Improving and Measuring Productivity at

AMPAGLAS S.A. (PTY) LTD.

by

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Executive Summary

AMPAGLAS SA Pty (Ltd) is the leading rigid plastic sheeting manufacturer in South Africa and produces high quality plastic sheets for the automotive, building, security and display industries.

Three opportunities for improvement currently exist at AMPAGLAS:

1. Re-evaluating the number of packers employed and on duty,
2. Reducing the strip and clean time of extruders and streamlining the process, and
3. An efficient method of recording, monitoring and analyzing machine downtime and plant efficiency.

The purpose of this project is to address all three opportunities and submit relevant suggestions to improve and measure productivity. This report documents a literature study on relevant topics, methodologies and alternative methods to be used in this project. It also analyses relevant data gained through time studies and other methods, and relates suggested solutions.

Through simulation it is found that the number of packers employed may be reduced to increase productivity. A detailed analysis of some elements of the strip and clean process revealed that at least 20 per cent time is wasted during the procedure. Lastly, a comprehensive information system was developed to accurately record and communicate relevant plant effectiveness statistics.

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1 Introduction and Background

AMPAGLAS is the leading extruder of rigid plastic sheeting in South Africa, supplying the refrigeration, automotive, building, security, glazing and display industries with sheet product running in thousands of metric tonnes per annum. AMPAGLAS was established in 1973 and has since been awarded with the ISO 9002 Quality Certificate. Development of local technology has resulted in the company's ability to blend, co-extrude and laminate specially stabilized and modified materials to suit specific market demands and requirements.

Products include:

- *Acrylonitrile butadiene styrene (ABS)* - high impact resistance plastic, suitable for heavy duty applications especially in the refrigeration and automotive industries.
- *High impact polystyrene (HIPS)* - also extensively used in the refrigeration and automotive markets, where its superior qualities for thermoforming make it a versatile choice.
- *Acrilan* - both medium impact (Acrilan MI) and ultra high impact (Acrilan UHI) have outstanding optical properties.
- *Ampagard* – an extremely good alternative to glass, used for viewing panels, industrial safety and riot visors and riot shields.
- *"Ampalite"* - an amorphous co-polyester sheet with exceptional clarity, toughness and chemical resistance. It can be welded, drilled, sawed and heat and cold bent.
- *Coruplas* – a light weight, water resistant plastic used for advertising, point of sale, storage and packaging.
- *Polypropylene* – a widely used plastic with a variety of applications due to its inherent properties of impermeability to gases and vapours, high molecular mass and good impact strength.
- *Polyethylene* – both high density polyethylene (HDPE) and linear low density polyethylene (LLDPE) have various uses in engineering such as industrial packaging.

The company is situated in Edenvale, Johannesburg and was the first company in South Africa to successfully manufacture flat and profile polycarbonate and twin wall polypropylene sheet. The company has specialised technology agreements worldwide with strong links to international raw material and machinery suppliers.

Management suspects that productivity may be improved in at least two processes:

- Packers – employees who pack sheet from the extruder onto pallets. Depending on the type and size of the product being extruded, packers sometimes stand around with no work to do.
- Strip and clean – This process involves machine setup for different products. According to other extrusion manufacturers, AMPAGLAS' strip and clean process takes four times longer than necessary.

Another AMPAGLAS requirement is an effective system to record and analyze machine downtime and overall equipment effectiveness (OEE), especially with increasing Eskom load shedding in the area.

2 Project Objective

The Objective of this project is to accomplish three goals:

i. Establish time standards for packers as well as evaluating the schedule and number of packers on duty.
ii. Establish time standards for the strip and clean process, evaluate time and motion studies to reduce time wasted and implement accepted suggestions.
iii. Design, implement and test an information system to record and analyze downtime and OEE for specific manufacturing lines.

Informal observation has shown that, depending on the type of product produced, packers are either very busy or do nothing at all. Another consideration is that packers aren't needed when machine setup is done. Currently AMPAGLAS employs one packer per manufacturing line and suspects that the packer work force may be reduced while maintaining the same level of efficiency.

Whenever a different type or colour plastic or a different type of product must be produced, the machine must be stripped, cleaned and set-up for the next product.

This process takes a lot of time since components need to be heated to be effectively cleaned. The components then need to cool down to be reassembled and then heated again before manufacturing can begin. Reducing the strip and clean time is of paramount importance when aiming to meet production targets.

Getting accurate production data is often difficult and requires discipline. An effective information system is essential to record and analyze data. Standard definitions of statistics must be established and data recorded directly from the floor need to be formalised and managed to ensure real time and accurate statistics.

3 Project Scope

A detailed process map must be established as well as time studies for the strip and clean process to identify non-value adding and wasted time during the process. Suggestions how to improve the process time must be made. Lean manufacturing principles may be applied to reduce wasted time.

After performance rating and time study analysis on the number and efficiency of packers, alternatives to the current work force number and duties must be evaluated.

Only production related topics will be included in the information system. It will have no financial capabilities and is purely a tool to record and analyse machine downtime as well as machine effectiveness.

4 Literature Review

4.1 Sources of Information

A variety of sources have been consulted for knowledge about existing best practices and to gain insight on improving productivity at AMPAGLAS.

Detailed interviews were held with employees of AMPAGLAS. Mr. Pieter Lemmer, production manager and factory engineer, supplied most of the information regarding processes at AMPAGLAS. He also gave an extensive overview of process flows and general operating procedures. Other employees such as operators, packers, technicians and production planning staff were also interviewed regarding their individual functions and responsibilities at AMPAGLAS.

Publications and articles found on the internet were reviewed to asses the relevancy of information. The topics researched were:

- Productivity
- Time and motion studies
- Time standards
- Lean manufacturing
- Six sigma (6σ)
- Work measurement
- Performance rating
- Scheduling
- Information systems
- Monte Carlo Simulation
- Overall Equipment Effectiveness (OEE)

4.2 Information Obtained

4.2.1 Productivity

Although nearly all publications differ on the exact definition of productivity, most agree to the general definition that productivity is the amount of units of output produced per unit of input. Rogers (1998) defines and measures productivity using a single firm approach. The firm produces one output (y) using a single input (x), the ratio of these two (y/x) gives a measurement of productivity. Diewert (1992) considers this ratio an input-output coefficient and only attributes the word ‘productivity’ when the change is measured over time (t) i.e.

$$Prod_{t-1,t} = (y_t / y_{t-1}) / (x_t / x_{t-1}) \qquad [1]$$

A critical analysis of processes may be very useful when attempting to improve productivity. Asking the questions in table 1 regarding current operational procedures, the analyst can identify and evaluate suitable alternatives.

Table 1: Critical analysis technique

Present method		**Alternative**	**Selected alternative**
Purpose: What is achieved?	Is it necessary? Why?	What else could be done?	What should be done?
Means: How is it done?	Why that way?	How else could it be done?	How should it be done?
Place: Where is it done?	Why there?	Where else could it be done?	Where should it be done?
Sequence: When is it done?	Why then?	When else could it be done?	When should it be done?
Person: Who does it?	Why that person?	Who else could do it?	Who should do it?

According to Niebel and Freivalds (2003:1) the only way a business or enterprise can increase its profitability is to increase its productivity. Productivity improvement refers to the increase in output per work-hour of input.

4.2.2 Time and Motion Studies, Time Standards and Work Measurements

Time studies are a very effective means to establish time standards. Estimates, historical records and work measurement procedures all help determine time standards. When evaluating a process to identify elements of value adding, non-value adding and waste, a time study is one of the most effective methods to do so.

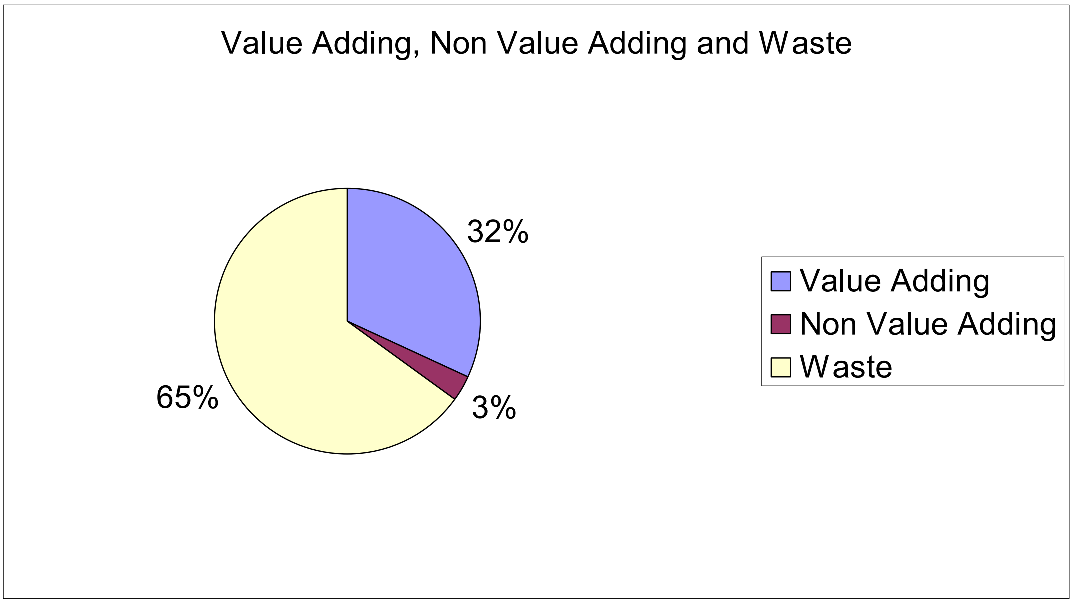


Figure 1: An example of analysed time study data representing time wasted in a process. Taken from vacation work report at Aerosud 2006

Time standards are very important, especially when tasks are repetitive. Since some jobs carry personnel, unavoidable and avoidable delay times, a time standard is needed to accurately evaluate the process. According to research done on the internet standard times are needed for:

- Planning the work of a workforce,
- Manning jobs, to decide how many workers it would need to complete certain jobs,
- Scheduling the tasks allocated to people
- Costing the work for estimating contract prices and costing the labour content in general
- Calculating the efficiency or productivity of workers - and from this:
- Providing fair returns on possible incentive bonus payment schemes.

Managers-net (2008), also defines work measurement: a term which covers several different ways of finding out how long a job or part of a job should take to complete. It can be defined as the systematic determination, through the use of various techniques, of the amount of effective physical and mental work in terms of work units in a specified task. The work units usually are given in standard minutes or standard hours.

2.2.3 Performance rating

Performance rating is most likely the most important step in work measurement, but is also the step most subject to criticism, since it is entirely based on the experience, training and judgement of the work measurement analyst. The main focus of performance rating is to establish performance standards. Performance standards are defined as the level of performance attained by a thoroughly experienced operator working under customary conditions at a pace neither too fast nor too slow. (Niebel and Freivalds 2003:409)

Rating methods include:

- Speed rating – only considers the rate of accomplishment of the work per time unit
- Westinghouse method – considers skill, effort, conditions and consistency
- Synthetic rating – does not rely on the judgement of the analyst
- Objective rating – establishes a single work assignment to which the pace of other jobs is compared.

A synthetic performance rating approach will likely be used to rate packers' performance since it does not rely on the analyst's judgement.

4.2.4 Lean manufacturing and Six Sigma (6σ)

Lean manufacturing or lean production, which is often known simply as "Lean", is the optimal way of producing goods through the removal of waste and implementing flow, as opposed to batch and queue processes. Lean manufacturing is a generic process management philosophy derived mostly from the Toyota Production System (TPS). It is renowned for its focus on reduction of the original Toyota seven wastes in order to improve overall customer value. However, there are varying perspectives on how this TPS objective is best achieved. The steady growth of Toyota, from a small company to the world's largest automaker, has focused attention on how this objective was achieved.

The original seven wastes are:

- Overproduction - production ahead of demand

- Transportation - moving products that are not actually required to perform the processing
- Waiting - waiting for the next production step
- Inventory - all components, work-in-progress and finished product not being processed
- Motion - people or equipment moving or walking more than is required to perform the processing
- Over processing - due to poor tool or product design creating activity
- Defects - the effort involved in inspecting for and fixing defects

Six sigma seeks to identify and remove the causes of defects and errors in manufacturing and business processes. It uses a set of quality management methods, including statistical methods. Six sigma is mainly used for quality assurance and since quality control is not included in the scope of this project, the six sigma methodology will not be used extensively. It may be used to evaluate certain changes made at AMPAGLAS.

4.2.5 Scheduling and Absenteeism

An effective workplace schedule balances the needs of employees, tasks, and in some cases, customers. Most labour staffing and scheduling models presume that all employees scheduled for duty reliably report for work at the beginning of their shift. For industries with even moderate turnover or absenteeism, this assumption may be quite costly. Easton and Goodale (2002) presented a profit-oriented labour scheduling model that accounts for the day-to-day flux of employees and capacity induced by voluntary resignations, new hires, experience curves, and absenteeism.

This model may be used when constructing a schedule for the packing employees at AMPAGLAS.

4.2.6 Information Systems

"Information systems (IS) in organisations capture and manage data to produce useful information that supports an organisation and its employees, customers, suppliers and partners." (Bentley and Whitten 2007:6)

A back-office information system is one that supports internal business functions as well as deal with suppliers whereas a front-office information system support functions that reach out to customers. The IS AMPAGLAS requires is purely to record and analyse downtime of the different lines, therefore a back-office IS is applicable.

To design a system efficient for its purpose, Bentley and Whitten (2007:77) suggest using the PIECES framework during the requirements phase to identify problems or opportunities in the current system. The framework aims to improve or correct

Performance
Information
Economics
Control
Efficiency
Service

4.2.7 Monte Carlo Simulation

There is no single Monte Carlo method; instead, the term describes a large and widely-used class of approaches. However, these approaches tend to follow a particular pattern according to Kruger (2006):

1. Define a domain of possible inputs.
2. Generate inputs randomly from the domain, and perform a deterministic computation on them.
3. Aggregate the results of the individual computations into the final result.

In short: Mont Carlo simulation uses randomly generated variables to calculate meaningful outputs or measures for a number of iterations. The data from the iterations can then be statistically analysed to reveal trends.

4.2.8 OEE and TEEP

OEE (Overall equipment effectiveness) quantifies how well a manufacturing unit performs relative to its designed capacity, during the periods when it is scheduled to run, while TEEP (Total effective equipment performance) measures OEE against calendar hours, i.e.: 24 hours per day, 365 days per year. OEE and TEEP are dependent on the following measurements described below:

- Loading: The portion of the TEEP Metric that represents the percentage of total calendar time that is actually scheduled for operation.
- Availability: The portion of the OEE Metric represents the percentage of scheduled time that the operation is available to operate. Often referred to as Uptime.
- Performance: The portion of the OEE Metric represents the speed at which the Work Centre runs as a percentage of its designed speed. Note that performance does not take quality produced into account.
- Quality: The portion of the OEE Metric represents the Good Units produced as a percentage of the Total Units Started. Commonly referred to as First Pass Yield.
- Scheduled Time – Time the machine is scheduled to run, excluding planned shut down i.e. Strip and Clean

Usually OEE is measured per machine for a period of time (week, month), but is also useful to evaluate the whole plant effectiveness for that period.

4.3 Literature study conclusion

After carefully analysing all methods and tools researched, the following will be used to accomplish the goals:

- Packers
    - Time study
    - Monte Carlo simulation

  - Microsoft Excel
  - Scheduling principles
  - Performance rating principles
- Strip and clean process
  - Time study
  - Observation
  - Microsoft Excel
  - Lean manufacturing
- OEE and DT system
  - OEE and TEEP calculation
  - Microsoft Excel
  - Information systems design
  - Productivity principles

5 Data and Information Gathering

5.1 Packers

As stated in the project objectives, the main deliverable here is an accurate schedule indicating the number of packers on duty at certain times, as well as the number of packers employed.

5.1.1 Type of product

AMPAGLAS produces a wide variety of products according to the 'Make to order' approach. This makes it increasingly difficult to permanently hire packers since the throughput rate differs greatly based on the type of product. Types of product depend on thickness, material density, size and type of material.

When producing with the aim to build stock, the machine will generally run for longer, enabling the work force to better divide themselves between the machines.

5.1.2 Synthetic Rating

Niebel and Freivalds (2003) states that the synthetic rating procedure determines a performance factor for representative effort elements of the work cycle by comparing actual elemental observed times to times developed through fundamental motion data. Thus, the performance factor may be expressed as:

$P = F_t / O$

Where: P = Performance factor

F_t = Fundamental motion time

O = Observed mean elemental time for the elements used in F_t

This factor is then applied to the remainder of the manually controlled elements comprising the study.

Synthetic rating is very useful when evaluating individual personnel, but since packers at AMPAGLAS move around and work at different manufacturing lines, synthetic rating will not apply. Instead the group of packers on duty will be seen as a pool. The efficiency of this pool will determine the number of packers in the pool at any given time.

Table 2: Extract of information gained for packers

Sheet sizes	Packers needed	Freq/Rate (Sheets)	Duration (Min)
2500 x 1250	1	20	18
1600 x 1250	2	5	9
1830 x 1220	2	5	9
3200 x 2050	2	5	12
1873 x 777	1	15	9
2000 x 1000	1	20	12
CP Rolls	2	1	60
CP Polos	2	25	8
PPH Rolls	2	1	60
1130 x 900	1	10	10

Assuming all packers in the pool work at the same rate, time studies revealed information on work rate and the number of packers required at a specific machine at a time. See Appendix A for all information obtained.

5.1.3 Informal Observations

Merely observing the packers at random times revealed:

- Packers very often have no work
- Once the machine is running, the operator checks settings at intervals of about 30 minutes; the rest of the time he does nothing
- There are often two packers at a machine when one would suffice
- Packers are very important to ensure no product build-up occurs in the manufacturing line
- Packers can easily move between manufacturing lines to work at a different machine
- Packers often work at a reduced work rate
- Sometimes the type and size of product restricts the packers work rate
- When smaller sheets are produced, up to four packers are needed to avoid product build-up

5.2 Strip and Clean

The Strip and Clean process entails all necessary changeover and setup processes needed to produce. This is a very lengthy process since certain parts need to be cooled and heated again before production. Since the process takes so long, often exceeding 24 hours, only parts of a single strip and clean could be attended at a time.

5.2.1 Process and Time Study

Table 3: Processes for Strip and Clean procedure and existing AMPAGLAS time study results

Strip and Clean Process and theoretical time		
Step	**Process**	**Time (min)**
1	Purge machine	30
2	Switch off MC	1
3	Move calendars back	1
4	Switch off calendar temp & pumps	1
5	Switch off die element	1
6	Remove plugs	5
7	Strip & clean die	180

8	Assemble die	60
9	Strip & clean static mixer	20
10	Strip & clean gear & pumps	60
11	Strip & clean filter	30
12	Remove degassing	15
13	Remove screw	120
14	Clean barrel	30
15	Clean screw	120
16	Fit screw	45
17	Fit filter	15
18	Assemble gear pump & fit	40
19	Fit static mixer	10
20	Fit & align die	45
21	Fit plugs on die	15
22	Drain water from calendar	30
23	Remove rotary union	10
24	Remove gear box	120
25	Fit roller supports	20
26	Remove roller	30
27	Fit new roller	30
28	Fit gear box	120
29	Fit rotary union	10
30	Remove roller support	20
31	Open water valve	50
32	Switch on heater	1
33	Tighten all bolts & caps	60
34	Set lip	60
35	Set stops	30
36	Change filter	5
37	Clean rollers	20
38	Set roller gaps	10
39	Move calendars forward	1
40	Start-up & set	120
	Total	**1591**
	Total (Hours)	**26.52**

Also see Appendix B for a high level process map.

5.3 OEE and DT System

AMPAGLAS has a real and urgent need to measure total downtime. Downtime includes: breakdowns, setup, idle time and any other time the machine is not producing. The main area of focus will be on the effect preventative maintenance has on the total downtime, measuring and analysing it. It is envisioned that preventative maintenance will reduce total breakdown time. No system to measure downtime is currently in place.

Along with the need to measure total downtime, AMPAGLAS needs a way to measure and communicate plant effectiveness. OEE (Overall equipment effectiveness) measures how effectively equipment is being used. Currently a basic system consisting of 3 different Excel spreadsheets is used to merely calculate and communicate total production.

5.3.1 Definitions

BD – Total breakdown time – Total hours per month not producing due to any breakages, setup or machine failure.

EBD – Engineering breakdown time – Total hours per month spent fixing the problem on the machine. EBD is divided into two categories based on the cause of the problem: 1) Electrical and 2) Mechanical

LBD – Lost breakdown time – Total hours per month not producing due to machine failure, but not fixing the problem, does not include setup time.

IdT – Idle time – Total hours per month the machine is idle, i.e. not producing, maintenance, setup, fixed or breakdown.

PM – Preventative maintenance – total hours per month spent doing scheduled maintenance.

5.3.2 Preventative Maintenance (PM)

The goal of preventative maintenance is to schedule regular maintenance on a machine before it breaks down, thus minimising machine breakdowns. The trick however is to calculate the amount of PM needed to decrease downtime but still meet demand targets. PM will not affect idle time or setup time.

5.3.3 Graphs

Management requires an easy way to view and analyse downtime, therefore graphs will be used to communicate the data. Preventative maintenance will be scheduled monthly while actual hours completed and downtimes will be recorded using the OEE and DT system on a daily basis.

An example of a simplified system follows. This example shows what the expected effect of preventative maintenance is on downtime over a period of time. I.e. A trend decreasing downtime as preventative maintenance increases is expected. Note that because no data regarding preventative maintenance or total downtime currently exists, all figures used in this example are approximated.

Table 4: Example of scheduled maintenance times

	Preventative maintenance										
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Hours issued	85	90	100	110	115	130	123	135	132	140	145
Hours completed	80	80	100	105	109	125	120	125	130	136	140
% Completed	94.12	88.89	100.00	95.45	94.78	96.15	97.56	92.59	98.48	97.14	96.55

Table 5: Example of breakdown times

	Breakdowns										
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
EBD	130	115	100	95	95	94	90	85	64	60	55
LBD	60	55	60	50	43	45	42	35	32	30	25
IdT	20	20	10	15	16	14	15	10	15	12	9
Setup	50	60	54	55	50	45	43	40	38	35	35
BD	260	250	224	215	204	198	190	170	149	137	124

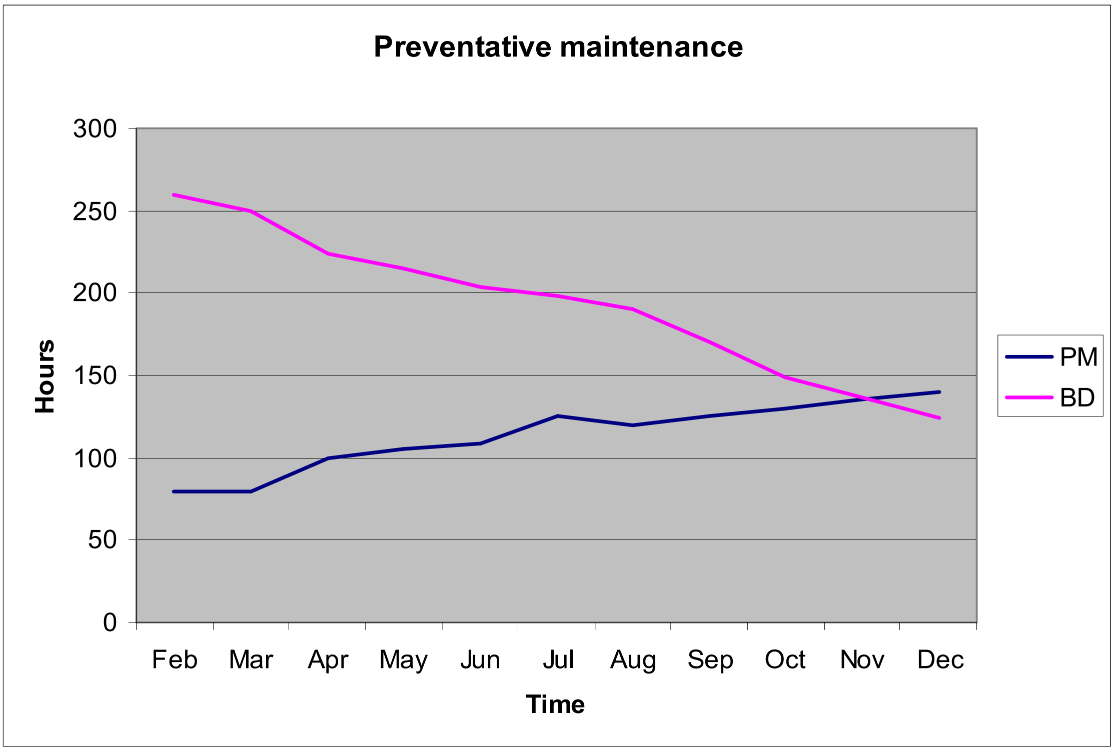


Figure 2: Example of preventative maintenance reducing breakdowns

Graphs relating to the OEE and TEEP will be communicated later in the document.

6 Design and Problem solving

6.1 Packers

6.1.1 Approach

Since the objective is to evaluate and determine the total number of packers employed, individual packer performance ratings were not necessary. Instead the group of packers were seen as a whole and assessed as such. The packer pool currently consists of 11 packers.

Because AMPAGLAS has an almost infinite number of products ranging in thickness, material density, size and type of material, it was decided to only study the ten most commonly manufactured sizes and types. Monte Carlo simulation was used to simulate the effect of the number of packers on duty at a time.

Time studies were done to determine standard times for packing sheets after manufacturing. Relevant information gained from the time studies include:

- Whether the sheet type requires a packer full-time
- The number of sheet packed at a time
- The duration of physically packing the sheets
- The number of packers needed to pack
- The frequency of packing
- The number of sheets manufactured per hour

See Appendix A for time study results.

After careful consideration it was decided that the deciding measures for evaluation would be:

i) packer pool efficiency,

This is a percentage of how efficient different pool sizes are with regards to packing sheets. It is calculated to show the percentage of time the pool is busy with packing. And,

ii) the percentage of time the packer pool is insufficiently staffed,

This percentage indicates the time during an average shift that the packer pool is not big enough to accommodate the packing demands.

Management has indicated a target efficiency of at least 80 per cent adhering to the time understaffed target of at most 17 per cent, i.e. time understaffed has priority over the efficiency percentage.

Using Microsoft Excel and the Monte Carlo methodology the effect of packer pool sizes between 1 and 20 were simulated and assessed. Random variables were generated to accurately simulate the production schedule using a uniform distribution.

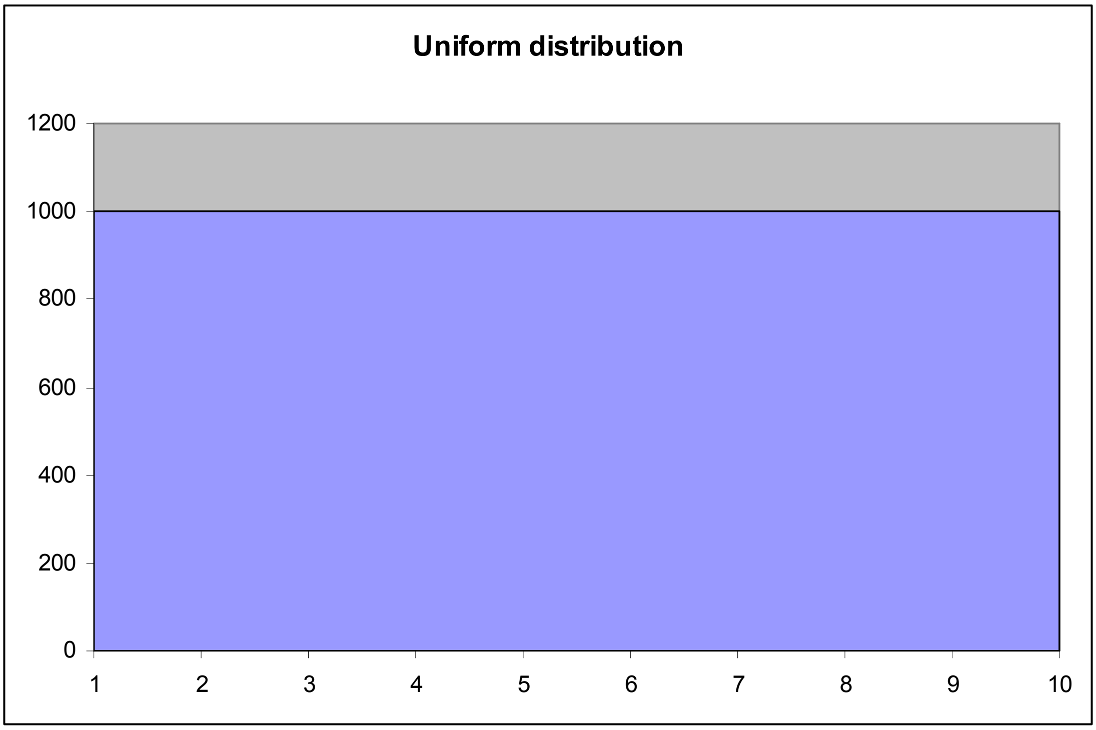


Figure 3: A representation of a uniformly distributed variable

6.1.2 Results

After running the simulation for 100 iterations, it can be seen that at least 10 packers are necessary in order to maintain the acceptable target of 17 per cent understaffed, at an efficiency of 51 per cent. It is also clear that in order to maintain 80 per cent efficiency no more than 6 packers must be on duty, but then the understaffed percentage is 26. In order to first adhere to the understaffed target at least 10 packers must be on duty at any given time.

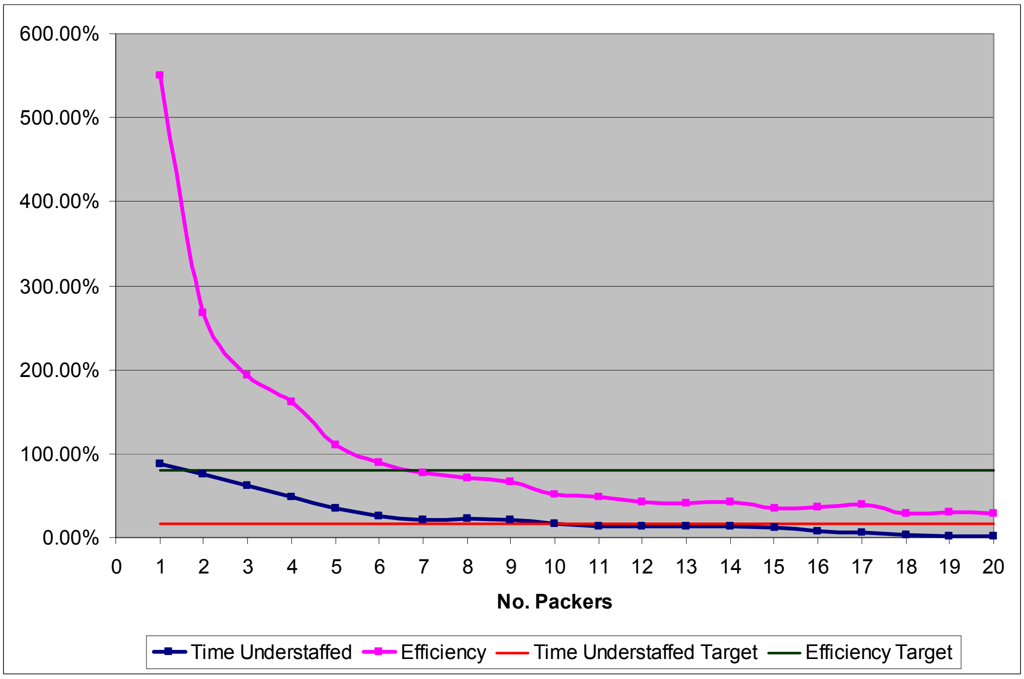


Figure 4: Results of Monte Carlo simulation for different packer pool sizes

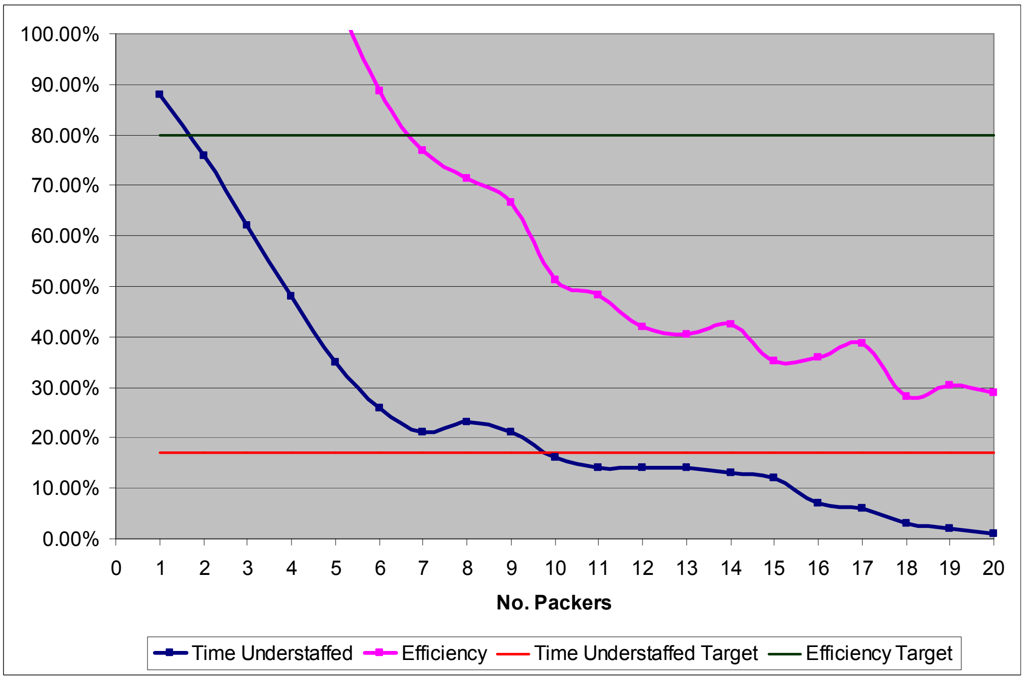


Figure 5: A clearer result of Monte Carlo simulation for different packer pool sizes

6.2 Strip and Clean

Due to the fact that strip and clean processes are not scheduled and the analyst is not employed full time at AMPAGLAS, no single strip and clean procedure could be analysed fully. Another restriction is that the process generally takes more than 24 hours to complete, which makes it difficult for one analyst to note the whole procedure. However, certain elements of the process were fully analysed with the assumption made that the process is generally the same for all extruders at AMPAGLAS.

6.2.1 Approach

Since this is a setup process no value-adding elements exist in the time study. Non value-adding elements are elements which have to be done but are not wasteful while waste are those times that should not exits in a perfect process. An example of waste is when tools are not properly organised and the worker spends time looking for tools.

6.2.2 Results

A detailed time study was done on the “strip and clean die” element of a strip and clean procedure. After careful analysis it was found that waste took up 33 per cent of time spent doing this procedure, actual work on the die accounted for the rest.

See Appendix B for complete time study results.

Table 6: Summary of raw time study data for the strip and clean process

	Element				
	Fetch	**Work**	**Break**	**Wait**	**Total**
	0.00	26.60	0.00	0.00	
	4.90	0.00	0.00	1.43	
	0.00	40.45	23.45	0.00	
	0.00	19.17	0.00	0.00	
	9.38	0.00	0.00	4.22	
	0.00	19.90	0.00	0.00	
	7.43	9.23	0.00	11.25	
	0.00	9.48	0.00	0.00	
Total	21.72	124.83	23.45	16.90	186.90

Figures are in decimal minutes i.e. 2min 20sec = 2.33

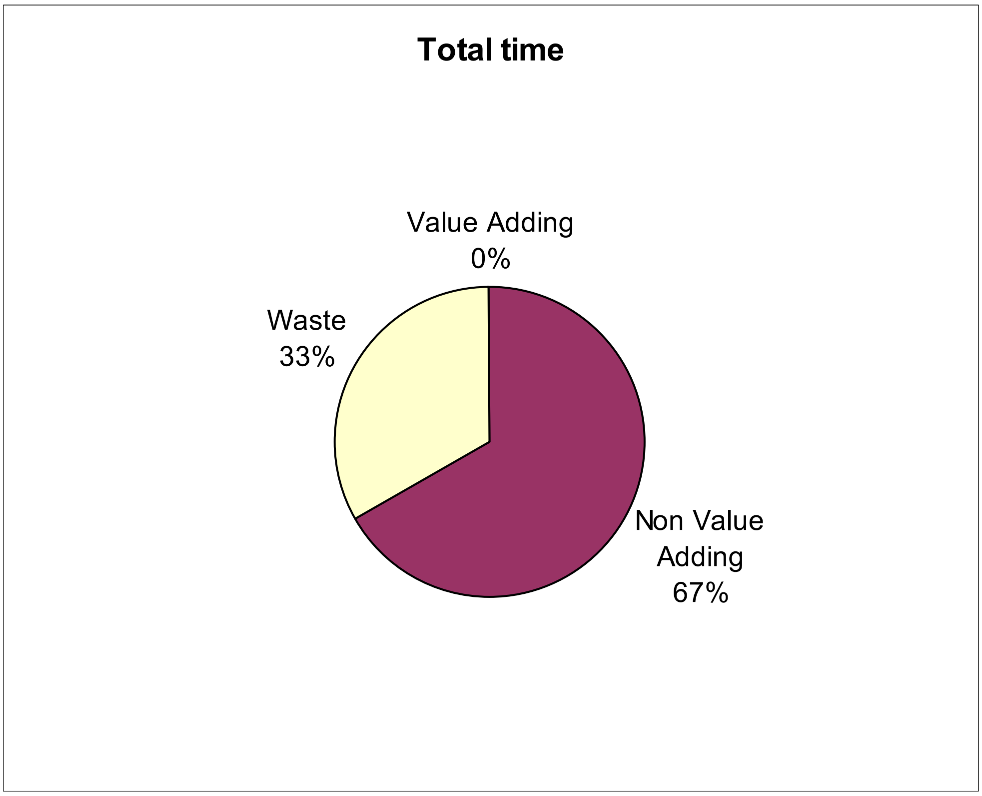


Figure 6: Pie-chart of total strip and clean process time

These results indicate that the “strip and clean die” element should only take approximately 2 hours, but with its position in the overall strip and clean procedure a break is inevitable. This means that a 20 minute break has to be accounted for when analysing this process.

The process seems to be well designed and established. Changing the process will likely not be worth the time or money. To improve efficiency during the process some problems that can be addressed are:

- Housekeeping – Technicians and workers leave tools lying around after using them, increasing the time they spend looking for and fetching tools.
- Work pace – Workers often stand around and socialize with other workers, greatly decreasing efficiency. Workers also seem to work at a slower than optimal pace.

Addressing these problems to find a long term solution is somewhat difficult since they are normally short lived and requires time for the workforce to become familiar with, but possible solutions are:

- Incentives – Reward the strip and clean team for every hour they shave off the total time. Operators should ensure that their immediate machine area is clean and neat at all times – reward the team with the neatest cell.
- Disciplinary action – Warn and eventually take disciplinary steps against workers who blatantly do not work.
- General discipline and morale – Employees generally work faster and more attentive when they feel good about their duties and responsibility.

6.3 OEE and DT system

6.3.1 Approach

All relevant data originates at the factory floor level and therefore should be captured by the operator. Operators currently fill out a form on an hourly basis to capture data, but current data is either irrelevant not complete enough to calculate OEE. A new form has been designed to capture relevant and needed data.

AMPAGLAS S.A. (PTY) LTD.

Product	Date
	Time
Material	Extruder nr.
Material lot nr.	Operator

Time	Time (Minutes)	Production (KG)	Details
07:00 AM			
08:00 AM			
09:00 AM			
10:00 AM			
11:00 AM			
12:00 PM			
01:00 PM			
02:00 PM			
03:00 PM			
04:00 PM			
05:00 PM			
06:00 PM			
07:00 PM			
08:00 PM			
09:00 PM			
10:00 PM			
11:00 PM			
12:00 AM			
01:00 AM			
02:00 AM			
03:00 AM			
04:00 AM			
05:00 AM			
06:00 AM			

Comments:

Signed: ______________________ Date: ______________________

Figure 7: The new form the operator will use to record data for the OEE and DT system

Once all data has been recorded to the form, an analyst must enter said data to the OEE spreadsheet. When all data has been entered the OEE will be calculated automatically and presented by means of graphs.

Another feature of the OEE spreadsheet is that it also calculates the total breakdown time as well as time spent on preventative maintenance. This is also represented in a graph. With time and historical data trends may be seen of the effect of preventative maintenance on total breakdown time.

See Appendix C for screenshots of the system.

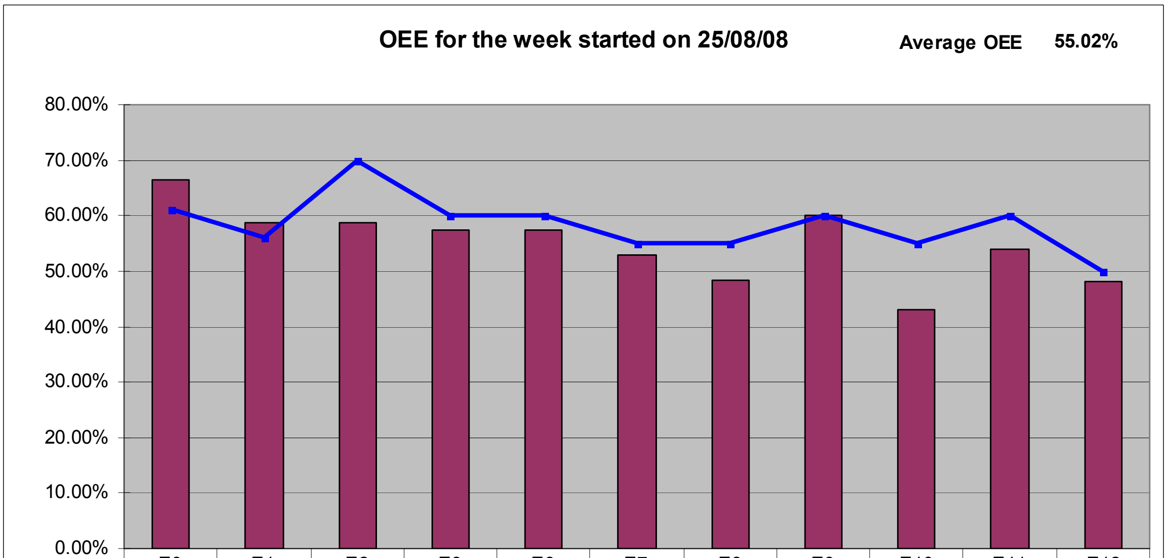
The system is neatly packed into one Excel workbook consisting of fifteen worksheets. Eleven of the worksheets are used to input data for respective manufacturing lines, two for calculating OEE, TEEP and total downtime, one sheet for communicating the results through graphs and a last sheet with the operator input form template.

6.3.2 Results

After testing the system with historical data, management agrees with OEE figures and find relevant figures easily communicated.

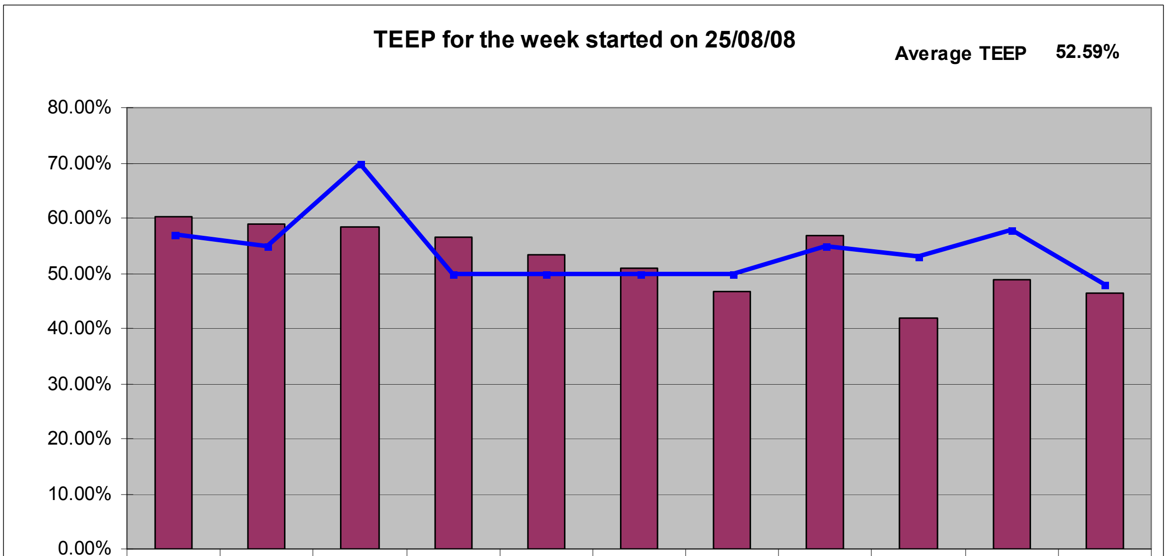
The responsibility to maintain this system falls to the plant manager, analyst and operators. With enough data entered into the system they will be able to calculate monthly and even yearly OEE figures, enabling them to recognise trends of production.

Following are system output graphs communicating all relevant results:



	E0	E1	E2	E3	E6	E7	E8	E9	E10	E11	E12
OEE	66.47%	58.81%	58.71%	57.51%	57.45%	52.94%	48.28%	60.04%	43.08%	53.83%	48.10%
Target	61.00%	56.00%	70.00%	60.00%	60.00%	55.00%	55.00%	60.00%	55.00%	60.00%	50.00%

Figure 8: OEE statistics for entire plant



	E0	E1	E2	E3	E6	E7	E8	E9	E10	E11	E12
TEEP	60.14%	58.81%	58.36%	56.49%	53.34%	51.05%	46.56%	56.82%	41.80%	48.70%	46.38%
Target	57.00%	55.00%	70.00%	50.00%	50.00%	50.00%	50.00%	55.00%	53.00%	58.00%	48.00%

Figure 9: TEEP statistics for entire plant

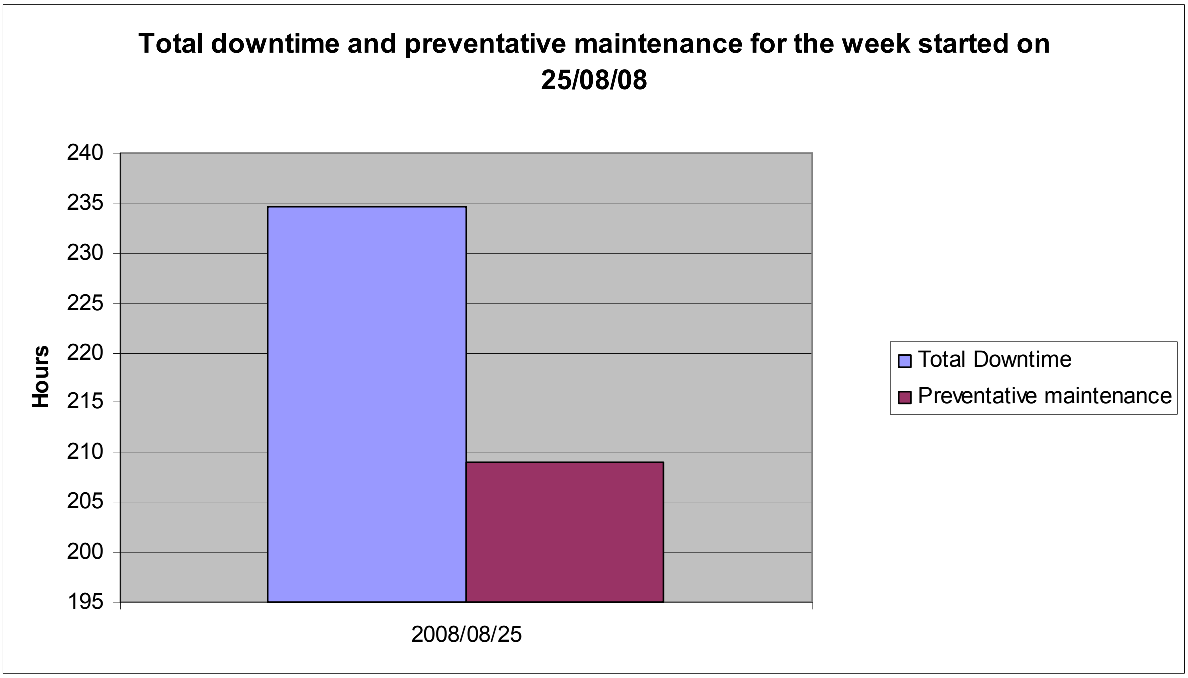


Figure 10: Total hours DT and PM for the entire plant

7 Suggested Solutions and Conclusion

7.1 Packers

Depending on the production schedule, it may be necessary to employ any number of packers at a given time. However, it is strongly suggested to decrease the permanently employed packer pool to 9. This will increase productivity statistics and more importantly, decrease cost. When the work load is higher than normal, additional packers may be employed on a temporary basis.

Once the extruder is set up and running, the operator only checks settings at regular intervals. He is free most of the time when the machine is running. Another suggestion is that the operator does some of the packing when the machine runs, relieving some of the work load from the packer pool.

7.2 Strip and Clean

Disciplinary action against any worker or technician who is found not working at a normal and achievable rate should be taken.

However, threatening workers in any way may not achieve the desired outcome. Instead incentives should be awarded for faster than normal work pace, good morale and good housekeeping.

7.3 OEE and DT system

Using the approved information system will enable management to reveal actual plant effectiveness. The accuracy of the data is of course dependant on the input so operators have to be trained and instructed in the correct way to record raw data.

The analyst recording the raw data into the system has to know the definitions of all input categories. This is an ongoing system and responsibility to maintain the system and all aspects thereof falls to the factory manager.

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- www.answers.com/topic/productivity?cat=biz-fin – 16/5/2008

- www.ampaglas.com – 1/3/2008

- www.managers-net.com/workmeasurement.html - 16/5/2008

- http://www.oee.com/faq.html - 4/9/2008

- www.wikipedia.org - March – June 2008 – viewed at various times on the following topics:
    - Lean manufacturing
    - Productivity
    - Six sigma
    - Systems engineering
    - Time and motion study
    - Schedule (workplace)

Appendix A

# Packers			11
%time understaffed			**20.00%**
Effieciency			**51.81%**

	Sheet sizes			Machine rate											Packers needed	Freq/Rate (Sheets)	Duration (Min)
				E0	E1	E2	E3	E6	E7	E8	E9	E10	E11	E12			
1	2500	x	1250	20	20	32	80	28	25	58	138	110	30		1	20	18
2	1600	x	1250	42				22	30						2	5	9
3	1830	x	1220					38	37						2	5	9
4	3200	x	2050						20						2	5	12
5	1873	x	777									125			1	15	9
6	2000	x	1000	50	34	45	120			98	158			68	1	20	12
7	CP Rolls												6		2	1	60
8	CP Polos						150				144		49		2	25	8
9	PPH Rolls									6					2	1	60
10	1130	x	900											128	1	10	10

Figure 11: Input and output section of Monte Carlo simulation

Table 7: Results of Monte Carlo simulation displaying decisive measures

Number of packers in packers pool	**Understaffed**	**Efficiency**
	20.00%	**51.81%**
1	88.00%	549.80%
2	76.00%	268.01%
3	62.00%	193.00%
4	48.00%	162.21%
5	35.00%	110.46%
6	26.00%	88.70%
7	21.00%	76.76%
8	23.00%	71.26%
9	21.00%	66.47%
10	16.00%	51.32%
11	14.00%	48.26%
12	14.00%	42.04%
13	14.00%	40.39%
14	13.00%	42.40%
15	12.00%	35.26%
16	7.00%	35.98%
17	6.00%	38.66%
18	3.00%	28.24%
19	2.00%	30.46%
20	1.00%	28.81%

Appendix B

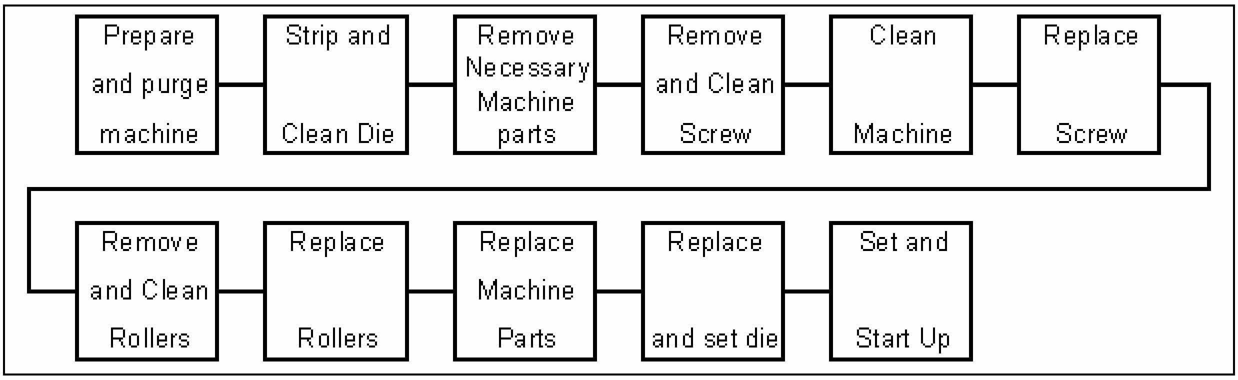
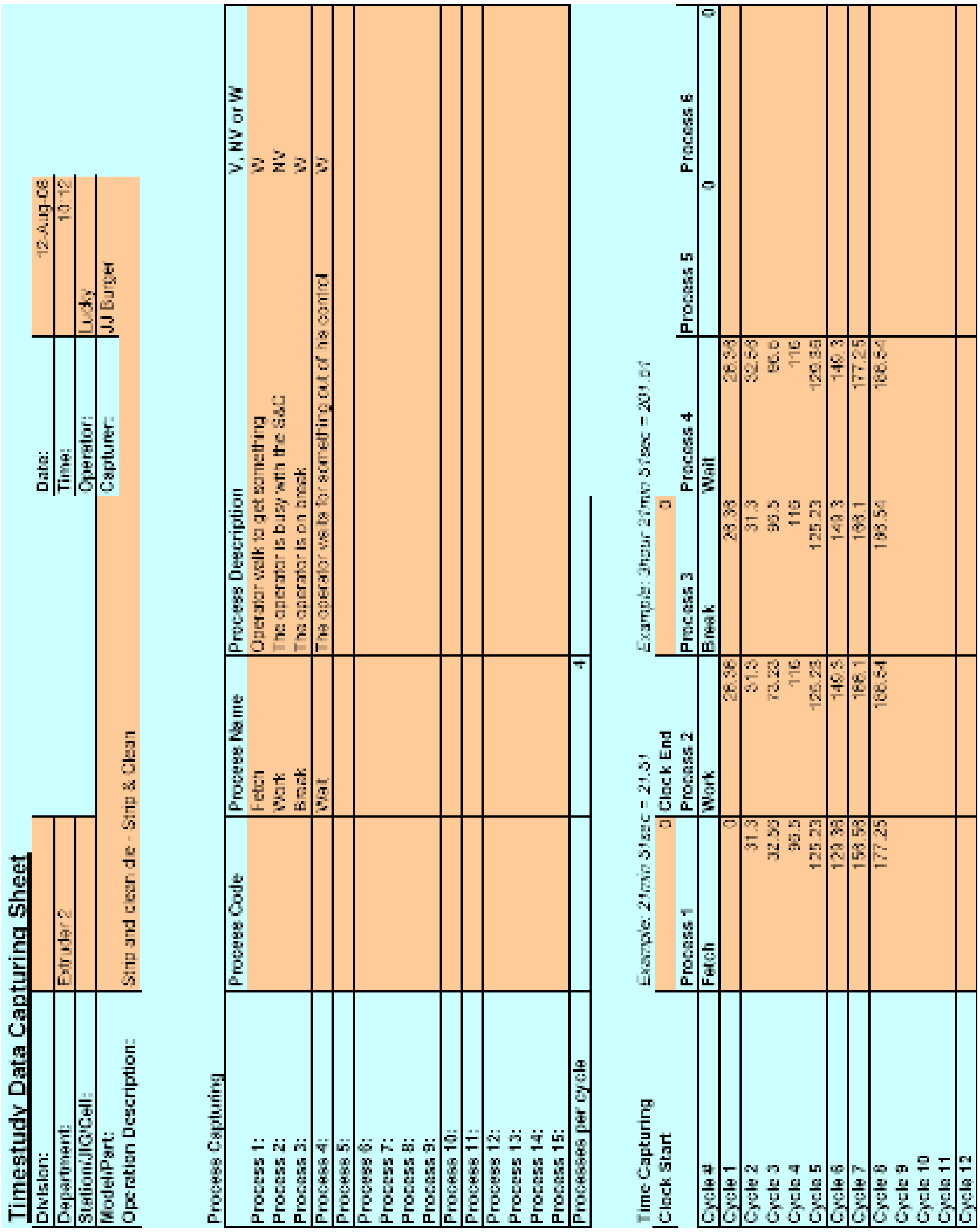


Figure 12: High level representation of the strip and clean process



Timestudy Data Capturing Sheet

Division:		Date:	12-Aug-08
Department:	Extruder 2	Time:	10:12
Station/JIG/Cell:		Operator:	Lucky
Model/Part:		Capturer:	JJ Burger
Operation Description:	Strip and clean die - Strip & Clean		

Process Capturing

	Process Code	Process Name	Process Description	V, NV or W
Process 1:		Fetch	Operator walk to get something	W
Process 2:		Work	The operator is busy with the S&C	NV
Process 3:		Break	The operator is on break	W
Process 4:		Wait	The operator waits for something out of his control	W
Process 5:				
Process 6:				
Process 7:				
Process 8:				
Process 9:				
Process 10:				
Process 11:				
Process 12:				
Process 13:				
Process 14:				
Process 15:				
Processes per cycle		4		

Time Capturing — *Example: 21min 51sec = 21.51* — *Example: 3hour 21min 51sec = 201.51*

Clock Start: 0 — Clock End: 0

Cycle #	Process 1 Fetch	Process 2 Work	Process 3 Break	Process 4 Wait	Process 5	Process 6
					0	0
Cycle 1	0	26.36	26.36	26.36		
Cycle 2	31.3	31.3	31.3	32.56		
Cycle 3	32.56	73.23	96.5	96.5		
Cycle 4	96.5	116	116	116		
Cycle 5	125.23	125.23	125.23	129.36		
Cycle 6	129.36	149.3	149.3	149.3		
Cycle 7	158.58	166.1	166.1	177.25		
Cycle 8	177.25	186.54	186.54	186.54		
Cycle 9						
Cycle 10						
Cycle 11						
Cycle 12						

Figure 13: Extract of MS Excel spreadsheet used to analyse strip and clean time study

Appendix C

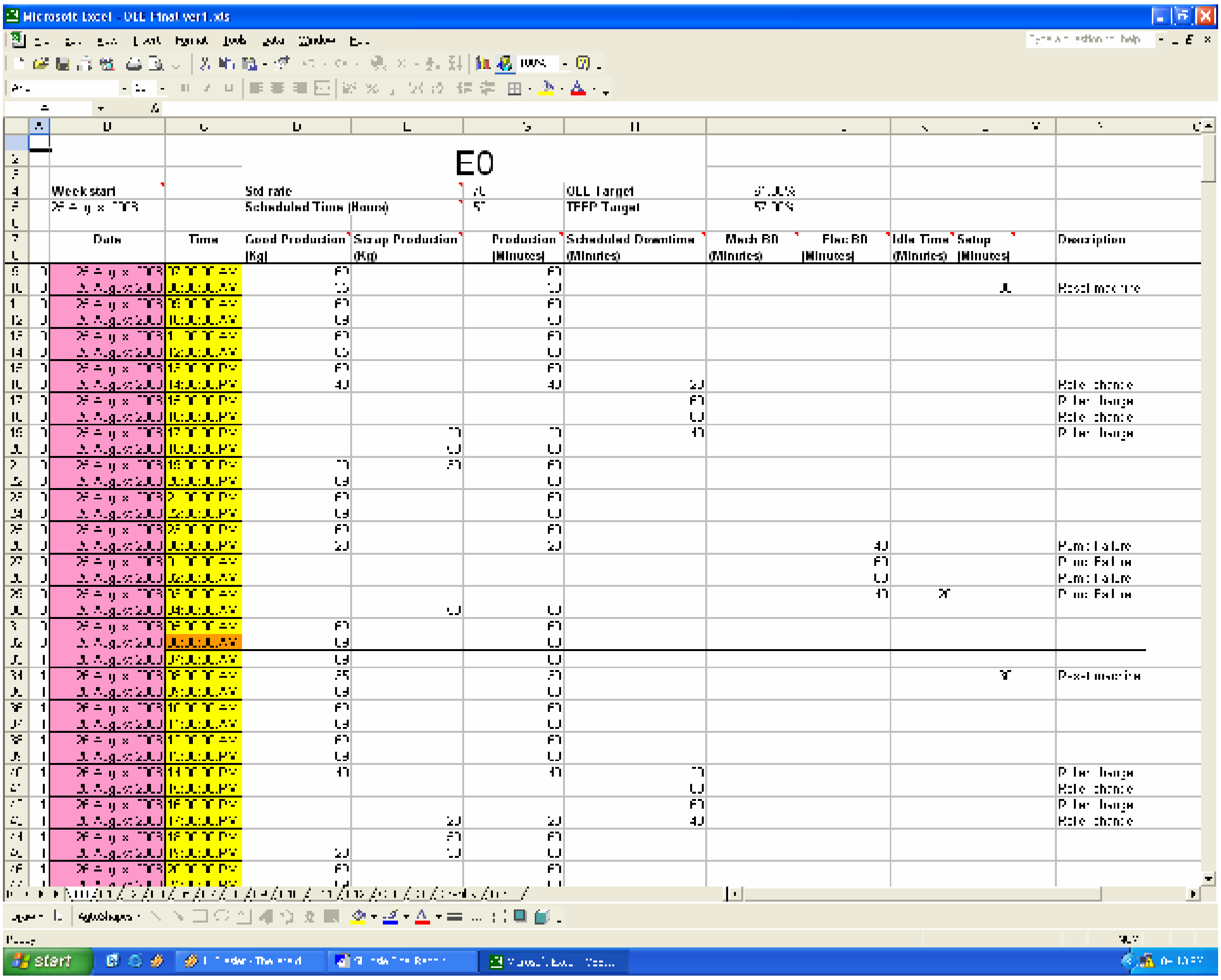


Figure 14: Sample of the OEE and DT system input screen

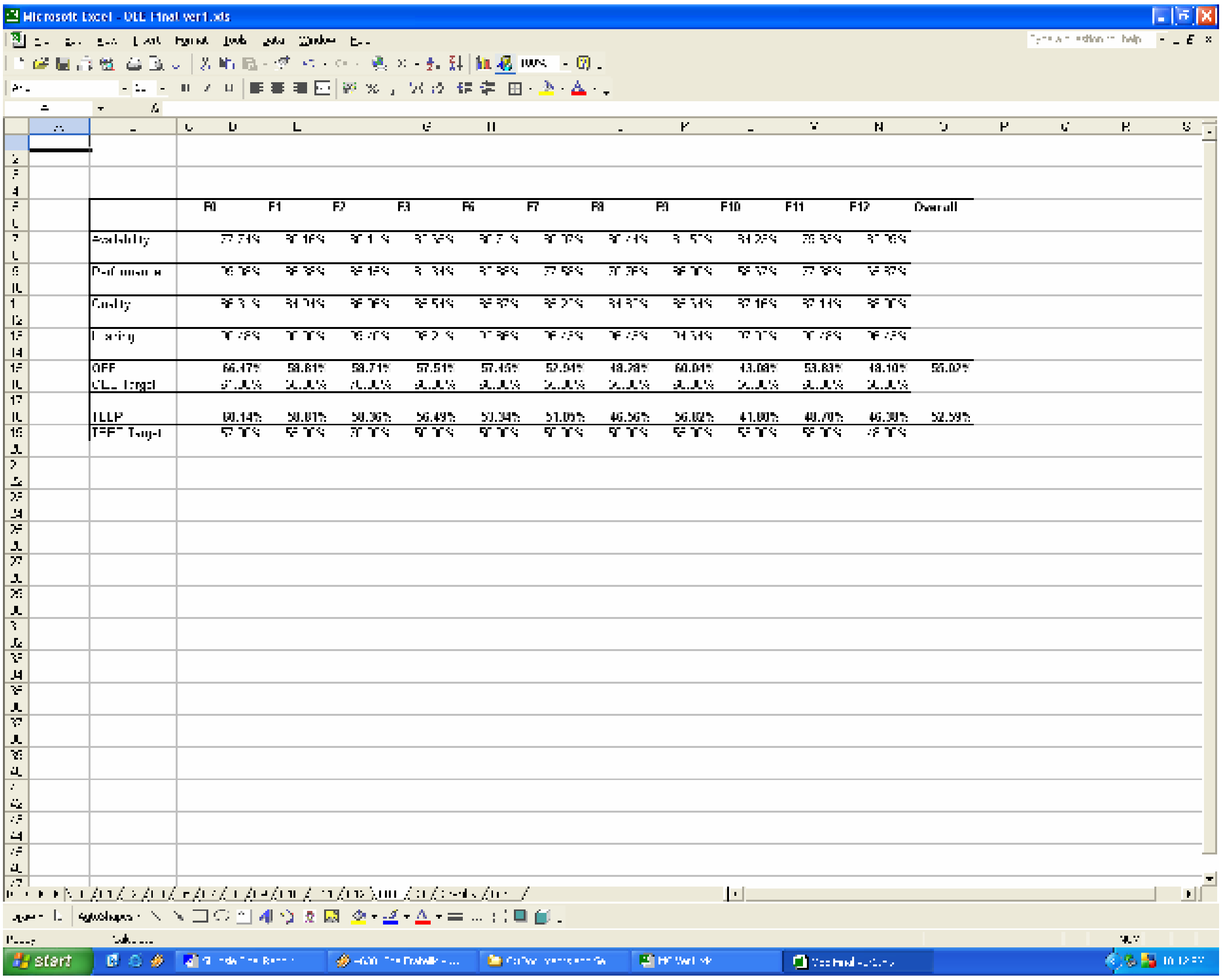


Figure 15: Screenshot of the OEE calculation

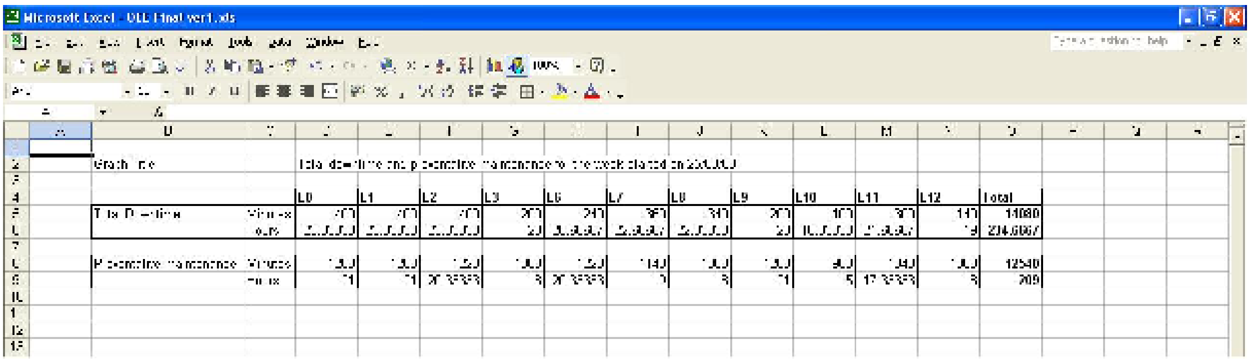


Figure 16: Screenshot of the downtime calculation