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Productivity & Quality Improvement Through Overall Equipment Effectiveness

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Introduction to PTC:

Pakistan Tobacco Company (PTC) is a subsidy of British American Tobacco (BAT), which is the world’s most international tobacco group, with brands sold in 180 markets around the world. PTC, with annual sales over 24 billion sticks, is the 6th largest BAT companies based on volume. PTC produces high quality tobacco products to meet the diverse preferences of millions of consumers, and strives for improvement in all areas of the business - ‘from seed to smoke’, which shows its commitment to delight the consumers with through excellent products at the best possible price.

Pakistan Tobacco Company (PTC) has achieved one of the most remarkable transformations ever seen inside British American Tobacco through an extraordinary team effort.

PTC’s long-term vision of becoming the “First choice for Everyone”, and its medium-term mission of “Transforming PTC to perform with speed, flexibility and enterprising spirit of an innovative, consumer-focused company” are not just statements but the whole team, in the leadership of our chairman Jerimy Pike, are putting in their best to moving towards realisation of these with a spirit of continuous improvement.

During the last 8 years, PTC has embarked upon many programs to help achieve the goals of its medium mission and march towards the long term vision. These programs were

1. BEST 2000. (A TQM program)
2. ‘Winning in Our World’ (WOW) Change Management Model
3. Manufacturing Resource Planning (MRPII – Oliver Wight version 5 checklist)
4. ISO 9000 -2000, ISO 14000

"PTC’s top management belief in its people, the strength of our brands, our values and the pride to be an ethical company are the driving forces behind all the success stories in the past and our confidence in the future. The sense of urgency and commitment to do every thing possible to satisfy our consumer more than anyone else prevails all over the company. We have a strong belief that the key to success is to get the best possible of our assets (our people, brands and facilities)

Focus on Quality & OEE:

True to its long-term vision of “First Choice for everyone” and medium term mission of “Transforming PTC to perform with speed, flexibility and enterprising spirit of an innovative, consumer-focused company”, PTC is committed to make available the best quality product at the most competitive prices in the market. In order to honor this commitment, we need to focus on the quality of our product and get the best out of our processes. Focusing on the product quality means to be well aware of the customer requirements and be able to translate his requirements into the technical language understood by the product developers and shop-floor employees. To make the voice of customer the basis of the activities of the design and manufacturing teams, we are using tools like; market research, simulated test market, Focus group surveys, QFD and DoE. The extensive use of these tools helps us in designing the product in accordance with the voice of the customer while DoE helps in identifying the impact of the changes in key process input variable on the key process output variable. In other words they provide us the know-
how about the customer requirements, which is just a part of the journey in the right direction. The real thing is taking steps towards availability of the quality product in the market at the best possible price. Price of a product in the market is always related with the product cost and to keep that low, we need operate 100 percent of the time at 100 percent capacity producing 100 percent good quality product. The optimum crewing of machines is also a must for getting the desired level of results. Although an ideal situation, one can try to reach as near as possible to this ideal operating conditions by focusing on the overall equipment effectiveness (OEE). This means:

1. Best Quality product
3. Optimum machine crewing.
4. Reduced level of wastes.

These are the lagging indicators, the areas to focus upon to have the highest overall equipment effectiveness are:

1. Maintenance System
2. Knowledge, skills and attitude of the shop-floor employees
3. Incoming raw-material quality (Supplier performance)
4. Proper planning and scheduling
5. Avoidable process losses.
6. Housekeeping

Before we go into details of what PTC has done in the above areas, it will not be out of place to discuss the concept of OEE in general.

**Overall Equipment Effectiveness**

When we operate a factory, Ideally the equipment should be all the time loaded to its 100 percent capacity and it should not be rejecting a single unit produced. This means hundred percent good quality product at 100 percent capacity 365 days a year, however, there is always a substantial gap between this ideal situation and the actual operational conditions. The main causes for this gap are the losses due to:

1. Ineffective planning.
2. Operational losses
   a. Down Time losses
   b. Equipment failures
   c. Time lost during brand changeovers
   d. Speed Losses
   e. Minor Stoppages.
   f. Defect (Quality) losses
   g. Scrap & Rework.
   h. Fast movers changeover time.

**Ineffective Planning:**

Planning and Scheduling plays an important role in increasing the loading time of the machines. In other words it reduces the scheduled downtime of the machines. Effective scheduling depends upon our ability to load the machines in such a way to maximize the scheduled running time of the machines. Unfortunately the effective planning does not only depend upon the ability of the production team to schedule effectively, it also depends upon:

1. Effective and reliable (with in reasonable limits of accuracy) sale-forecast.
2. Demonstrated capabilities of the manufacturing team to meet the plan in near past. This, in turn, depends upon the skills, knowledge and attitude of the members of the production team at all levels as well as the conditions of the machines.
3. Company policy about running the factory (How many shifts per day).
If we look into the general trends of scheduling of PTC old machines as far as scheduling is concerned. A graphical presentation is:

![PTC's Schedule of Old M/Cs](image)

The main reasons for this low ratio of planned scheduled time to the total time were:

1. Very high seasonal (Pre & post budget months) variations in demand.
2. The policy to run old machines in double shift instead of triple shift to ensure proper maintenance and product quality.

Forecast (sales) is highly dependent on the type of product and the market situation, however one can bring in reasonable accuracy in the forecast by providing inputs in terms of training to understand the dynamics of the forces acting in the market as well as provision of proper ERP tools like demand solution and DRP (Distribution Resource planning) modules.

PTC has taken steps in the right direction and has also started monitoring actual performance against the plan, in order to gain an insight into the effectiveness/accuracy of our forecasting process and continuously improve it. Improvements in forecasting accuracy helps in optimizing both inventory levels and capacities, which in turn results in reduced unscheduled time.

At the same time PTC embarked on gradual modernization program and all the incoming new machines are to be run in accordance with a 24 hour a day seven days a week program called the Continuous Running. This changed the ratio of the scheduled to run time to the total available time drastically. Ratio during the high production part of the year became:
This ratio will further improve towards year-end, when the new machinery induction program will be completed. The real challenge is to reduce the losses in the scheduled time. We will explain this with example of one of our packing machines.

The overall Scheduled time is divided into:
1. Running Time
2. Scheduled Down time
3. Major Losses

**Running Time:**
This is the time in which the machine is actually producing good product. The equivalent time, when the machine will be running at 100% capacity and producing 100% good quality product. To narrow the gap between the stated ideal situation and the actual demonstrate, we need to focus on increasing the running time.

**Scheduled Down time:**
This is the time when the machine remains idle (not producing product) for some reasons, which are deemed to be important by the team and are utilized to improve the performance of the machine. In our case these typically include:

1. **Communication Package:** The machines operated by the teams are stopped for monthly briefings of the team-members. They are provided information about the company, Factory and their team’s performances during the month. This helps them connecting, their contributions, to the big picture and also compare the performance of their team with the overall performance.

2. **Long Maintenance:** Extensive maintenance is performed on machines after 1000 & 4000 hours of running. The machines used to be stopped for 4 days for this activity and now with the introduction of sub-assemblies, we have reduced his time to three days with further improvements in sight.

3. **Weekly Maintenance:** Every week machines are stopped for one shift to carry out weekly maintenance. This is essentially oiling and greasing of the machines associated with deep cleaning.

4. **Daily Cleaning:** Every shift machines are stopped for half an hour to carry out the necessary cleaning.

The analysis of the scheduled Downtime reveals that we can bring in improvements in all the areas by streamlining the maintenance activity, cleaning the machines in more methodical manner and making the communication package more precise and to the point. Already work has been done on the long maintenance and introduction of sub-assemblies are helping us in reducing the downtime in this category.

**Unscheduled Down time:**
This is the category which comprises of the big six losses, namely:

1. Changeovers
2. Fast movers replacement
3. Speed losses
4. Defect losses (Rejections/reworks)
5. Major Stoppages
6. Minor Stoppages

A graph showing each loss as a percent of the total losses, for PTC’s example, is given below.
Changeovers:
This is the time lost during the changeover of machines from one brand to another. Changeovers are considered to be non-value added because they contribute a significant amount of lost time that should be available for running more demand. In order to reduce the time lost in changeovers, we must look into three aspects:

a. Changeover frequency: The overall production program for the period (taking into consideration the market demand, inventories of finished goods available, supply schedules of the raw materials and capacity in hand) should be scheduled in a way to ensure longer runs and reduce the number of changeovers.

b. Categorize the changeovers in accordance with the requirements. Changeover to some brands form the existing running requires lesser changes than the other. So changeovers should be scheduled in such a way that they are less time consuming.

c. Standardize the procedure for all changeovers and make them available to the operators with appropriate inputs to understand these.

Speed Losses:
These are the losses suffered when machines are not operating at their rated speeds. There are many reasons for machines not operating at the required design speed:

a. Machine Conditions: When maintenance of machine doesn’t get specific attention and due to production pressure, maintenance schedules are not followed.

b. When due to specific cost drives, sub-standard spares are used.

c. Very old vintage machines.

d. Raw material’s quality and run-ability.

e. Knowledge/ skills and attitude of the team members.

The issue with speed losses is that if appropriate actions are not taken at the right time to address these, people take the new speeds as the rated speed and then no actions are deemed necessary to be taken to bring the machine on the rated speed. Very destructive paradigms get developed, e.g. Running the machine at higher speed will affect our product quality adversely and increase waste at the same time reduce productivity.

Defect Losses (Rejects and Reworks)
These are the products which are rejected and scrapped are sent back for rework. Quality Losses occur when a machine is used to produce product, which is not immediately available for distribution. This is considered a loss, because of the delay created in the supply chain. Often some of the product can be release after inspection, but this increases inventory on the production floor and reduces customer service. This creates a safety hazard and present a housekeeping problem.

Quality Losses are normally calculated by dividing the quantity of finished/semi finished product initially held by the design rate produces the equipment time used to generate Quality Losses.

Example:

<table>
<thead>
<tr>
<th>Initial Hold</th>
<th>500,000 units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Speed</td>
<td>5000 units/ minute</td>
</tr>
<tr>
<td>Quality Loss</td>
<td>100 min</td>
</tr>
</tbody>
</table>

Fast Movers:
Every machine involved in the manufacturing industry has some parts, which wear out quickly and replaced at a relatively higher frequency. E.g. Cutting knives, garniture tapes etc.

To reduce time wasted in replacing these fast movers we have to:

a. Do very possible effort (material, setting, timings etc.) to enhance the life of these parts, which will reduce the frequency of replacement.
b. Train the machine operators to reduction of the replacement time.

**Minor Stoppages and Major Stoppages:**

Typically stoppages (jams, rod breakouts), which take less than ten minutes to restart the machine on full production are considered to be minor stoppages and all other are considered to be major stoppages. Following are some of the contributing factors in high losses due to these stoppages:

a. Machine conditions (Poor machine conditions result in high number of breakdowns)
b. Operator’s knowledge, skill and attitude are the basic requirements in setting and timing the machines properly, which results in reduction in the frequency of breakdowns. Highly trained operators are able to reduce the duration of a particular breakdown too.
c. Housekeeping (The quality of housekeeping has a direct effect on the frequency of machine breakdowns).
d. Raw material quality. The consistency in the quality of raw material not only improves the product quality, it also enhances productivity by reducing reworks/rejects and also the frequency of breakdowns.

**Metrics of OEE**

In order to improve product quality and productivity we should be able to improve our overall equipment effectiveness. Nothing can be control if it is not measured properly and if you can’t control something, you can’t improve it. Measurement of the overall equipment effectiveness at a plant may not be sufficient to provide guidelines for drawing up an effective action plan for improvement. In order to get proper information we must know, how much we are loosing in:

a. Planning the utilization due to errors in sales forecast.
b. Availability rate
c. Major Losses

Proper ratios will be:

**Planned Utilization Rate:**

This will provide a measure of the company’s ability to forecast correctly and balance its capacity against that. If the forecast has higher seasonal variations and higher inaccuracies, then a higher capacity will be required to meet the contingencies and there will many unwanted idle equipment times. The planned utilization ratio (based on 24hours a day, 7days a week) can be measured as:

Planned Utilization Ratio = \( \frac{\text{Total time} - \text{Unscheduled Time}}{\text{Total time}} \)
It is the ratio between net operating time and the planned time.

\[
\text{Availability ratio} = \frac{\text{Planned time} - \text{planned down time}}{\text{Planned time}}
\]

In order to enhance availability ratio, one must train the operatives, write proper procedure and adhere to schedules to reduce planned downtime utilized in different maintenance and cleaning activities.

\[
\text{Availability Ratio} = \frac{\text{Running}}{\text{Sched./Downtime} + \text{Major Losses} + \text{Unscheduled}}
\]

**Overall Equipment Effectiveness:**

This measures the ability to run equipment at the designed speed with zero defects. In order to maximize OEE one must reduce the 7 major losses to zero.

Graphically Presented:

\[
\text{Overall Equipment Effectiveness} = \frac{\text{Running}}{\text{Sched./Downtime} + \text{Major Losses} + \text{Unscheduled}}
\]

In order to improve the overall production outputs, we must be able to improve our equipment availability ratio by improving our forecasting and planning activities along with
our ability to reduce the six major losses to the minimum. The following figure shows the
different stages we loose valuable operating time.

<table>
<thead>
<tr>
<th>Total Available Time (24 hrs a day, 7 days a week)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planned Time</td>
</tr>
<tr>
<td>Unplanned Time</td>
</tr>
<tr>
<td>Operating Time</td>
</tr>
<tr>
<td>Planned Downtime</td>
</tr>
<tr>
<td>Running Time</td>
</tr>
<tr>
<td>The six Major Losses</td>
</tr>
</tbody>
</table>

**PTC Initiatives for improvements:**

As it is clear from the vision (First Choice for everyone) and mission (“Transforming
PTC to perform with speed, flexibility and enterprising spirit of an innovative,
customer-focused company”) statement, the top most priority of PTC as a company
is the satisfaction of the customer. To meet this goal, product quality and effective
utilization of our assets to produce at the optimum possible rates as the two areas
which can help us in getting a competitive edge in the market.

**Product Quality:**

In order to have a have our product quality in accordance with the expectations of
our customer, we need to know his preferences and then a vehicle to translate the
“voice of customer” into the technical terms used by our product developer. Then we
need to covert the product design terminology into the shop-floor language, with
conducting studies to know the impact of input variables on the key output variables.
For this we are using different tools used in market surveys.
Then we are using QFD & DoE for the translations & effects. During last few years
many level houses of quality have been developed. Details of all the activities in this
field are out of the scope of this paper. Our activities are not only confined to these,
we have our comprehensive systems to follow the product throughout the
manufacturing process and even samples are taken from the market to study the
effects of our logistics and distribution activities on our product. The tools used are:

a. Manufacturing Quality Index. (MQI).
b. Product Quality Index (PQI)
c. Retail Quality Index (RQI)

**Overall Equipment Effectiveness:**

In order to improve the overall equipment effectiveness, we are working on three fronts.

1. Enhance the forecasting and planning capabilities. Trainings and forecasting tools
   are being provided. We monitor our actual sale against the sale forecast and the
   actual production volume against the plan. This is done on regular basis and analysis
carried out at proper levels.
2. Maintenance plays an important role in the quality and productivity levels of an organisation. Knowing this concerted efforts were made to improve our maintenance process. These include:

   a. A course on maintenance management was arranged for the management members involved in the maintenance and operation activities. The objective of the course was to introduce new maintenance techniques used in the modern industry.

   b. Some of our maintenance technicians were sent abroad to work on the rebuilding of machines at the supplier’s premises. They took part in the activities at all levels from stripping down the machines to rebuilding them.

   c. Improve the time utilised in the scheduled downtime activities like maintenance, communication and cleaning activities. Procedures have been developed for these activities to eliminate the non-value added activities. E.g. We have been able reduced the downtime of the 4000 hours maintenance of a machine from 4 days to 3 days by introducing the use of subassemblies.

   d. Monitoring of maintenance performance started. The machine is run on protocol for one shift before it is taken on 4000 hours maintenance and all quality and output results recorded. Then the machine is taken on maintenance and is handed over after a post maintenance protocol run for one shift. All the results are again monitored and improvements recorded.

3. To utilise the available net operating time in producing good quality product. This means reduction of the six big losses. These losses, as mentioned above, are Changeover, major & minor breakdowns, Fast movers replacement time, speed and defect (quality) losses, We at Akora khattak have identified the following areas to work upon in order to reduce the six big losses.

   a. Knowledge & skills of Team Member: Our team members are our most valuable assets. We need to do continuous efforts to enhance their product knowledge and skills on the machines. Following training activities are a regular feature at our factory.

      i) Modular training on machines. Two trainers from abroad have been arranged to provide training to our operatives on the newly acquired machines.

      ii) Training abroad: We are regularly sending our operatives to UK, Belgium, Uzbekistan and other countries for inputs at the supplier’s premises and learn at our sister OpCos.

      iii) Focus training: This training is provided on the need basis of individual. Based on the technical capabilities, a training requirement grid has been developed and a schedule to train people, in the areas where inputs are required, is in place.

      iv) In order to develop the capabilities and encourage the use of seven basic statistical quality control tools. Regular sessions, three days each, are arranged for machine operators. This training is provided through a tailor made course specific to the requirements of our industry.

      v) To enhance the product quality knowledge, the quality assurance department provides inputs, to the team members, on MQI (Manufacturing quality Index) on regular basis.

   b. Attitude of the team members: The attitude of the team members play even more important role than the knowledge & skills to improve the productivity of an organisation and its product quality. We have designed some activities to bring in positive change in the attitude of our team members.

      i) Connecting to the big Picture: Pride in the job brings in quality and productivity into someone’s actions and pride in the job
stems from ownership. To create ownership one must know the impact of his job on the overall performance of the organisation. This is possible when he has knowledge about his team's performance as well as the company’s performance and must be aware of the developments with in the organization. PTC’s management strives to keep all the team members updated upon all these information and “communication Package” is the vehicle used for this. This is about two hours long session, which is properly designed to provide the team members all the required information and also get their feedback. These sessions are conducted on monthly basis.

ii) Environment has a definite impact on the productivity of both men and machines. A better environment helps us keep the raw material at the desired temperature and humidity. We have gradually air-conditioned all our secondary manufacturing department and efforts are underway to change the layout to assist us in better material through the process and facilitate better housekeeping.

iii) Absenteeism is a multi-facet monster. This not only ruins the discipline of an organisation but also reduce the productivity of the equipment by depleting the skill level. At PTC, this problem is dealt with in a different way. We recognise that “there is a reason behind every crime” and absenteeism is no exception. So in order to reduce absenteeism, we must try to know the reason behind it. We have records of all the team members and those with higher absenteeism records are issued an invitation letter for a meeting to discuss any problems he is facing and the willingness of management to help him resolve the problems. Letter of appreciation is served upon improvement.

c. Quality throughout the supply chain is emphasised. This was done through formal sessions the concept of internal and external customers, process mapping and Team-Working. The idea of satisfying the internal customer in pursuance of the satisfaction of the external customer not only helps in improving the product quality, it also reduces scrap and rework with an increase in the productivity through better equipment setting at all level of the manufacturing process.

d. Improved Raw Material: PTC believes in long-term partnership with our suppliers and we are regularly working with our key suppliers to improve their processes helping them to improve the quality of their product, which is our raw material. Better quality raw materials, not only result in conforming product, but it also have a positive impact on the smooth running of the machines thereby increasing the productivity.
PTC (Results):
In light of the above, when PTC started its efforts for improvements in its OEE, the following areas were addressed (Discussed in detail above):
1. Providing proper training (focusing on knowledge, skills & attitude) to its team members
2. Streamlining its maintenance program.
3. Improving the overall work environment.
5. Providing knowledge about product quality to the team members.
6. Establishing regular communication channels to help all in connecting their roles to the big picture.

The results were improvements in product quality, machine efficiency (Productivity) and reduction in idle capacity.

Machine Efficiency:

![Graph showing Machine Efficiency]

<table>
<thead>
<tr>
<th>Efficiency %</th>
<th>March 03</th>
<th>April 04</th>
</tr>
</thead>
<tbody>
<tr>
<td>58</td>
<td>64.84</td>
<td>76.91</td>
</tr>
</tbody>
</table>
Product Quality improvement:

Work on product quality improvement was one of the focus areas from the beginning, however the pace of improvement became much faster when we started educating our people and enhanced maintenance activities. MQI (Manufacturing Quality Index) & PQI (Product Quality Index) are our indices for measuring the product quality. The increase in these indices had a result on our consumer’s complaints.

All these efforts are also reflected in the Overall Equipment Effectiveness and our effectiveness in equipment utilization stands at a much higher level than March 2003, when we started actually measuring it.
In order to improve productivity and quality, a company has to enhance its overall equipment effectiveness and that is a team work activity, which requires team building, management of knowledge, Improving maintenance system and the sense of ownership in all.