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# Evaluation of Overall Resource Effectiveness for Job Shop Production System

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**ABSTRACT**

ORE addresses various kinds of losses associated with manufacturing system which can be targeted for initiating improvements. Evaluating ORE will is helpful to the decision maker(s) for further analysis and continually improves the performance of the resources. Overall Resource Effectiveness (ORE) encompasses seven factors are; performance, quality rate, readiness, changeover efficiency, availability of material and availability of manpower. In this research Job shop production of General Company for hydraulic industries, with focus on Damper and Tasks Factory (DTF)is tested as a case study for two of the most customer demand rear dampers (Samaned and Nissan). Data are collected and analyzed for years 2016-2017 to evaluate of ORE values. Results show that process performance factor among other seven factors have the less value causing the highest loss in ORE decrease. Where the highest ORE value is (58.6%) for Nissan and (69.3) for Samaned rare production. Also, time loss due to set up time is detected where it ranges from 3% to about 13% per month for the above mentioned two tested dampers. Results are generated employing Minitab Version 17, Quality Companion Version 3 soft wares. It is recommended to introduce SMED (Single Minute Exchange of Dies) concept that could decrease losses in set up time .Also improvements in maintenance programs are vital, and above all improving process performance values is essential by employing lean manufacturing that result in fast outcomes ,and TQM process improvement strategy for long term outcomes these two process performance strategies may enhance ORE values therefore, decrease losses, and consequently increase quality and productivity.



## 1. Introduction

Overall resource effectiveness is the level of effectiveness in case of using all resources, equipment, operators, technicians, floor management and support systems. It is the only approach that takes a holistic view of manufacturing and production. It incorporates manufacturing losses, maintenance losses, productivity issues, planning issues and system issues. ORE is helpful to decision makers for further analysis and continually improve the performance of the resources. It is used to identify the current status of manufacturing system and also for benchmarking the manufacturing effectiveness with the World class standard to become a world class organization [1]. Overall Resource Effectiveness Model (ORE) is shown in Fig. 1 while Table 1 classified seven type of losses ans their relative description.

The measurements of ORE lead to focused improvement required to enhance the effectiveness of manufacturing system. ORE provide a useful guide to aspects of the production process where losses can be targeted and remanded. Overall Resource Effectiveness (ORE) encompasses seven factors are; readiness, changeover efficiency, availability of material and availability of manpower. ORE address various kinds of losses associated with manufacturing system which can be targeted for initiating improvements. ORE is calculated according to equation below [2];

$$ORE = (R * A_f * C * A_m * A_{mp} * P * Q * 100) \quad \dots (1)$$

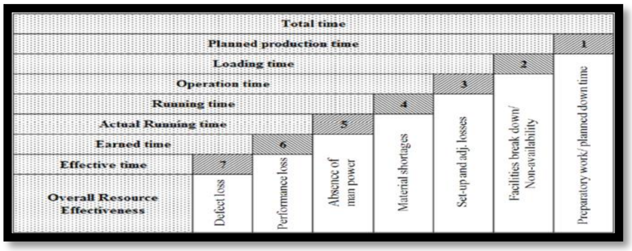


**Figure 1.** Overall Resource Effectiveness (ORE) [1]

In this research ORE of job shop production system is quantified, where Dampers and Tasks Factory (DTF) has been selected as a case study. Two rare dampers which are the most requested in the local market are; Nissan, and Samand cars rare damper` s, so as assess losses in this manufacturing system. The next paragraph offers a theoretical background of detailed ORE aspects, and detailed calculation. That paragraph is followed by literature survey that highlights the searchers interest worldwide in evaluating ORE and identifying losses in resources throughout different types of manufacturing systems. Furthermore, data is collected for the above-mentioned manufacturing system for 2016-2017 yrs. These data are further analyzed, and discussed. In The last paragraph the major conclusions are deduced, and recommended future work is offered.

**Table 1.** Classification of Losses [2]

| ORE factors | classification of losses |
|---|---|
| Readiness | Losses due to preparatory on machine or facilities/Planned down time. |
| Availability of Facility | Losses due to equipment and accessories break down. Break down/ non- availability of machine accessories, tools, jigs and fixtures, gauges and instruments, etc., related to facility. |
| Changeover Efficiency | Losses due to set-up and adjustments. |
| Material availability | Losses due to non-availability of raw material/components / sub-assembly/WIP. |
| Man power availability | Losses due to non-availability/absence of manpower. |
| Performance efficiency | Losses due to operator performance, speed loss and ergonomic related issues. |
| Quality losses | Losses due to quality issues/defects. |

## 2. Theoretical Background

ORE is the measure of overall effective time of the manufacturing system (resources) [4].The losses presented in Table 1 could be calculated as follows:-

### 2.1 Readiness (R)

It is a measure concerned with the total time that system is not ready for operation because of planned down time due to preparatory/planned activities. Readiness indicates the ratio of planned production time to the total time available. R could be calculated as shown below [3]:

$$\text{Readiness (R)} = \frac{\text{Planned production}}{\text{Total time}} \quad \ldots\ldots\ldots\ldots(2)$$

Where;
Total time = Shift time or period decided by the management
Planned production time= (Total time _ Planned downtime) ... (3)

*Planned down time includes:

- Preparatory work like cleaning, inspection of machine, initial part inspection, lubrication, tightening, data collection and updating.
- Meeting, audit, operator training.

### 2.2 Availability of Facility ($A_f$)

It is a measure concerned with the total time that the system is not operating due to down time of facilities. It indicates the ratio of loading time to the planned production time. ($A_f$) could be calculated as shown below [1].

$$\text{Availability of facility } (A_f) = \frac{\text{Loading time}}{\text{Planned production time}} \quad \ldots\ldots(4)$$

Where:

*Loading time = Planned production time-Facilities down time ....... (5)

Facility down time includes:

- Down time of machine and its accessories.
- Non-availability of tools, jigs and fixtures.
- Non-availability of gauges and instruments, test rigs related to facility.

### 2.3 Changeover Efficiency (C)

It is a measure that is concerned with the total time that the system is not operating because of set-up and adjustments. It indicates the ratio of operation time to the loading time, and could be calculated as shown below [1]:

$$\text{Changeover efficiency } (C) = \frac{\text{Operation time}}{\text{Loading time}} \quad \ldots\ldots\ldots(6)$$

Where:

$$\text{Operation time} = \text{Loading time-Set up and adjustments} \quad \text{..... (7)}$$

*Set-up and adjustments include:

- Changeover time of tools, dies, jigs and fixtures.
- Minor adjustments after the changeover.

### 2.4 Availability of Material (Am)

In manufacturing scenario, sometimes, the raw materials, components, sub-assemblies are not available due to shortages and various other reasons. Am is concerned with the total time that the system is not operating because of material shortages. It is the ratio of running time to the operation time. Am could be calculated as shown below [2]:

$$\text{Availability of material } (A_m) = \frac{\text{Running time}}{\text{Operation time}} \quad \ldots\ldots(8)$$

Where:

$$\text{Running time} = \text{Operation Time-Material shortages} \quad \text{..... (9)}$$

*Material shortage includes:

- Non-availability of raw materials, consumables, parts and sub-assemblies, and
- Non-availability of WIP.

### 2.5 Availability of Manpower (Amp)

In manufacturing system, sometimes, the operator/s may not be available at work station due to absenteeism and discussions. Amp is concerned with the total time that the system is not operating because of absence of manpower. Amp could be calculated as shown below [1]:

$$\text{Availability of manpower } (A_{mp}) = \frac{\text{Actual running time}}{\text{Running time}} \quad ..(10)$$

Where:

$$\text{Actual Running time } = (\text{Running time} - \text{Manpower absence time})\ldots(11)$$

*Man, power absence includes:

- Permission, leave and absenteeism.
- Discussion with supervisor, team leader, and
- Medical related.

### 2.6 Performance Efficiency (P)

It measures the total time that the operator how efficiently is utilized. It is the time earned in producing the product as against the actual running time. It could be calculated as shown below [3]:

$$\text{Performance efficiency } (P) = \frac{\text{Earned time}}{\text{Actual running time}} \quad \ldots(12)$$

### 2.7 Quality Rate (Q)

It is the rate of quality products produced by the system. It is the ratio of quantity of parts accepted to the quantity of parts produced. It could be calculated as shown below [2]:

$$\text{Quality rate } (Q) = \frac{\text{Quantity of parts accepted}}{\text{Quantity of parts produced}} \quad \ldots\ldots(13)$$

$$\text{Quantity of parts accepted} = (\text{Quantity produced} - \text{Quantity rejected}) \quad \ldots(14)$$

## 3. Literature Review

Mohanram P.V., et al. (2013). developed Overall Resources Effectiveness (ORE) methodology for performance measurement. Losses targeted are due to the resources using Dash Board. In their research ORE shows stratified lost time of Set-up and adjustments which could be improved by using SMED (Single Minute Exchange of Dies) concept. Therefore, Availability of Materials is addressed (material shortage separately to initiate action on the external and internal suppliers). Operator leave and absenteeism was also addressed including small portion of absence due to discussion with supervisors and team leaders. In addition to the above, actions improvement of Performance Efficiency and Quality can be initiated to enhance the ORE continually [17].

Mast J. D., et al. (2011) adapted standard models from operation management to healthcare services. They proposed concepts for organizational modeling by breaking down work into micro processes, tasks, and resources. In addition, they proposed an axiological model which breaks down general performance goals into process metrics. The connection between both types of models is made explicit as a system of metrics for process flow and resource efficiency. The proposed methodology links on to process improvement methodologies such as business process reengineering, six sigma, lean thinking, theory of constraints, and total quality management. In these approaches, opportunities for process improvement are identified from a diagnosis of the process under study. These models offer an instrument for hypothesizing about alternative configurations, and predicting their performance. Finally, they facilitate laying down the specifications for a redesigned process [18].

Garza J. A. (2015) purposed an alternative measure derived from OEE (Overall Equipment Effectiveness, and (ORE). Their results are derived from both empirical and simulation-based investigations that demonstrate OEE may not be an appropriate measure for some specific processes and that ORE may offer more complete perspective on and information of key performance indicators. They declare that their research presented a novel and alterative approach to measure the performance of manufacturing equipment and processes [19].

Lamyaa M. D. and Zuher H. A (2018 employed two both of OEE, and ORE approaches to study process manufacturing system performance where AL-Kufa /Iraq Cement plant is employed as a case study. They identified certain process (finish grinding process) as having the lowest value of performance, quality rate, availability of material, readiness, and availability factors of the whole production system that cause reduce OEE and ORE performance indicators of 65.02 % and 15.45% [20].

## 4. Data Collection and analysis

In order to evaluate ORE and highlight loss in the manufacturing system the General Company for Hydraulic Industries with focus on dampers and tasks factory (DTF) has been selected as a case study. Generally, two types of dampers are produced in this factory are; front and rear dampers for different car brands such as Hammer, Chevrolet, Samaned, Nissan pick-up, Ford, pride and Byd are produced. Sample of dampers produced are shown in Fig 2.

The main parts produce in this company manufacturing processes are: body, inner cylinder, bushing, pipes and standard exported from various countries like Spain, or China. DTF produces different car dampers where the production processes are rather similar. The current annual production plan is preplanned in advance according to the market needs of products.

**Figure 2.** Different Types of Dampers

The damper which is known as shock absorber, consists of 29 parts 26 parts of them are imported and three parts are manufactured in the factory (as maximus).

Nissan and Samaned Rear Dampers have been selected as the most customer demanded products. Two parts of Samaned rear damper are produced in the company which are:

- Body (manufactured parts for one damper is one piece for each rear damper).
- Inner cylinder (manufactured parts for one damper is one piece for each rear damper).

While three parts of Nissan Pick-up rear damper are produced in the company and these are:

- Body (manufactured parts required for one damper is one piece for each rear damper).
- Inner cylinder (manufactured parts required for one damper is one piece for each rear damper).
- Bushing (manufactured parts required for one damper are four pieces for each rear damper).

Figs., 3 and 4 show 2D detailed dimensions for the above-mentioned rear dampers generated using AutoCAD (2010), all dimensions are in (mm).

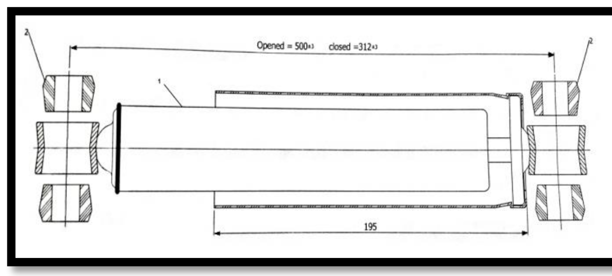


**Figure 3.** Nissan (Pick up Rear) Damper

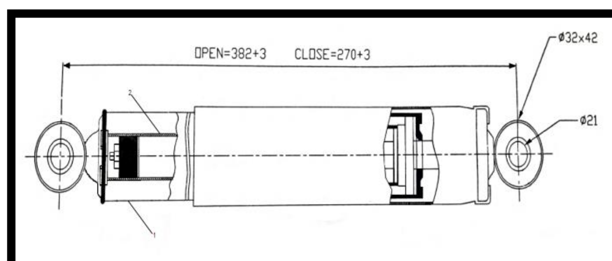


**Figure 4.** Samaned Rear Damper

4.1 Technological Path

- DTF factory encompasses processing (processes 1-7) and assembly (8-19) . Each of the selected dampers is passing through 20 (packaging)different processes to be a final product.
- The sequence of processes that are shown in Table 2 and the process flow diagram for this production line is shown in Fig 5. Where the two parts are hypothetically divided by dotted line in Fig.5.

- Most of the inspections are either visual or using manual inspection tool (Vernia) except the final test which is employed using machine where this machine measures speed, extension force, and compression force for damper within the specified standards.
- All the transportation processes are manual (two operators) in the processing and assembly areas. Where they use containers (van) between these processes.
- Inventories type in DTF factory is raw materials inventory, WIP (all WIP inventories are kept in the containers), and finished products inventories.
- Raw materials inventories are of two types: Semi-processed materials referred as standard parts (standard Parts are parts or subassemblies imported i.e. not manufactured in DTF factory), and raw materials to be remanufactured later on.

**Table 2.** Detailed Production Processes of the Dampers

| | No. | Processes | Description of the Process/ Stage |
|---|---|---|---|
| PROCESSING | 1. | Cutting | Raw material for body and inner cylinder and bushing are brought to cutting machine which single automated. Where the whole factory depends on it knowing that there is another manual machine not used. |
| | 2. | Chamfering | Bushing and the body pass through this process to perform edge break. |
| | 3. | Turning | Where the length and break edge of the inner cylinder at 45 angles is processed. |
| | 4. | Chemical cleaning | Treatment of corrosion for body and bushing. By using 10% HCl at (at a room temperature which approximately from (25-35) $C^{\circ}$ . |
| | 5. | Point welding | The ring and the tip (Standard parts) are welded by point welding machine then welded together with the Shift (Standard part) and Bushings. |
| | 6. | Arc welding | The body and reservoir head (standard part) are welded with ring (standard part) and Bushing in point welding process. |
| | 7. | Cleaning | Inner cylinder, body, and shift are cleaned from the slag and impurities. Further clean is conducted manually by a piece of cloth. |
| ASSEMBLY | 8. | Compression | Seven Standard parts are compressed together in compression machine and then assembled with the shift. |
| | 9. | Extension | Eleven standard parts are assembled together to perform the extension set that will be assembled with the inner cylinder and shift. |
| | 10. | Guiding set | Three standard parts are assemble with the inner cylinder. |
| | 11. | Oil filling | The damper is filled with oil depending on the size, speed, weight, and type of car. |
| | 12. | Bending over | The tip is bended over with the body using rotary turning machine. |
| ASSEMBLY | 13. | Testing machine | The assembled dampers are tested (it a machine that used to measure the speed, extension force, and compression force for damper within the specified standards rate), if the tested part is not throughout this rate the part will be reworked. |
| | 14. | Join operation | Joining the damper with the plastic cover (standard part). |
| | 15. | Washing process | The parts are immersed in tanks to be washed by water. |
| | 16. | Phosphate coating | Phosphate coating protect parts from rust, by spraying or immersion. Phosphating steps are; remove grease and fat, using three Chloride Ethylene or Sodium Chloride, Sodium Hydroxide, Sodium Triphosphate. This process is conducted at 90 $C^{\circ}$ for 10-15 minutes. Benefits are; limit the moisture access to the metal surface and prevent rust, and offer good base for the cohesion of the layers of paint. |
| | 17. | Washing process | In cold water wash basin, the parts are immersed for 15 minutes. |
| | 18. | Painting | The dampers are painted by electrostatic painting. |
| | 19. | Drying | Dampers are dried for three hours (air drying). |
| | 20. | Packaging | Packaging all the dampers, two pieces in each package |

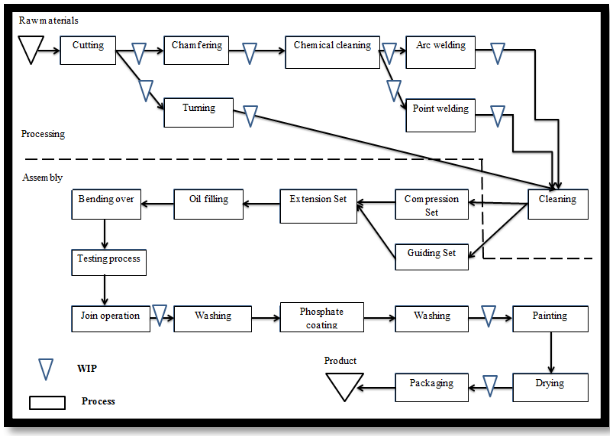


**Figure 5.** Flow Chart for Manufacturing Processes

## 4.2 Process Data.

Actual production data are collected DTF factory during 2016-2017 Yrs., for one shift and the two pre-selected products are; Nissan and Samaned rare dampers as shown in Table 3.

**Table 3.** Detailed Data for Nissan and Samaned Rear Dampers

| | Month | Designed Operating Time(hr.) | Planned Downtime (hr.) | Actual Breakdown Time (hr.) | Actual Production Time(hr.) | Actual Production Quantity (Piece/hr.) |
|---|---|---|---|---|---|---|
| NISSAN | January | 154 | 11 | 14 | 129 | 525 |
| | February | 154 | 11 | 7 | 136 | 550 |
| | March | 154 | 11 | 25 | 118 | 475 |
| | April | 154 | 11 | 0 | 143 | 558 |
| | May | 154 | 11 | 10 | 133 | 530 |
| | Jun | 154 | 11 | 7 | 136 | 550 |
| | July | 154 | 11 | 5 | 138 | 556 |
| | August | 154 | 11 | 0 | 143 | 558 |
| | September | 154 | 11 | 0 | 143 | 198 |
| | Average | 154 | 11 | 7.5 | 135.44 | 500 |
| SAMANED | October | 154 | 11 | 5 | 138 | 556 |
| | November | 154 | 11 | 20 | 123 | 475 |
| | December | 154 | 11 | 42 | 101 | 400 |
| | January | 154 | 11 | 10 | 133 | 530 |
| | February | 154 | 11 | 0 | 143 | 558 |
| | March | 154 | 11 | 0 | 143 | 558 |
| | April | 154 | 11 | 0 | 143 | 23 |
| | Average | 154 | 11 | 11 | 132 | 442.86 |

- The Designed operating time mentioned in Table 3.2 is calculated as follows;
  7 hr. /day x 22 days/month= 154 hr. /month
- Planned downtime is the time that the production line is down because of regular maintenance (planned production, and planned maintenance so as to stabilize the production and enable decision makers to revise whenever gaps are available) activities which are;
  - ❖ Cleaning.
  - ❖ Inspection of machine.
  - ❖ Lubrication and tightening, and
  - ❖ Changing the product.

From Table 3, it can be seen that the:

- Actual breakdown time is fluctuated from Zero up to 42 hrs. on December 2016 and thus planned maintenance programs need to be revised.
- Actual production time is always less than designed production time. The maximum actual production for producing Nissan products during April and August was 558 dampers, and for Samaned during February and March was 558 dampers which has the least breakdown value.

### 4.2.1 Processing Time

Table 4 shows the cycle time for each process that will be used in mapping: the current state of both Nissan and Samaned car dampers. Knowing that, the number of pieces produced of Nissan and Samaned rear dampers are 25 Pcs. / day.

**Table 4.** Actual DTF Designed Data for Both Products

| | Processes | Available time (min/day) | Cycle Time (min/day) | No. of Operators |
|---|---|---|---|---|
| PROCESS | Cutting | 420 | 3 | 2 |
| | Chamfering | 420 | 3 | 2 |
| | Chemical cleaning | 420 | 15 | 2 |
| | Point welding | 420 | 10 | 2 |
| | Arc welding | 420 | 15 | 2 |
| | Turning | 420 | 10 | 2 |
| | Cleaning | 420 | 15 | 2 |
| ASSEMBLY | Compression set | 420 | 1.5 | 2 |
| | Extension set | 420 | 1.5 | 4 |
| | Guiding set | 420 | 1.5 | 2 |
| | Oil filling | 420 | 3 | 2 |
| | Bending over | 420 | 5 | 2 |
| | Testing machine | 420 | 2 | 2 |
| | Join operation | 420 | 5 | 2 |
| | Washing process | 420 | 15 | 1 |
| | Phosphate coating | 420 | 15 | 2 |
| | Washing process | 420 | 5 | 1 |
| | Painting | 420 | 5 | 2 |
| | Drying | 420 | 180 | ----- |
| | Packaging | 420 | 3 | 2 |

## 5. Results and Discussion.

Evaluation of Overall Resource Efficiency (ORE) for DTF Factory is important since ORE address various kinds of resources loss within a manufacturing system. For this production system ORE is calculated according to the above mentioned equations (1-14) respectively.

### 5.1. Readiness (R) for DTF Factory

From Table 3, the total time (planned operating time), and the planned downtime, using equations 2 and 3,
Where

$$Planned\ production\ time = 154 - 11 = 143\ hr.$$

Therefore,

$$R = \frac{143}{154} = 0.92$$

### 5.2 Availability of Facility (Af) for DTF Factory

Availability of facility is calculated using the equations 4 and 5:

$$= 143 - 14 = 129\ hr.$$

Where,

$$Af = \frac{129}{143} = 0.90$$

### 5.3 Changeover Efficiency (C) for DTF Factory

Table 5 below shows the set-up time for Nissan and Samaned rear dampers. Changeover efficiency was calculated using equations 6 and 7 respectively:
Where:- $Operating\ time = 129 - 10 = 119\ hr.$

$$C = \frac{119}{129} = 0.92$$

**Table 5.** Set-Up Time for Nissan and Samaned Rear Dampers

| Month | Set-Up Time hr. for Nissan | Month | Set-Up Time hr. for Samaned |
|---|---|---|---|
| January | 10 | October | 5 |
| February | 5 | November | 15 |
| March | 15 | December | 11 |
| April | 6 | January | 13 |
| May | 15 | February | 10 |
| Jun | 20 | March | 7 |
| July | 12 | April | 9 |
| August | 11 | | |
| September | 5 | | |

- From this table, it could be noticed that loss due to set up time ranges from 3% to about 13% per month. Proper scheduling and production planning according to customers' requirements may decrease changeover time and retain productivity.

### 5.4 Availability of Material (Am) for DTF Factory

Availability of material is independent on product type and process and could be calculated using the equations 8 and 9 respectively:

$$Running\ time = 119 - 3 = 116\ hr.$$

$$Am = \frac{116}{119} = 0.97$$

### 5.5 Availability of manpower (Amp) for DTF Factory

Availability of manpower also is independent on product type and process and could be calculated using equations 10 and 11:

$$Actual\ running\ time = 116 - 10 = 106\ hr.$$

$$Amp = \frac{106}{116} = 0.91$$

### 5.6 Performance efficiency (P) for DTF Factory

The whole performance efficiency could be calculated by using equation 12:

$$P = 0.46$$

### 5.7 Quality Rate (Q) for DTF Factory

Quality rate could be calculated using equations 13 and 14: $Q = 0.91$

Its worth's mentioning that quality should be higher since this factory was accredited according to ISO 9000 quality system on 2008.

Therefore, ORE is calculated for DTF factory accordind to equation 1 as:

$$ORE = (R * Af * C * Am * Amp * P * Q)$$
$$ORE = 0.288 = 28.8\%$$

Tables 6 and 7 show detailed ORE calculations of Nissan and Samaned rear dampers, While Figs 6 and 7 show the so-called Dash board (is an information management tool that visually tracks, analyzes and displays key performance indicators of ORE) of the above-mentioned rare dampers respectively.

**Table 6.** ORE for Nissan Rear Damper

| Month | R % | Af% | C% | Am% | Amp% | P% | Q% | ORE% |
|---|---|---|---|---|---|---|---|---|
| January | 92 | 90 | 92 | 97 | 91 | 46 | 91 | 28.8 |
| February | 92 | 95 | 96 | 92 | 83 | 20 | 92 | 12 |
| March | 92 | 82 | 87 | 85 | 93 | 37 | 89 | 17.5 |
| April | 92 | 99.9 | 95 | 85 | 87 | 94 | 86 | 53.5 |
| May | 92 | 93 | 88 | 99 | 90 | 62 | 96 | 40.9 |
| Jun | 92 | 95 | 85 | 93 | 90 | 97 | 95 | 58.6 |
| July | 92 | 96 | 91 | 94 | 89 | 62 | 92 | 39.6 |
| August | 92 | 99.9 | 92 | 81 | 76 | 98 | 95 | 50.1 |
| September | 92 | 99.9 | 96 | 97 | 77 | 90 | 90 | 54.7 |
| Average | 92 | 94.52 | 91.33 | 91.44 | 86.22 | 67.3 | 91.7 | 39.52 |

**Table 7.** ORE for Samaned Rear Damper

| Month | R % | Af% | C% | Am% | Amp% | P% | Q% | ORE% |
|---|---|---|---|---|---|---|---|---|
| October | 92 | 96.5 | 96.3 | 81.9 | 88.9 | 98 | 98 | 60.4 |
| November | 92 | 86 | 87.8 | 90.7 | 88.7 | 70 | 95 | 37.5 |
| December | 92 | 70.6 | 89.1 | 94.4 | 82.3 | 94 | 92 | 39.3 |
| January | 92 | 93 | 90.2 | 95 | 78 | 62 | 89 | 31.8 |
| February | 92 | 99.9 | 93 | 84.9 | 89.3 | 94 | 90 | 55.4 |
| March | 92 | 99.9 | 95.1 | 93.3 | 88.9 | 63 | 95 | 43.9 |
| April | 92 | 99.9 | 93.7 | 88.8 | 91.5 | 98 | 99.9 | 69.3 |
| Average | 92 | 92.25 | 92.17 | 89.85 | 86.8 | 82.71 | 94.12 | 48.23 |

From Tables 6 and 7:

- it seems that less factor value causing the highest loss is the process performance that decrease the whole ORE values to (58.6%) for Nissan and to (69.3%) for Samaned rare dampers.

While Figs. 6 and 7 are important for monitoring and better understanding of various losses, therefore decisions would be required and consequent improvements actions of ORE these Figs., shows ORE fluctuation reaching up to about 60% for Nissan car dampers where low ORE values are noticed on February (10%) and almost 20% on march. For Samaned rare dampers ORE values were also fluctuating but rather higher values where highest value was about 70% relative to each aspect of ORE.

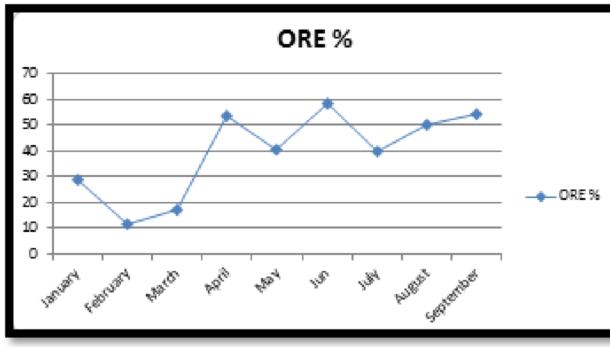


**Figure 6.** ORE Value in Nissan Rear Damper for (January-Septemper) 2016

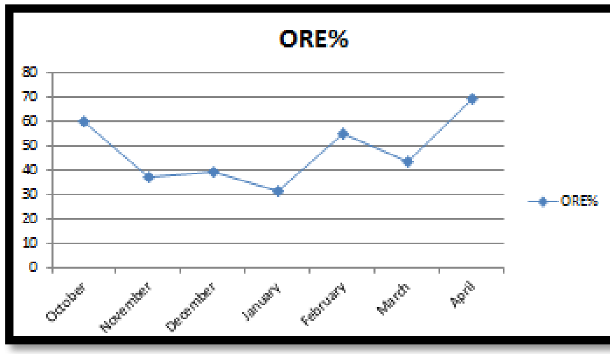


**Figure 7.** ORE Value in Samaned Rear Damper for (October-April) (2016-2017)

It worth mentioning that these results are generated employing Minitab Version 17, Quality Companion Version 3.

## 6. Conclusions and Recommendations

ORE provides a useful guide to all resource's aspects of the production process where losses can be targeted which are created by the resources. Major conclusions deduced from the above results are;

i. Process performance value is less factor values among other ORE values causing the highest loss in ORE that decrease whole ORE values (58.6%) for Nissan and (69.3%) for Samaned. Therefore, improvements toward process performance should be targeted.

ii. Time loss due to set up time ranges from 3% to about 13% per month for both tested dampers. Set-up and adjustments lost time which may be improved by using SMED

(Single Minute Exchange of Dies) concept. In addition to the above, action can be initiated

iii. Breakdown time is higher than the designed value hence planned maintenance programs need to be revised. Also enhancement of maintenance programmes is required to decrease breakdown and losses of production time this requires representatives from operation, maintenance, engineering, and facilities as team and empower maintenance team to act. Introducing another maintenance program such as TPM may be considered.

It is also recommended to introduce process improvement strategies and their relative tools such as lean manufacturing for fast outcomes, and or TQM for long range outcomes that may raise quality rate and the whole process performance and consequently raise ORE values toward better resources utilization.

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