. Compressor 2 no
   60 HP 1
6.5.4. Machine Moulding

Molding process may be classified as hand molding or machine molding according to whether the mould is prepared by hand tools or with the aid of some molding machine. Hand molding generally found to be economical when castings are required in a small number. On the other hand, when the castings are required in large quantities, hand molding is more time consuming and laborious and becomes expensive considerable skill is also needed to make good moulds by hand. In such case, machine molding is generally employed.

- Operation of simultaneous Jolt Squeeze Molding Machine

In this case, both squeeze and jolt actions can be obtained one after another. The table is attached to a jolt piston, which is raised and dropped in the jolt cylinder by the action of compressed air. The jolt cylinder is an integral part of the squeeze piston that can move up and down due to air pressure in the squeeze cylinder. The upper surface of the squeeze piston remains in contact with the bottom of the table.

During jolting, the squeeze piston lies solidly on the base of its cylinder, and the lift of the jolt piston cause the table to rise. During squeezing, the jolt piston and cylinder move along with the squeeze piston and the table through the desired height.

6.5.5. Sequence of Moulding operations

1. Mould pattern firmly on the table.
2. Place the box on the lifting pins.
3. Lower the box.
4. Fill sand.
5. Jolt for 4-6 seconds.
6. Swing in squeeze head.
7. Squeezing (Jolt and squeeze simultaneously).
8. Swing out squeeze head.
9. Remove sprue.
10. Remove box and position the next empty box.
11. Repeat the operations.

6.5.6. Preventive Maintenance of Jolt Squeeze Molding Machine

The preventive maintenance of molding machines is to be carried out in four stages

1. Inspection or checking
2. Smaller repairs
3. Medium repair
4. Complete overhaul

Depending up on the frequency of use, the molding machines should be over hauled once in year.

After commissioning of the machines or after the disassembly of the table or any other work to the jolting unit requiring the loosening of the screws or nuts, they will have to be checked for tightness after an operation time of one month; especially the nuts of the vibrator fixing bolts and the fixing bolts of the jolting table guiding rods. Check whether the air hose and the oil lubrication hose for the jolter as well as the threaded connections for the other lubrication points
are firmly connected. To begin with the frequency of checks is once in every 20-30 days. There after the frequency of checks would depend on the operation of the machines. These checks have to be repeated as preventive maintenance procedure.

i. Inspection

1. Check all hose connections for air and hydraulic systems and take corrective actions if necessary.
2. Check oil levels in hydraulic tank and if necessary fill with proper hydraulic oil to the specified level.
3. Check oil level in air filter lubricator unit.
4. Check adjustment of roller valves, provided down in the frame actuated by lifting lever and at the rear side of the frame above the door for releasing the impulse for squeeze head operation. The tightness of these valves has to be checked with respective actuating parts for trouble free operation.
5. Check lubrication connection and oil level in lubricating pump. The transparent pipeline gives clear indication of operator. It ensures that oil flows through the pipeline when machine is in operation. There has to be oil film level always on table mating surface.
6. Check jolting table lock nuts fastened to guide rods and
7. Check the central plug of jolting table lubricating oil and put the plug back.

ii. Small repairs

1. To partly disassemble the machine, units that are subjected to maximum wear should be disassembled. After disassembly, defective parts are listed out and are to be replaced. Repair work to be done on the disassembled unit is given below for the various machine units.
A. Squeezing mechanism

- To clean the piston and cylinder
- To inspect the foundation bolts and check the level of the bed.

B. Jolting mechanism

To clean piston and cylinder
To check the fastenings
To replace the piston rings
To repair the shock absorbers
To check their level and to replace the worn-out broken parts of the shock absorber.
To clean and regulate the guides, clamping plates, wedges and bushes.
Distortion, if any, on the surface of the jolting table should be machined.

C. Vibrators

To replace the plungers, springs, bearings and other worn-out parts.
To check the pattern plate.
To check the control system of the machine to tighten the bolted connections and to replace the packing.
To check the condition of the pneumatic system and to eliminate packages.

iii. Medium repairs

Machine is partly disassembled but more number of units is opened.
Cylinders, pistons of the disassembled units are rebored and sleeves installed. Welding is to be carried out for repairs and cracks in the table, cylinder and piston.
Bearings are repaired by babbling. (Pouring new lining)

The main parameters of the machine are checked as per technical conditions.

iv. Complete Overhaul

A. Overhauling jolting unit

1. Disassemble the jolting table along with anvil and scraper ring. The jolting hose, lubrication hose and the guide nuts, will have to be removed. Remove the central plug and lift along with anvil by hook.

2. Unload the table and anvil on a clean surface, remove anvil and scraper ring from the table.

3. Check the table and anvil machined surface and clear them properly by light diesel oil if rust is observed, apply very fine emery paper to remove the rust only. The machine surface should be protected from scratches.

4. Remove the spring and spacer ring and mark the serial number on spring and spacer.

5. Remove press plunger or squeezing piston. (Two threaded holes are provided for dismantling work.)

6. Now the supporting frame is to be cleaned properly. If any rust is observed apply very fine emery paper.

7. Lubricating system is to be cleaned and checked to ensure that all oil passage provided in supporting frame are in good working condition.

8. Remove the front cover. Check table stop cylinder. Overhaul the cylinder by disassembling it. The cylinder piston acts as a stopper to the bolting guide in, when lifting operations take place, check the operation of cylinder at the time the lifting pin up.

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9. Check the impact ring. This has to be about 2 mm above the anvil surface. If this height is reduced to such an extent that impact ring is flush with the anvil surface, then replace the ring.

10. Replace all rubber parts like scraper ring, sealing ring etc.

B. Overhauling of lifting pin system

The lifting cylinder with oil tank assembly valves has to be dismantled for cleaning and damaged seals, collars, and bushes are replaced. It is possible to replace lifting transfers in the supporting frame without removing the machine from pit. For this remove two lateral covers of the supporting frame. Remove the nuts of guide rods and guide rods to be lifted in upward direction.

The central guide rod can be removed from the supporting frame. Remove the split ring by loosening the screw and pushing the guide rod in downward direction. Now the guide rod can be pulled up from the frame. In this position lifting transfers can be moved out freely. The lifting lever can be removed from the rear.

C. Overhauling of squeeze head

For disassembling the squeeze head both covers of the swivel drive have to be removed and the rear stop has to be removed further more, the collar ring has to be removed on one side. The squeeze head has to be turned backwards till it is possible to remove the toothed swivel piston. In this case, the piston of the squeezing head at which it is possible to remove the piston should be marked in order to mesh with corresponding tooth of the assembly.

The bush of the squeezing spindle can only be removed in downward direction provided. The cover and the guide bolt behind it have removed earlier. In this case the squeeze spindle bush has to be supported in such a way that it will not fall down after the last pitch.
6.5.7. Lubrication System

The molding machine mechanisms operate by fully pneumatic control. Therefore it is the prime important to give full attention to the lubrication system. Failure to do this will cause serious damage to the machine or may result in seizing of jolting table of machines. Lubrication instructions, Recommended lubricants and Moulding machine details are shown in table 6.5.7.1, 6.5.7.2 and 6.5.7.3 respectively (given in annexure A).

6.6. CONCLUSION

From many points of view, TPM concept appears to be similar to TQM concept. This led to the conclusion that TPM concepts can be modified and improved if an approach involving the integration of quality in maintenance function is adopted. In this context, the feasibility of adopting statistical methods was considered. Since statistical methods do not envisage error free operation at an economical price, the adoption of TOLQC methods became an imperative. The foundry division of the PSGII was selected to implement the preventive maintenance on the different types of simultaneous jolt-squeeze molding machines and the results indicated that an application of TOLQC methods, the maintenance quality is expected to improve considerably.