Evaluation of Maintenance Techniques Performed On The Mobile Fleet of Kenana Sugar Company

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I would like to acknowledge my supervisor

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الخلاصة

نُظُّم القائمة بحَدِّيثة، وَفَضْلًا وَمَعْرَفَةً. كَنْ يَلْعَبُ، كَانَ يَتَلُّبُ، كَانَ يَتَكَلَّبُ، كَانَ يَتَرَاكَبُ. وَإِلَيْهِ تَكُونُ، وَإِلَيْهِ يَلْبِسُ، وَإِلَيْهِ يَتَكَلَّمُ.

هَلْ يَلْعَبُ، هَلْ يُلْعَبُ، هَلْ يُتَلُّبُ، هَلْ يُتَكَلَّبُ، هَلْ يُتَرَاكَبُ؟ وَهَلْ يَلْبِسُ، وَهَلْ يَتَكَلَّمُ؟

فَإِنَّهُ كَانَ يَعْمَلُ، كَانَ يَكْتَبُ، كَانَ يَتَلَّبُ، كَانَ يَتَكَلَّبُ، كَانَ يَتَرَاكَبُ. وَإِلَيْهِ تَكُونُ، وَإِلَيْهِ يَلْبِسُ، وَإِلَيْهِ يَتَكَلَّمُ.
Abstract

Maintenance is very important for any equipment so as to make it function efficiently and economically during the investment period.

The objective of this work is to study the maintenance techniques performed on the mobile fleet of Kenana Sugar Company.

This work discusses and evaluates the size of the mobile fleet and its different types and models, the different maintenance carried and the nature of operations and conditions of cane and sugar production.

The study also depicts the operating and maintenance expenditure and an economical evaluation of all processes is given.

Conclusions drawn about the existing maintenance techniques and recommendations to improve the quality of maintenance performed, are presented.
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</tbody>
</table>
Chapter (1)

Introduction

The Kenana Sugar Company was founded in 1975. The ambitious plan was to create an integrated Cane Sugar Estate and Factory capable of producing 300,000 MT of sugar per year. This target was soon achieved and then surpassed. The 2000/01 crop yielded 403,596 MT of sugar. Kenana is currently the largest single integrated producer of white sugar in the world.

Kenana Sugar Company is located near Rabak town on the east bank of the White Nile, some 250 km south of Khartoum and 1,200 km from Port Sudan. Kenana has offices in Khartoum, Port Sudan and London.

Historically the Sudan has imported the bulk of its sugar requirements with a consequent drain (second only to the importation of petroleum products) on its limited foreign currency resources. The founding principle of the Kenana Sugar Project was to combine the natural resources of the Sudan with the surplus Arab oil revenues and Western technology. Kenana now produces sufficient sugar to satisfy the home market and export substantial amounts.

A process of continuous up-rating and expansion is taking place. The plantation area has now been expanded to over 100,000 feddans of sugar cane fields. Two more pumping stations have been recently added to the existing four at a total of inward investment of around US$ 270 million.

Kenana has always adopted a farsighted and rounded approach to business. It is in keeping then that it continues to branch out and diversify into other related products and services. They believe in utilizing all their resources fully – both human and natural – all by – products are put to effective use to ensure that nothing is wasted.

Within the Kenana Site there is a state of the art scientific research department, as well as a school, vocational training centres and a hospital for Kenana employees and their families.

Kenana employs a massive work force of around 20,000 permanent and seasonal employees. It has brought prosperity not only to these local people working for Kenana but also to the area as a whole. This part of Central Sudan now benefits from a modern water supply the scale and quality of which is unsurpassed throughout the country.

Kenana Sugar Company has offices in Khartoum, Port Sudan and London. There are five main departments, i.e. maintenance, factory (sugar production), agriculture (cane production), harvesting and general service.

The maintenance department is responsible for all maintenance work carried out on the mobile fleet operating all over the company premises. All types of maintenance is performed throughout the season starting with preventive maintenance, routine maintenance and ending with corrective maintenance.

Based on the fact that maintenance is very important for any equipment rendering it to function efficiently and economically during its investment period, the present study is undertaken to investigate the maintenance techniques and procedures performed on the mobile fleet of Kenana Sugar company. A critical review and an economical evaluation will be conducted and suitable recommendations will be suggested.
Chapter (2)

Types of Mobile Machines and their functions

The mobile fleet owned by Kenana Sugar Company is very large and diversified. It is composed of different units, each with a different function. The following tables to show the composition and size of this fleet

2.1 Types and quantity of equipment.

Table 2.1

<table>
<thead>
<tr>
<th>No</th>
<th>Type</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Light vehicles</td>
<td>526</td>
</tr>
<tr>
<td>2</td>
<td>Trucks and buses</td>
<td>174</td>
</tr>
<tr>
<td>3</td>
<td>Mini buses and mini trucks</td>
<td>114</td>
</tr>
<tr>
<td>4</td>
<td>Tractors</td>
<td>344</td>
</tr>
<tr>
<td>5</td>
<td>Heavy equipment</td>
<td>140</td>
</tr>
<tr>
<td>6</td>
<td>Harvesters (cane harvesters)</td>
<td>35</td>
</tr>
<tr>
<td>7</td>
<td>Motor cycles</td>
<td>190</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>1535</td>
</tr>
</tbody>
</table>

2.1.1 Light Vehicles

Total number of light vehicles is 526 it is used for personnel transport

Classification of light vehicles according to the fuel type is shown in table 2.2.

Table 2.2 Light Vehicles

<table>
<thead>
<tr>
<th>Fuel type</th>
<th>Toyota</th>
<th>Suzuki</th>
<th>L/rover</th>
<th>Nissan</th>
<th>Mitsubishi</th>
<th>Isuzu</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Petrol</td>
<td>255</td>
<td>6</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td>263</td>
</tr>
<tr>
<td>Models</td>
<td>15</td>
<td>4</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td>21</td>
</tr>
<tr>
<td>Diesel</td>
<td>234</td>
<td>3</td>
<td>5</td>
<td>20</td>
<td>1</td>
<td></td>
<td>263</td>
</tr>
<tr>
<td>Models</td>
<td>11</td>
<td>1</td>
<td>5</td>
<td>7</td>
<td>1</td>
<td></td>
<td>25</td>
</tr>
<tr>
<td>Grand total</td>
<td>489</td>
<td>6</td>
<td>3</td>
<td>7</td>
<td>20</td>
<td>1</td>
<td>526</td>
</tr>
<tr>
<td>Models</td>
<td>26</td>
<td>4</td>
<td>1</td>
<td>7</td>
<td>7</td>
<td>1</td>
<td>46</td>
</tr>
</tbody>
</table>

2.1.2 Trucks and buses
This group includes transportation buses, fuel and water tankers, dumpers for construction and road control. The Classification of trucks according to make and model is shown in table 2.3.

Table 2.3 Trucks and Buses

<table>
<thead>
<tr>
<th>Machine</th>
<th>Austin Layland</th>
<th>Nissan</th>
<th>Magrus</th>
<th>Fiat</th>
<th>DAF</th>
<th>Mack</th>
<th>Man</th>
<th>Mitsubishi</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Diesel</strong></td>
<td>1</td>
<td>1</td>
<td>134</td>
<td>20</td>
<td>5</td>
<td>8</td>
<td>2</td>
<td>1</td>
<td>174</td>
</tr>
<tr>
<td><strong>Model</strong></td>
<td>1</td>
<td>1</td>
<td>6</td>
<td>7</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>24</td>
</tr>
</tbody>
</table>

2.1.3 Mini-buses and Mini-trucks

Used for transporting personnel staff and machines around sugar estate. Classification of buses according to the fuel type, make and model as shown in table 2.4

Table 2.4

<table>
<thead>
<tr>
<th>Fuel type</th>
<th>Civilian</th>
<th>Urvan</th>
<th>Mazda</th>
<th>Canter</th>
<th>Dyna</th>
<th>Coaster</th>
<th>Rosa</th>
<th>Hacek</th>
<th>MT</th>
<th>KIA</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Petrol</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Model</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Diesel</td>
<td>4</td>
<td>1</td>
<td>47</td>
<td>2</td>
<td>11</td>
<td>34</td>
<td>10</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>113</td>
</tr>
<tr>
<td>Model</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>19</td>
</tr>
<tr>
<td>G. Total</td>
<td>4</td>
<td>1</td>
<td>47</td>
<td>2</td>
<td>11</td>
<td>34</td>
<td>10</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>114</td>
</tr>
<tr>
<td>Model</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>20</td>
</tr>
</tbody>
</table>

2.1.4 Tractors

Total number is 344 small size tractors (80) HP are used in sugar company in many applications (in agricultural jobs) like:-
- Cultivation:-All operation related to sugar cane after plantation such as:-
  - Sprayers- to apply the agrochemicals
  - Cleaning -to clean the field after harvesting (for the second Raton)
- Inside estate transportation by trailers for distributing fertilizers and agrochemical.
  - Large tractors (120HP) are used in land preparation by drawing scrapers and leveling implements for new plantation field.
Table 2.5 TRACTORS (HP), MAKE AND MODELS

<table>
<thead>
<tr>
<th>Make</th>
<th>Models</th>
<th>HP</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>MF</td>
<td>185</td>
<td>75</td>
<td>40</td>
</tr>
<tr>
<td>MF</td>
<td>4230</td>
<td>120</td>
<td>1</td>
</tr>
<tr>
<td>MF</td>
<td>2705</td>
<td>120</td>
<td>8</td>
</tr>
<tr>
<td>MF</td>
<td>265</td>
<td>75</td>
<td>1</td>
</tr>
<tr>
<td>MF</td>
<td>1134</td>
<td>120</td>
<td>8</td>
</tr>
<tr>
<td>John Deere</td>
<td>2650</td>
<td>80</td>
<td>36</td>
</tr>
<tr>
<td>MF</td>
<td>2700</td>
<td>80</td>
<td>7</td>
</tr>
<tr>
<td>John Deere</td>
<td>7700</td>
<td>120</td>
<td>2</td>
</tr>
<tr>
<td>John Deere</td>
<td>6200</td>
<td>80</td>
<td>1</td>
</tr>
<tr>
<td>John Deere</td>
<td>6210</td>
<td>80</td>
<td>7</td>
</tr>
<tr>
<td>John Deere</td>
<td>6180</td>
<td>120</td>
<td>2</td>
</tr>
<tr>
<td>MF</td>
<td>290</td>
<td>80</td>
<td>161</td>
</tr>
<tr>
<td>MF</td>
<td>390</td>
<td>80</td>
<td>68</td>
</tr>
<tr>
<td>Landini</td>
<td>8860</td>
<td>80</td>
<td>1</td>
</tr>
</tbody>
</table>

2.1.5 Heavy Equipment

2.1.5.1 Wheel loaders (w/l)

These are composed of different makes and models like for example:-

Models:- 930, 966C, 966E, 966F2, 938F.
Make:- Caterpillar

Its function is loading trucks by e.g. sand, gravels.
Also to feed boilers in the factory by baggase (remainder of cane after crushing), Quantity: 16 Loaders.

Table 2.6 Wheel Loader

<table>
<thead>
<tr>
<th>MODEL</th>
<th>Horse power</th>
<th>Bucket capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>966E</td>
<td>220HP</td>
<td>3.6m³</td>
</tr>
<tr>
<td>966F</td>
<td>220HP</td>
<td>3.6m³</td>
</tr>
<tr>
<td>966G</td>
<td>220HP</td>
<td>3.6m³</td>
</tr>
<tr>
<td>950</td>
<td>170HP</td>
<td>3.1-9.2m³</td>
</tr>
<tr>
<td>938F</td>
<td>140HP</td>
<td>2.5m³</td>
</tr>
<tr>
<td>930</td>
<td>105HP</td>
<td>1.7m³</td>
</tr>
</tbody>
</table>

2.1.5.2 Crawler dozer

Make: Caterpillar.
Models: D5B, D6C, D6C, D7C, D8K, D8L, D9G D9R.
Rubber Crawler dozer (challenger) CH85, CH35. See Fig(1) and Fig(2).

These machines are used for two applications mainly:-

A-Used in land preparation for sugar cane by pulling disc plough, disc harrow (uprooting)
   The operations are:-
   - Uprooting – Deep plough using D8K and D8C machines.
- Disking-Plough of soil by using disc, the old stools must be uprooted and destroyed by the passage of discs. In doing this, large clods of earth are formed.

- Harrowing – To harrow with chisels, discs to form a seedbed and breakdown the large clods turned out during the primary disc.

- Planning – Leveling to get rid of undulation.

B-Dozing baggage (remainder of cane after crushing) and preparation of sand heaps for loader also are used in preparation of the field in harvesting season. (Leveling the entrance of the field).

The most important application in Kenana Sugar Company is the land preparation (using agriculture crawler tractors) for deep plough (special application in sugar cane plantation)

Crawler tractors are used primarily to pull implements such as plough, harrows.

The concept of draw bar pull and the draw bar are particularly important when considering agricultural applications.

Draw bar pull for a given implement is the force required to move it forward through the ground, first established based either on experience or on the implement manufactures data.

Obviously a tractor must be selected that can exert a force or draw bar pull at least this value if the implement is to move at all.

In other words, tractors draw bar pull must exceed implement draft (draft is the force required to pull an element forward)(Reference 5).

We must, therefore check two aspects of the proposed tractors specification.

First, its theoretical drawbar pull must be equalized.

Secondly, the tractor must be capable of developing this draw bar pull on the ground in question.

The maximum practical draw bar pull will not exceed tractor weight multiplied by coefficient of traction.

<table>
<thead>
<tr>
<th>Ground surface</th>
<th>Tracks</th>
<th>Rubber tires</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay, dry</td>
<td>90%</td>
<td>55%</td>
</tr>
<tr>
<td>Clay, wet</td>
<td>70%</td>
<td>45%</td>
</tr>
<tr>
<td>Earth, loose</td>
<td>60%</td>
<td>45%</td>
</tr>
<tr>
<td>Earth placed</td>
<td>90%</td>
<td>55%</td>
</tr>
</tbody>
</table>

Table 2.7 Traction as a percentage of machine mass
<table>
<thead>
<tr>
<th>Sand, dry</th>
<th>30%</th>
<th>20%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand, wet</td>
<td>50%</td>
<td>40%</td>
</tr>
</tbody>
</table>

**Source (Reference 5)**

**Note:-**
The above factors give traction as a percentage of the machine mass on driving wheel or tracks. This means that they are independent of the system of unit used.

**Dozers Models and Horse power**
These are found in different sizes and models.

<table>
<thead>
<tr>
<th>Model</th>
<th>Horse power</th>
</tr>
</thead>
<tbody>
<tr>
<td>D9G</td>
<td>405</td>
</tr>
<tr>
<td>D9R</td>
<td>405</td>
</tr>
<tr>
<td>D8L</td>
<td>338</td>
</tr>
<tr>
<td>D9G</td>
<td>285</td>
</tr>
<tr>
<td>85C</td>
<td>333</td>
</tr>
<tr>
<td>D7G</td>
<td>240</td>
</tr>
<tr>
<td>D6D</td>
<td>140</td>
</tr>
<tr>
<td>D6C</td>
<td>140</td>
</tr>
<tr>
<td>D6R</td>
<td>140</td>
</tr>
<tr>
<td>35C</td>
<td>144</td>
</tr>
<tr>
<td>D5B</td>
<td>105</td>
</tr>
</tbody>
</table>

The total quantity of dozers =34
D9G, D9R are used for baggase bushing blade type and capacity
Semi –U-Shape -13.5m³ S.T.D
D8 – Used as agricultural and tractors and dozer {dozing}. in land preparation
Out put
D8L 5 Feddan per hour- Disking (using disc plough for deep uproot).
D8K 2 feddan per hour- Disc plough.
Challenger 85C- Rom disc (agricultural tractor 5 Fadden /hour) D7G
Land preparation
Rom Disc (3611)
Out put 1.5 feddan /hour – Disc plough
Dozing in irrigation section
-D6D- Harrow Disc 64 Disc (28)- Breaking of clods to small sizes.
Out put 6 feddan /hour
- Dozing to prepare for harvesting.
Challenger 35C Harrow 10 feddan /hour.
D5B-scraper (land preparation) 10 feddan /hour.

**2.1.5.3 Motor Grader**
Models: 14G, 14H, 16G, 12G, 120G
Make: Caterpillar. Fig (3)

![Fig : (3)Motor graders](image)

Its function is to level the field (part of land preparation) also the leveling of the roads for harvesting (cane transportation trucks) prepares the small canals and the leveling of field during the harvesting season.
(Leveling the entrance to field for harvester)

Table 2.9 Motor Grader

<table>
<thead>
<tr>
<th>Model</th>
<th>Horse power</th>
</tr>
</thead>
<tbody>
<tr>
<td>12G</td>
<td>135HP</td>
</tr>
<tr>
<td>14G</td>
<td>180HP</td>
</tr>
<tr>
<td>14H</td>
<td>215HP</td>
</tr>
<tr>
<td>120G</td>
<td>125HP</td>
</tr>
</tbody>
</table>

**2.1.5.4 Excavators**
Models =22RB VC20 -20 and 325L, RB34, RB38
Make = Different (Caterpillar, RB).Fig (4)
Their function is for cleaning main canal and branched canals to get good irrigation facilities (cleaning from precipitated mud and weeds).

2.1.5.5 Lift Trucks (Forklift)
Model= V55, DP40, DP100, R60, and V70.
Make = Caterpillar. Fig (5)
Fig: (5) Lift Truck

Their function is to lift and transport oil drums, spare part cases and boxes, help in various jobs in the workshop (transport and lift of equipment components such as engines … etc.)
Large lift trucks are used in factory to lift the cane containers from trucks and transport it to the cane carrier to feed the factory mills.

Table 2.10 Lift Truck

<table>
<thead>
<tr>
<th>Model</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>V550</td>
<td>25 Ton</td>
</tr>
<tr>
<td>DP100</td>
<td>10 Ton</td>
</tr>
<tr>
<td>DP40</td>
<td>3 Ton</td>
</tr>
<tr>
<td>R60</td>
<td>3 Ton</td>
</tr>
<tr>
<td>V70</td>
<td>3 Ton</td>
</tr>
</tbody>
</table>

2.1.5.6 Road roller

Model = BS500
It is used in maintenance of paved roads

2.1.5.7 Cranes

Used in the factory maintenance and erection jobs, stores for unloading containers imported machines.
Models = TM750, TMS473, RT6305

Table 2.11 Crane

<table>
<thead>
<tr>
<th>Model</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMS 7505</td>
<td>50 Ton</td>
</tr>
<tr>
<td>TMS 475</td>
<td>30 Ton</td>
</tr>
<tr>
<td>RT 6305</td>
<td>25 Ton</td>
</tr>
<tr>
<td>HC 40/181</td>
<td>18 Ton</td>
</tr>
<tr>
<td>Grove</td>
<td>80 Ton</td>
</tr>
</tbody>
</table>

2.1.5.8 Backhoe loader

Model = 438B
Make = Caterpillar. Fig (6)

Fig : (6) Backhoe Loader

Used in construction and cleaning of drains and preparing building foundations.

2.1.6 Harvester (cane harvester)

Single furrow chopper cane harvester with proper attachment capable of cutting - in 1.5 m spacing with slew (by tow side) elevator continuously loading it into cane trucks going along side. Fig (7) and Fig (8)
It is used in harvesting cane (70% of total weight transported to mills is mechanically harvested) (about 2,500,000 Metric Ton per season). Total number of cane harvesters is 35. The model used is Case-Austoft 7000. There are two sizes in which, the engine rated power are 240 Hp and 325 Hp. The more horse power machines equipped with more power hydraulic components, give more productivity. All new purchased machines are equipped with 325 horse power engine. There are many moving components, most of their power is hydraulically transmitted to avoid complication of mechanical transmission. Fig (9)
Chapter (3)

Maintenance Workshops & Types of Maintenance Implemented

3.1 Maintenance workshops

The maintenance department (central workshops is one of the five main departments in Kenana sugar company)

These five main departments are: -
1- Maintenance department
2- Factory (Sugar production).
3- Agriculture (Cane Production).
4- Harvesting.
5- General management and service (Including civil engineering, hospital and human resources).

Maintenance department is responsible for all maintenance jobs carried on all mobile fleet of Kenana Sugar Company except the cane

Fig. (9) Harvester Transmission
transportation trucks and continuous cane loader which belong to harvesting department.

Part of these responsibilities include: -

1- The proper selection of all equipment to match the various job including: -
   a- The required power.
   b- Technical specifications.
   c- Compatibility with the local environment.

2- To direct the optimum operation to avoid accidents and breakdown and this include: -
   a- Operation by well –trained people.
   b- Operation within the designed capacity.
   c- Operation within the environmental conditions.
   d- Conduct all types of maintenance through well-trained and specialized personnel.
   e- Use of suitable equipment for each specific job.
   f- Decision-making regarding replacement of machine according to technical and economical information.

The maintenance department is consisted of the following sections: -

1- Harvesting shop.
2- Heavy equipment shop.
3- Tractors and seed cane shop.
4- Light vehicle shop.
5- Trucks, buses and semi –trucks shop.
6- Service section (service shop, fabrication shop, supporting equipment shop, generators and compressors, and tires)
7- Components section (Machine shop engine, over hauling shop, vehicles electricity shop.
8- General electricity shop.
9- Areas workshops.
10- Planning and control section.
11- Administrative section.
12-Tools and consumable materials section (stores belong to materials control department, there is a store in the central workshop and there is a good co-ordination between the two departments).

3.2 Different Types of Maintenance Carried In Central Workshops

Maintenance is very important for any equipment so as to make it function efficiently and economically during the investment period. There are three types of maintenance carried out at Kenana central workshops:-
3.2.1 Preventive maintenance: -
Preventive maintenance is the maintenance carried to a void the breakdowns occurrence. This type of maintenance is carried as recommended by the manufacturers.
It is carried out according to the operating hours or mileage. For stationary or low speed equipment it is conducted according to the number of operating hours.
In Kenana Sugar Company regarding heavy equipment it is carried out according to operating hours (e.g. earth moving equipment, harvesters). But for cars (light vehicles, trucks and buses) it is not taken by mileage because the work shop could not monitor the mileage, they count it by fuel consumption where they established a satisfactory co-ordination between the central workshops and the fuel supply stations. For any type of car they estimate the number of mileage for every gallon of fuel and they convert the recommended mileage to number of gallons.
For example a Toyota car (light vehicle) is estimated to consume one gallon for every 45 km and there for recommended to carry out preventive maintenance every 4500km. That means after the consumption of 4500\45 =100 gallon. Specific preventive maintenance on it.
The car is warned by fuel station personnel that it is not going to be refueled unless the specific type of preventive maintenance is carried on it, and after that is done they will commence issuing of fuel to the car (I think it is an ideal control for a large fleet and different users).

3.2.1.1 Types of preventive maintenance
Type A: Change of engine oil, grease and general check (5000 Km).
Type B: Change of engine oil, engine oil filter, grease and general check (10000).
Type C: Change of engine oil, oil filter, fuel filter, grease and general check (20000).
Type D: Change of all oils, filters including air cleaner element (40000 Km).

3.2.1.2 Jobs carried out during preventive maintenance are: -
1- Daily general check.
2- Cleaning the air filter element.
3- Change the different type of oils, hydraulic oil.
4- Change of filters {Air cleaners, engines oil fitter, hydraulic filters, fuel filter}.
5- Revision of tyre bolts and nuts, tyre inflation pressure.
6- Readjusting valves clearance.
7- Change of spark plugs in S-I-engines, change of atomizer nozzles in C-I engines
8- Change of radiator coolant.
9- Greasing of all recommended points and joints e.g. steering rods bearings universal joints.

3.2.2 Corrective maintenance: -
This type of maintenance is carried out after a break down has taken place. The maintenance is done as prescribed by manufacturer referring to the maintenance manual for each specific type and model. This type of maintenance is to restore the defective equipment to the standard condition as prescribed by the manufacturer.

3.2.3- Scheduled maintenance (or overhauling maintenance)
Maintenance that restore the major parts of the equipment to the standard condition.
This type of maintenance is carried out as a scheduled program according to specific period of time.
In Kenana Sugar Company this type of maintenance is carried during the off crop period where there is no production—about five month a year (from May-October)

3.3 Types of maintenance conducted in different workshops
3.3.1 Mechanical harvesting
There are two periods for maintenance
3.3.1.1 On crop {production season}.
During this period the preventive and corrective maintenance are carried out.
There are four phases (phase 3, phase 4, phase 5, phase 6) (phase 1 and 2 are hand cut harvesting) each phase has 7 to 8 harvesters working simultaneously in different areas of the field. The maintenance is carried out in the field.
There is a mobile workshop equipped with well-trained manpower and tools and all supporting facilities (generators, air compressor, welding machine, and grinding discs). Fig (10)
During this period the work is done all day round in two shifts bases system. This period extends over six months (season time). Mechanical harvesters in this period harvest about 60% from the total cane transported to the factory (This percent is weight wise). {Mechanical harvesters mean all harvesting stages are done mechanically} 40% of harvesting is harvested manually (hand cutters). For all harvesters it is estimated that the harvester is working for 20 hours per day for the on crop period. The preventive maintenance is controlled by operating hours. Every eight hours any harvester must do the following  
- Cleaning the harvester (First by compressed air then by water).
- Cleaning the air filter by compressed air.
- Checking the level of all oils.
- Grinding of the cutting knifes (base cutter knifes).
- Checking of hydraulic hoses and lines for leakage.
- Checking of bolts and nuts.
- After this check, the machine is operated and all functions switched on to check that all parts work satisfactory.
Change of oils and filters and other preventive maintenance is carried out according to the operating hours as specified by the manufactures. If there is any breakdown –corrective maintenance is carried out inside the field. If the break down is a major one, corrective maintenance is done at the phase workshops, which must not be more than two kilometers from the field (harvesting area). There are stocks of consumable parts and fast moving parts as stand-by in the mobile workshops to reduce the down time.
There are delivery cars responsible for feeding the four mobile workshops with spare parts and daily requirements from the central workshops. Which are on call day round.

**3.3.1.2 Off crop maintenance**

During this period, which continued for five month from May to the beginning of October, the scheduled maintenance must be finished before the first of October to prepare for the operation period. During this period the major or overhauling maintenance is carried out. Reference is made to the operation period reports to help in the scheduling and maintenance jobs to be carried, which cover the things that must be changed or done. Also the engines that need major overhauling are taken care of. They are replaced by stand-by ones and the defected one sent to over hauling (always there are stand-by for major units during operation season such as engines, hydraulic pumps, gearboxes, elevators, crop dividers. Fig (11) Annually there is a replacement program of two to three units of harvesters. (The average life of the machine is estimated as 8 years) In this type of maintenance a job order must be opened. (Appendix 1)(the job order) which describe some details about the machine, the defect, the property code no, cost centre (each department has a cost centre) and man hours for repairing.

![Fig: (11) Stand-by Units](image)

**3.3.2 Heavy Equipment Section**
The job of this section is divided into two functions:
A- Continuous operation.
B- Seasonal operations.
For the machine that work continuously the preventive maintenance is carried out in the field in the different agricultural areas.
Example of these machines is motor graders and excavators)
In case of break downs, the maintenance is carried in the field unless the break down is major which imply to transfer the machine (by low bed truck) to the central workshop to do the maintenance.
All light maintenance jobs are carried out by the mobile workshop (trucks) covering all machines in different areas according to the preventive maintenance program or the break downs reporting.
The major maintenance is carried out with a certain program so as not to effect the different operations.
The machines that operate during the season include the land preparation equipment (bulldozers). During the season of land preparation there are two mobile workshops to carry out the preventive and corrective maintenance the same as the mechanical harvesting in a two-shift system (24hours operation)
The preventive maintenance is carried out according to the number of operating hours.
Forklifts are used to unload containers from trucks at the factory {20 metric ton forklift truck}. For these machines there is a workshop in the factory belonging to the heavy equipment workshop to carry the different types of maintenance during on-crop period, and scheduled maintenance during the off crop period.

3.3.3 Tractors workshop
The machines related to this workshop are divided into two types: -
  1- Machines that operate seasonally.
  2- Machines that operate continuously.
Continuously operated tractors are used in trailer transportation to transport fertilizers to different sections in the agricultural areas. Also they are used to transport drinking water to some Kenana personnel in some distance areas (All these tractors are 80 HP tractors).
Machines that operate seasonally are:
  i- Machines that support the harvesting operations and land preparation it is used to transport the mobile workshop from field to field and transport the supporting equipment e.g. mobile compressors, washing tankers, drinking water tankers.
  ii- Machines that transport seed cane for new plantation (80 HP tractors).
There are sub-workshops composed of 6 trucks and 4 grab loaders (which are used to load trailers with seed cane) work simultaneously with the tractors that transport seed cane.

-120HP tractors assist in the land preparation operation and are used to apply cane pushers employed during the harvesting season to open the fire lines (before burning the cane).

### 3.3.4 Areas workshops

These workshops cover all maintenance of tractors, which belong to different areas (each area is approximately 15000 acre). The preventive and corrective maintenance is done for all tractors, light vehicles and trucks related to each of these areas

### 3.3.5 Light vehicles and trucks

These vehicles belong to different department within Kenana

1. The preventive maintenance is carried according to the fuel consumption with a good co-ordination between the central workshop and fuel supply stations. The user brings the vehicle to the workshop and register for a job order (Appendix 1).

2. The corrective maintenance is carried when there is a problem. The user brings the vehicle to the workshop and register for a job order (Appendix 1). The inspection section inspects the vehicle and reports his comments and transfers the vehicle to do the required particular maintenance.

The scheduled, annual maintenance (off-crop maintenance), starts after securing spare parts and done in accordance with plans put forward by workshop personnel. Sometimes the spare parts are not sufficient for all vehicles (For some budgeting reasons). In this case maintenance is done to the vehicle that are directly involved in the production operation and after that the other vehicle are taken care of.

The job order (Appendix 1) consists of:

- The Kenana property number (for any machine there is a specific number to be registered for cost analysis).
- Job order number, date, cost centre (every department has specific cost centre to control and analysis each department and section separately).

The job order number and property number must be written in the S.I.V. (Store issue voucher) (Appendix 2) to issue spare parts from store for repair.
The spare parts issued and man-hours also registered in the job order. After the maintenance is completed the job order and a copy of S.I.V. (store issue voucher) is transferred to the production section so as to be kept in the equipment file.

### Chapter (4)

**The Most Frequent Breakdowns**

The nature of working environment in sugar estate is very tough especially for the equipment which are directly involved in the production sectors, e.g. heavy equipment (earth moving equipment), harvesters and tractors. Due to this nature, the most breakdowns is, engine failures due to tear and wear, hydraulic components failure in spite of the good preventive maintenance being carried out. The major factor for those failures is the dusty environment during which those machine work. If a mere pinhole leak in a hose is left for a full season in air cleaning system or an air intake hose comes off for only a few hours, an engine may be damaged completely. Preventive maintenance needs more attention. Service of cooling system is also very important. The cooling system absorbs about one third of the heat energy developed by the engine fuel. Another one third of the heat energy is used for power and the remaining one third is dissipated through exhaust gases and crankcase oil. If the cooling system fails to remove its share of the heat, the engine may be severely damaged. Any damage in the cooling systems leads to costly damage of the engine. Fig (12), Fig (13) and Fig (14)
Fig : (12) Connect Rod Failure

Fig : (13) Connect Rod Failure
Most engine failures include piston ring and liner wear due to dusty condition, turbocharger damage (internal leakage of lubricating oil) due to seals failure, overheating due to tough environment, trashes accumulated in the radiators (frequent cleaning is needed).

Hydraulic systems provide the (muscle) for doing work. Some machines, like tractors have a hydraulic system that performs several functions- steer, brake, control implements and operate remote functions.

Other machines may have only one or two hydraulic functions. All the functions may share a common oil supply or they may have their own reservoir.

The most common hydraulic functions are:-
- Steering.
- Brakes.
- Transmission.
- Remote cylinders.
- Hydraulic actuators (hydraulic motors and lifting cylinders).

Hydraulic systems are very sensitive and a major source of costly breakdowns.

A well-maintained hydraulic system seldom gives the operator any trouble. Regular checks must be done to make sure that the oil level is sufficient and changing the oil and filters regularly to prevent problems.

The oil in the hydraulic systems extremely sensitive to contamination by dust, rust and moisture.

Nearly all hydraulic component manufacturers and users agree that dirt is responsible for a majority of malfunctions, unsatisfactory component performance and degradation. Dirt comes from many resources and in various forms, such as chips, dust, sand, moisture, pipe sealant, weld spatter, paints and cleaning solutions.

The sources of contamination are numerous and include contaminants introduced
- with new oil
- at the time of hydraulic system construction
- with the air from the environment
- by wear within the hydraulic components
- through leaking or faulty seals
- by shop maintenance activities
- some of the contamination found in oil samples taken from a system after a short run-in period of a new machine includes metal chips from tubing burrs, pipe thread, component manufacturer particle, tank fabrication, pipe dope, Teflon tape shreds, lint from
wiping cloths, welding scale and beads, pipe scale, factory dust, rubber particles and debris from hose fabrication.

Contamination that enters the oil from environment surrounding the hydraulic system can do so by following several paths. These entry points include air breaths, access plates and seals.

Dirt is continually introduced into operating hydraulic systems because of wear and degradation of the working components. The wearing action of working parts in components such as pumps, fluid motors, valves and cylinders generates contamination.

Rust scale from the reservoir caused by condensation above the oil level is also a source of dirt. Burrs on tubing and piping break loose during service; and flexing of components continuously releases particles which were not removed during the initial cleaning of the system.

Contamination is added to the system when equipment is being repaired

a- Components pick up contamination from dirty workbenches.

b- Dirty rags are used to clean components.

c- Tubing and hose is left on the floor or exposed to dirt.

The solution to this apparent dilemma is to make the importance of system cleanliness known to the maintenance personnel through training activities. The awareness of the sources, the effect on the system and control of contamination will develop habits within the maintenance people that are conducive to minimizing the introduction of dirt by shop activities. Fig (16), Fig (17) and Fig (18).
It is well known that contaminant particles are of all shapes and sizes, and that the finer they are, the more difficult to count them and to determine the material of which they are composed. However we can say that the majority are abrasive and that when interacting with surfaces,
they plough and cut little pieces from the surface. This wear accounts for about 90% of the failures due to contamination or dirt (Reference 7). The effect of these contaminant particles on various system components reflects itself differently depending on the mechanism of operation.

The following is a list of what dirt does to hydraulic components and causes breakdowns

a- Pumps
- Erodes sticking of vanes creating erratic action.
- Causes vanes to wear out the cam ring.
- Wear out rotor slots.
- Increases shaft journal and bearing wear.
- Increases gear wear, which result decrease in efficiency.
- In compensator control on variable-volume pumps, causes sticking, slow response, and erratic delivery.
- Creates excessive heat and inefficient use of horsepower.

b- Relief valves
- Dirt causes chatter.
- Accumulated dirt causes relief valve to fail-safe, pressure becomes erratic.
- Dirt causes seat wear.
- Dirt causes plugged orifices on balanced piston-type valves.

c- Directional valves
- Dirt causes wear to spool and housing lands creating excess leakage.
- Dirt deposits cause spools to stick, which can cause solenoid failure.

d- Check valves
- Dirt permits fluid to bypass check.
- Dirt causes wear on the ball and seats, creating leakage.

e- Flow control valves
Dirt causes erosion of orifices, changing the flow setting characteristics.

f- Servo valves

- Dirt causes erosion of sharp edges, which affects metering.
- Dirt plugs nozzles because they contain very small orifices.
- Dirt leads to build up of varnish deposits.

g- Cylinders

- Dirt causes excessive wear of the cylinder rod, piston seals, rod seals and the tube bore.
- Dirt causes cushions to malfunction.

h- Fluid motors

- Dirt causes wear similar to pump wear.

i- Fluid

- Dirt acts as a catalyst, thereby breaking down the molecular structure of the oil, causing gummy residue (varnish) to form.
- Dirt in the tanks tends to attract additives, which changes the composition of the fluid.

From the foregoing, it can be seen that failures arising from dirt or contamination can be classified into three categories

a- Catastrophic failure occurs when a large particle enters a pump or valve. For instance, if a particle causes a vane to jam in a rotor slot, the result may be complete seizure of the pump or motor. In a spool valve, a large particle trapped at a certain place can completely stop a spool from closing.

b- Intermittent failure is caused by contaminant on the seat of a poppet valve, which prevents it from reseating properly. If the seat is too hard to allow the particle to be embedded into it, the particle may be washed away when the valve is reopened. Later, another particle may prevent complete closure only to be washed away when the valve opens. Thus a very annoying type of intermittent occurs.
c- Degradation failure follows wear, corrosion, and cavitations erosion. They cause increased internal leakage in the system components, but this condition is often difficult to detect.

Abrasion and erosion often create hard, metallic-wear products which enter the hydraulic fluid and cause additional wear. The total number of these particles also causes oxidation and other breakdown, hastening the deterioration of the hydraulic fluid. Very small amounts of free water in hydraulic fluid will cause corrosion, oil breakdown, acid formation and other problems.

Another most breakdowns on combine cane harvester are wears of chains and rotating parts, crack and damage of elevator which are exposed to damage by accidents with trucks during loading process or bad field preparation and front axle bearing due to the tough field conditions. E.g. front wheel hub bearings. **Fig: (19):**

Agricultural machines are designed for special kind of work. They are built tough, but are not “hot rods” and they must be handled with respect and care. Improper operation causes premature wear and damage. e. g. if the operator allows the tire to spin with inadequate inflation, serious tyre damage will result after a while (Reference 1).

The practice shows that the most important element to reduce breakdowns is the human factor, both maintenance and operation
personnel. Maintenance personnel must obey and follow the maintenance instructions as prescribed by the manufacturer in the workshop manual, operators must follow instructions in operation manual.

As most agricultural machines operate in tough conditions, the following are tips for good machine operation The operator must:

- Follow suggestions in the operator manual.
- Perform daily maintenance before using machine.
- Check the machine for damage and potential failures before starting it.
- Run the engine until it warm up before putting under load.
- Let a hot engine run a few minutes without load so that it cools before shutting it off.
- Keep bolts and nuts tight.
- Watch the instrument panel frequently.
- Keep the machine properly serviced.
- Operate at safe speeds.
Economical Evaluation and Discussions

Machine costing can be broken down into the following Elements:

5.1 Ownership Costs  
5.2 Operating Costs  
5.3 Labor Costs  
5.4 Total Machine Costs  
5.5 Idle Time Analysis  
5.6 Work Study Analysis  
5.7 System Balancing  
5.8 Overhead Costs  
5.9 Profit  

Not all of these necessarily need to be included when providing a machine costing.

5.1 Ownership Cost

The ownership cost is often referred to as a “Fixed Cost”, the logic being that a fixed payment is usually paid to the finance house every month. That rate is determined by:

- Purchase price  
- Residual value  
- Write-off period  
- Interest rate

A financial calculation provides the full cost of depreciation and interest. The ownership cost is also influenced however by:

- Tire price  
- License fees  
- Insurance

Tyres are costed in the operating costs, as will be seen later, and inclusion in the ownership cost would mean a double booking of one set of Tyres over the life of the machine.

It is logical then to add the cost of a new set of Tyres to the residual value. In many cases, especially when a new machine is being costed over a short-term contract of say 3 years, a residual value is a necessity. It is
reasonable then to included the estimated residual value along with the tyre cost in the financial calculation. The license and insurance cost must also be added to the annual ownership cost and is usually expressed as a percentage of purchase price. In order to convert this fixed ownership cost per annum to a cost per hour the number of hours the machine will work per annum must be known. To do this the following data is required:

- Shift length
- Idle hours/shift
- Mechanical availability
- Number of shifts/day
- Number of potential working days/annum
- Number of idle days/annum

The idle hours/shift are the hours that the machine will be turned off during the normal working shift due to various factors. Mechanical availability is the percentage of uptime the machine is expected to achieve on average over the year. The number of potential working days/annum is the number of days/annum an operation is planned to work. The number of idle days/annum are the number of potential working days expected to be lost, usually due to poor weather.

Machine hours/annum = (shift length - idle time/shift) X availability X Number of shifts/day X (Number of potential working days/annum - Number of idle days/annum).

The machine hours/annum finally arrived at and can now have an influence on other factors. For example, if the write off period is fixed and the machine hours end up being very low (as can often be the case with a wheel loader of loading trucks) there may be a case to increase the residual value or even decrease the maintenance cost. As a general guideline though, the ownership cost will be higher, the lower the machine hours/annum.

5.2 Operating costs
The operating costs are often referred to as the “variable costs”. The logic being that all the elements affecting operating costs can vary on a monthly or even annual basis.

5.2.1. Maintenance costs
This can be split into service costs and breakdown costs both of which have spares and workshop, labor element.

5.2.2 Fuel costs
The calculation is straightforward being fuel consumption multiplied by fuel costs/liter

5.2.3. Oil costs
Oil consumption is calculated as a percentage of fuel consumption and is multiplied by an average oil cost/litre. This includes all engines, hydraulic and transmission oil costs.

5.2.4. Tyre/Track costs
This cost is calculated by the tyre/track cost divided by tyre/track life. It is a difficult cost to calculate accurately for the following reasons:
- Tyre manufacturers constantly upgrade their Tyres.
- Extensive use of retreaded tyres.
- Tyre damage.
- Largely uncontrolled tyre pressure.
- Varying degrees of abrasiveness for different materials types
- Low, medium or high impact conditions

5.3 Labour costs
Labour costs relate to the drivers and labors associated directly with the machine. Fringe benefits are expressed as a percentage of direct wage. This can be left as zero if medical aid, protective clothing, housing, transport etc are to be included in overheads later. If not, then they must be included here. As a guideline, contractors usually run between 30–50% with large companies often in excess of 100%. Supervision can be expressed as a percentage direct wage. Again this can be included in overheads later.

5.4 Total machine cost
The total machine cost/hour = ownership cost/hour + Operating cost/hour + Labor cost/hour

5.5 Idle time cost
As discussed in the ownership cost, idle time analysis relates to the amount of hours that the machine will be turned off per shift. The most common elements are:

5.5.1 Daily maintenance
Fueling, greasing and checking the machine. Usually 30 mins/shift is allocated.

5.5.2 Rest allowance
Rest Time allocated to the driver during their shift for a smoke break, relieving himself, stretching, eating etc. This can vary due to a number of
factors, noise levels, temperature levels, fatigue and level of concentration required.

5.5.3. Waiting time
In operations where the machine has to wait for other units, the waiting time could be used to replace the rest allowance and the daily maintenance.

5.6. Work study analysis
This refers to the actual time it takes to do a job broken up into elements.

5.6.1. Non-productive time
Examples of this are traveling to and from a workshop, traveling between work sites or testing Machines.

5.6.2. Payload
In the case of a tractor / dump truck this is fairly obvious. In the case of loading equipment payload becomes the quantity of material in the bucket.

5.6.3. Loading time
Loading time refers to the time it takes to load the load. Loading time also includes the time it takes to enter or exit a site.
I.e. loading time = enter site / load area /cut+ Load trailer / bin / body+ Exit site / load area / cut

It is important to include these times with the actual loading times since the speeds are much lower than the road speed. These times are generally fixed for each cycle but, as the road lead distance varies so then does the traveling time. To include these figures with the traveling time then would be incorrect.

5.6.4. Unloading time
Unloading time refers to the time it takes to unload the load. Unloading time also refers to the time it takes to exit or depart a siding or mill. This is usually quick with between 30 seconds and 1 minute being allowed for entering and a similar time for leaving the site.
I.e. Unloading time = enter site / dump area / fill + Unload + Exit site / dump area / fill

5.6.5. Travel speed (loaded)
This refers to the speed at which the loading, hauling equipment moves between the completion of the loading time and the start of the offloading time. The speeds will vary greatly depending on ground conditions, weather, slope and payload.

5.6.6. Travel speed (empty)
This refers to the speed at which the equipment moves between the completions of the offloading time and the start of the loading time. The
speed will vary according to the same variables as in 5.6.5 with the exception of payload.

5.6.7. Lead distance
Lead distance refers to the distance traveled, one way between the completion of loading and start of off loading.
It must be stressed that the optimum lead distance is determined by costing out the alternatives. In other words the optimum lead distance for one piece of equipment is that which, when costed into the system fits into the most cost effective system.

5.6.8. Work study summary
The combining of above data allows one to arrive at a productivity rate per machine hour (tones/hour) combining this with the total machine cost/hour already arrived at in 5.4. leads us to the cost/tone for the operation.

5.7 System balancing
Through the work-study and idle time analysis one can arrive at a potential annual production for a machine.
However, in many studies an operation has a specific annual production, which may be more or less than that which the machine can achieve. If it is less then adjustments will have to be made in the study to reduce the annual production to that which is required. This can be achieved by reducing the annual hours worked, which can in turn be achieved in several ways:
- Reduce the shift length
- Reduce the number of shifts
- Reduce the number of potential working days/annum
- Increase the time to wait for tractors/loaders
The figure must be manipulated until the required annual production is achieved.
A look at the ownership cost and the cost/tone will show an increase in cost due to the reduced utilization of the equipment. If the operation required a production higher than that achievable by the machine then the study could be manipulated to produce the higher tonnage simply by the inverse of the above (i.e. increase shift length etc.) if these plans are feasible.
Alternatively one or more additional machines must be added to the system and their production figures adjusted again so that as a whole they balance with the required tonnage.
When balancing loading, offloading and haulage units one in variably has to favor one type of equipment over another when trying to optimize the utilization. In this case, favor the more expensive units which are usually the haulage equipment since this will keep the cost/tone as low as possible.
5.8 Overhead costs
Overhead costs or indirect costs can include the following:
- Supervision from foreman to managing director.
- Supervisory transport
- Office / Workshop lease
- Admin staff
- Telephone/fax
- Medical Aid
- Protective Clothing
- Entertainment etc, etc,
Some or all of these costs can be included in the “labor costs” or they can be added to the direct cost/tone of the operation. One must be careful not to leave out information and equally not to double book. For example, Workshop lease should be included in the “maintenance costs” of the machine. If this is not the case however then
The maintenance cost can be adjusted accordingly.

5.9 Profit
The company will use there own cash to purchase the equipment and are now looking for a return on the capital employed better than that which they would have received had they left their money in the bank. When producing a costing for this type of customer, the interest in the ownership cost will be left at zero and a financial calculation on the return on investment will be carried out.
A company usually compares the cost of a new system with that of an old system or a contractor’s price and if the saving creates a large enough return on investment then the operation is viable.

5.10 Conclusion
It is important to remember that the cost/tone for the entire system is the most important factor rather than just analyzing the capital cost.

5.11- Kenana Costing: -
In Kenana Sugar Company the economical evaluation is based on estimating the operating cost which is divided in two ways:-
A- Costing relating to the capital expenditures.
B- Costing relating to operating expenditures, the operating cost is the running cost during the year, so in Kenana, every year the budgetary section in accounts department, by the feeding with data of cost and management account relatively to the sections concern divided Kenana departments and sections in many cost centers and then let them to prepare forecasting
budget compare to the previous budget (Appendix 3). This budget concern with three categories:

5.11.1 **Man power (payroll):** Means the cost of labors and the staff (Appendix 4).

5.11.2 **Materials:** Concern all materials; fuel lubricants spare parts and other materials like tires and others. (Appendix 5, Appendix 6, Appendix 7, Appendix 8 and Appendix 9), showing costs.

5.11.3 **The others:** Expenses like telephones rent and other charges.

5.11.4 **Estimated cost:**
The cost of machines prepared by using the previous data adding the cost of payroll of all cost center related to the material, which is used like spare parts, fuel, lubricant and divided into the number of fleet, so we have the operating cost of the machine concerned (Appendix 10).

Also the (Appendix 10) showing that every cost center dealing with machine and something relatively to workshops, calculate the costing for whole cost center and then the cost and management account control the expenditure for all.

Operating cost is controlled by the system weekly, monthly or any other system of control regarding the budget. The amount appear in yearly budget should have to be valid by dividing into twelve months or into 52 weeks and then they can compare this figure and note accordingly. These reports are to be summarized for the whole company and discussed at Kenana Technical Committee meeting to show the variances comes and how long it takes to go through the budget.

5.12 **Depreciation**
Depreciation is the loss of market value of a machine during its working life. Depreciation is closely related to taxation and is therefore treated differently in different countries. At the same time, individual companies may have their own accounting preferences.

In Kenana Sugar Company all the fleet was registered at the book of the company, with its invoice price. The company uses the straight-line method in depreciation. Depreciation, often the largest cost of farm machinery, measures the amount by which the value of a machine decreases with the passage of time whether used or not. The value declines because:-

1- The parts of the machine worn with use and can not perform as effectively as previously. These parts are the economically irreparable mechanisms in a machine. For example the basic frame
may be worm or distorted. The field capacity of the machine may
decrease or its material performance may suffer.
2- The expense of operating the machine at its original
performance increases as more power, labor and repair costs for the
same unit of output are required. Repair and adjustment can renew
the machine but at an increased rate of cost.
3- A new, more efficient machine or practice becomes available.
When this situation develops the existing machine is said to be
obsolete. The existing machine may be functionally adequate but
because of new technology it is uneconomic to continue to operate
it.
4- The size of the enterprise is changed and the existing
machine’s capacity is not appropriate for the new situation.

It may be concluded from the above that depreciation is more
likely a function of time for machines having small annual use.
Obsolescence and rust are likely to end the life of these machines.
Only for large operations will the mechanical deterioration due to
use likely end a machine’s life.

5.13 Replacement Decisions
It is known that the total cost falls to a minimum about half way
through the assumed machine life and increases thereafter, once
this minimum is passed, consideration must be given to when to
replace a given machine. In practice, it is most important to keep
detailed records of the costs incurred by each machine in a fleet,
since it usually turns out that some machines cost more than
predicted, while other cost less.
If the actual costs for a given machine are below the minimum
predicted figure, it may be appropriate to continue to use that
machine beyond the life time initially assured. On the other hand, if
a machine costs much more than anticipated and an explanation
cannot be found, it may be best to trade it in earlier than originally
planned.
Replacement of machine is indicated when:-
1- Accidents have damaged the equipment beyond
repair.
2- Field capacity of the machine is inadequate
because of an increase in the scope operation.
3- A new machine or farm practice makes the old
machine obsolete.
4- Performance of a new machine is significantly
superior.
5- Anticipated costs for operating the old machine exceed those for a replacement machine. Estimation of yearly cost are adequate for determining crop production costs and for deciding if machine ownership is profitable, but the time of replacement decision depends on the accumulated costs over a period of years.

5.13.1 Economical Assessment (proposed example: cane harvester):
An example of costing assessment is the cost of combine cane harvester. The initial value is equal to 200,000 U.S.D. The expected use full time is seven years, estimated time in hours is 3000 hours/year. The total hours expected life = 3000 X 7 = 21000 Hours (unless major over hauling carried on).j

Straight line method depreciation using zero residual value

\[
\frac{200,000-0}{7} = 28571\text{USD.}
\]

Annual Cost:-

<table>
<thead>
<tr>
<th>Item</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depreciation</td>
<td>28571 USD.</td>
</tr>
<tr>
<td>Operating cost and others(estimated normal)</td>
<td>25000 USD.</td>
</tr>
<tr>
<td>Total</td>
<td>53571 USD.</td>
</tr>
</tbody>
</table>

The annual cane harvested per harvester is 116667 Ton
Annual harvesting cost is 0.46 Dollar/Ton (reference value).
The annual Cost/Ton can be calculated annually, if there is an increase in this cost, a revision action will take place to detect the source of expenses which is definitely in the operating cost (high consumption of spare parts or fuel).

5.14 Discussions:
The central workshops equipped with tools to implement the maintenance activities. The technical staff is well organized but no enough advance training to cope with the advanced technology of nowadays implemented in all modern workshops.

The readiness of the workshops not modern enough by using new technology, for example the machine shop need modern machines (lathe machine, boring machine, grinding machine) which can help effectively in maintenance activities.

There is a daily in the supply of spare parts for very important equipment so the maintenance can be done in appropriate time and make the necessary test before involving in operations especially for equipment directly affecting the production, for example mechanical harvesting and heavy equipment sections.
The supporting machinery like air compressors and generators are very useful in maintenance activities carried by mobile workshops during production season which are enough and good maintained condition.

The technical library is not kept updated by all operation and workshop manuals and spare parts catalogues to easily get the useful information which help in maintenance, operation and ordering of spare parts.

They are not implementing a computer recording and analyzing system using an advanced diagnostic and analytical systems. Also they are not conduct continuous training for both maintenance and operation personnel to be aware of the right procedures to handle maintenance activities and operation.

Chapter 6

Conclusions and Recommendation

6.1 Conclusions
From the previous discussions, the following conclusions may be drawn:-
- The periodic check up for engines is not carried out satisfactorily e.g. Engine tuning up, compression test, change of injectors nozzles in diesel engines and spark plugs in petrol engines to save fuel and get the maximum output power.
- A highly trained personnel is not enough to take care of the bulk quantity of machines and variety of different types and models.
- The periodic calibration of special tools is not conducted to avoid misleading results. Example of these tools are: torque wrenches and pressure gauges.
- There is accumulation of non-moving items being no longer in operation spare parts due to the written off of their equipment.
- There is no dynamometer to test engines after over hauling.
- There is no library for catalogues and service manuals.
- There is no software records for preventive maintenance and maintenance programs.
- Delay of spare parts according to maintenance program.
- The economical evaluation needs to follow the right analysis to exactly evaluate the cost.
- There is no compliance with the replacement program.

6.2 Recommendations
After the above mentioned comments it is appropriate to suggest the following
- Detection of faults should be done by using the diagnostics and analytical systems and experience due to complication in modern machinery (mechanical, automatic and electrical systems).
- Availability of spare parts in appropriate.
- Personnel should be given an up-to-date training.
- The replacement policy is to be implemented according to the prescribed program.
- Maintenance of roads to reduce breakdowns and hence maintenance cost.
- Equip the workshops with the necessary special tools to carry the maintenance in a proper way (e.g. dynamometer).
- The evaluation of performance of the machine after maintenance must be carried out.
- More effective periodic inspection system must be brought to troubleshoot faults in the right time before a major breakdown occur.
- Matching between personnel training and the accelerated technology of nowadays must be looked at.
- Good link between maintenance activities and stores should take place.
- Specialization in the different fields of maintenance like hydraulic and engine overhauling for workers is a necessity.
- Good computerized recording and registration system must be implemented.
- Recalibration of special tools should be done frequently.
- Laboratory oil analysis has to be conducted regularly which can remarkably reduce the operation cost.

- A forecasting procedure to detect breakdowns before it happens has to be found (e.g. forecasting of spare parts needed, time to bring machine in operation). Breakdowns repair time is very important specially in machines directly involved in production. (This time is troubleshooting; remove of defective part, issuing of spare part from store, time of assembly and the final adjustment and test).

- As the most frequent breakdowns are engine failures, special care is to be taken in preventing contamination of engine oil, (oil contamination can reduce engine life more than any other factor). Some sources of contamination are obvious while others are not. Some of these sources to be avoided is the storing and handling of the oil itself. Lubricants must be stored in a clean, enclosed storage area, with covers kept on. These practices not only keep dirt out of the oil, but also reduce condensation of water caused by atmospheric changes. Another obvious source is dust that is breathed into the engine with combustion air. It is very important that the air cleaner be cleaned or replaced regularly.

A major source of contamination in a cold engine, is that fuel burning efficiency is greatly reduced. This result in partially burned fuel blowing by the piston rings and into the crankcase. Oxidation of this fuel in the oil forms a very harmful varnish which collects on engine parts. Contamination from a cold engine can be prevented by: Properly warming up the engine before applying a load, making sure the engine is brought up to operating temperature each time it is used and using the proper thermostat in the cooling system to warm up the engine as quickly as possible.

- It is recommended to use a program called EM/PA (Equipment Maintenance through Progressive Analysis) applied to minimize the operating expenses and the maintenance cost for the expensive equipment that is operated for maximum productivity. This program depends on analyzing used oil samples in a very sophisticated laboratory that is provided with information about permissible limit of wear metals and other requirements specified by the equipment builders all over the world. The analyzed results report is composed of two parts namely the oil analysis and the metal analysis.

a) The oil analysis provide information about the condition of the oil in use to predict if the operating unit can run further hours or kilometers with current charge of oil or
not. The analysis measures the lube oil properties and the fuel and water contents in the sample. This will enable to prevent the use of a deteriorated lubricant and to optimize the use of lubricants to reduce the lubrication cost.

b) The metal analysis provides information about the condition of the equipment internal parts. This is accomplished by measuring the wear metals and the dust in the sample in parts per million. The comparison between the analysis values and their maximum permissible limits will exactly locate the faults in the operating unit. This program delivers the following benefits,

1) Eliminating the faults before they accumulate into major ones (spare parts saving and extended life time).
2) Detecting any defects in the fuels injection system (fuel economy and engine protection).
3) Detecting any defects in the cooling system (engine protection).
4) Detecting any defects in the air inlet filtering system (engine protection).
5) Extending drain intervals (lubricating oil economy).
6) Preventing the use of deteriorated oil (engine protection).

- The economical analysis needs more attention and implementing of more machine cost analysis as described in chapter (5) is essential to know the actual machine cost and try to reduce it by proper maintenance and operation.
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7- Anton H. Hehn, fluid power troubleshooting, second edition 1995, 647, Marcel Dekker, INC.