ffect of the external turnings process on surface roughness of steel37

Khaled Salh. ALwaer Higher Institute of Technical sciences AL-Garabulli
Kire Abduslam Zawila Higher Institute of sciences& Medical Technologies Emsalata
Moftah Omer Alfitore Higher Institute of Technical sciences Zleten

Abstract

Surface roughness plays an important rol in product quality and one of the most specified customer requirements , the smoothness and quality of good soft surfaces be friction between moving parts and not the least important screen breakdown of the metal and this leads to longevity of parts, machinery, this results in a decrease in costs and therefore higher degree it's enclosed surfaces roughness is of great importance in the world of industry, and in this paper. There are many parameters such as cutting speed , feed rate and depth of cut that are known to have a large impact on surface quality .We study this important (surface roughness) turning machine is used where programmed (CNC) of iron alloy st37 via three operating factors cutting speed , feed rate and depth of cut, variable values with other factors is constant in all experiments as the cooling process and insert type . By using MINITAB16 and Taguchi method to find number of experiments and use some mathematical equations and Statistical Analysis. shows that feed rate and depth of cut was a major effect the less value improved degree of surface roughness and cutting speed has less effect but whenever increase value improved degree Surface roughness, and we find optimal process conditions as cutting speed 300rpm ,feed rate 0.1mm/rev , depth of cut 0.25mm.

14. Sharma, R., & Singh, J. 2015, 'Impact of Implementing Japanese 5S Practices on Total Productive Maintenance', International Journal of Current Engineering and Technology, vol. 5, no. 2, pp. 818-825.
15. Thun, J-H 2006, 'Maintaining Preventive Maintenance and Maintenance Prevention: Analyzing the Dynamic Implications of Total Productive Maintenance', System Dynamics Review, vol. 22, no. 2, pp. 136-179.
16. Teeravaraprug, J, Kitiwanwong, K & SaeTong, N 2011, 'Relationship Model and Supporting Activities of JIT, TQM and TPM', Songklanakarin Journal of Science and Technology, vol. 33, no. 1, pp. 101-106.
17. Wickramasinghe, G. L. D., & Perera, A., (2016). 'Effect of Total Productive Maintenance Practices on Manufacturing Performance: Investigation of Textile and Apparel Manufacturing Firms', Journal of Manufacturing Technology Management, vol. 27, no. 5, pp.713-729.
18. Wireman, T., 1991, 'Total Productive Maintenance- an American approach', New York, Industrial Press.

2. Babbie, E., 2010, 'The practice of social research', London: Wadsworth Cengage Learning.
3. Chlebus, E., Helman, J., Olejarczyk, M., and Rosienkiewicz, M., 2015, 'A new approach to implementing TPM in a mine - A case study', Archives of Civil and Mechanical Engineering, vol.15, no.4, pp 873-884.
4. Chong, MY, Chin, JF & Hamzah, HS 2012, 'Transfer of total productive maintenance practice to supply chain', Total Quality Management, vol. 23, no. 4, pp. 467-488.
5. Jeon, J, Kim, C & Lee, H 2011, 'Measuring efficiency of total productive maintenance (TPM): a three-stage data envelopment analysis (DEA) approach', Total Quality Management, vol. 22, no. 8.
6. Krishnamoorthy, R., 2014, 'The Impact of Total Productive Maintenance Practices on Manufacturing Performance through SECS/ GEM Standard for Electronic Contract Manufacturing Companies', A Thesis, Doctor of Philosophy, University of Malaya.
7. Lazim, H & Ramayah, T 2010, 'Maintenance strategy in Malaysian manufacturing companies: a total productive maintenance (TPM) approach', Business Strategy Series, vol. 11, no. 1, pp. 387-396.
8. Monica, R., 2014, 'A Blueprint Paradox; Successful but Unintended Cross-National Translation of Total Productive Maintenance', Journal of Quality in Maintenance Engineering, vol.20, no.4, pp. 402-414.
9. Moses, T., 2017, 'Executive TPM Introduction and Overview'. TPM Exec Briefing, the JIPM. Retrieved from << https://www.tpmquality.com >> Article On: April 22, 2017.
10. Mwanza, B. G. & Mbohwa, C., 2015, Design of a Total Productive Maintenance Model for Effective Implementation: Case Company, International Journal of Industrial Engineering and Service Science, IESS 2015, Retrieved from http://www.sciencedirect.com
11. Nakajima, S. 1989, 'Introduction to Total Productive Maintenance (TPM)’, Productivity Press, Cambridge (translated into English from the original text published by the Japan Institute for Plant Maintenance, Tokyo, Japan, 1984).
12. Poduval, P, Pramod, V & Jagathy, R 2013, 'Barriers in TPM Implementation in Industries', International Journal of Scientific & Technology Research, vol. 2, no. 5, pp. 28-33.
13. Prabowo, H. A., Suprapto, Y. B. & Farida, F., 2018, ‘The Evaluation of Eight Pillars Total Productive Maintenance (TPM) Implementation and their Impact on Overall Equipment Effectiveness (OEE) and Waste’, Jurnal Ilmiah SINERGI, vol. 22, no. 1.

between 0.489 to 0.745 of the change in these variables. Finally, the value of the regression coefficient (β) is between 0.477 and 0.953, which means that a one-unit change in the values of the independent variables can lead to the change in the dependent variable (performance rates in this case study).

Conclusions

This study presented the total productive maintenance and its impact on the organizational performance within the Libyan oil and gas organizations. This study adopted the descriptive servey as a type of the quantitaive research, which incorporates careful description of a phenomenon in question beginning with a theoritical or applied research problem and ends with emperical measurements and data analysis. The proposed questionnaire were carried out within four companies, in order to determine the effeciacy of this instrument utilization within the Libyan oil and gas industries. The findings demonstrated that a TPM implementation has a significant impact on the organizational performance within the Libyan oil and gas organizations.

From the evidence of this study, the authors recommend that operators are required to continuously improve the performance of the equipment and accept the time required for cleaning operations and prevent the sources of pollution. Also, the top management could develop a plan to implement simple improvements for the purpose of increasing the overall effectiveness of work machinery and equipment, as well as make improvements to the technical and administrative functions within the maintenance departments.

References

1. Ahuja, I & Khamba, J 2008, 'An evaluation of TPM initiatives in Indian industry for enhanced manufacturing performance', International Journal of Quality & Reliability Management, vol. 25, no. 2.

Table (4) The linear regression analysis for testing the effect of the eight variables on the performance rate within the selected companies

Hypothesis	Correlation Coefficient (R)	Determination Coefficient (R^2)	Correlation Coefficient (β)	The Computed Value (F)	Indication Level
1	0.779	0.606	0.662	35.447	0.000
2	0.735	0.540	0.792	26.958	0.000
3	0.777	0.603	0.672	34.978	0.000
4	0.851	0.725	0.953	58.008	0.000
5	0.792	0.627	0.498	38.687	0.000
6	0.700	0.489	0.608	22.048	0.000
7	0.856	0.732	0.627	57.495	0.000
8	0.863	0.745	0.477	61.257	0.000

Table 4 depicts the autonomous maintenance study (as independent variables) on the performance rates of the companies' case study (as a dependent variable). Generally, the indication level is between 0.01 and 0.05; and the degree of freedom is between 1 and 24. As it is clear in table 4, the indication level is very significant (0.000), which is less than the lower level boundary (0.01) too much. In addition, the signal of correlation coefficient (R) is positive and its rate is between 0.700 and 0.863. This means that the correlation has a direct proportionality between the dependent and independent variables. Therefore, we can reject the null hypothesis (H_0: $\beta_1 = 0$) and accept the alternative hypothesis (H_0: $\beta_1 \neq 0$) because of the significant impact of these factors on the performance rates in the companies' case study. Moreover, the value of the determination coefficient (R^2) illustrates that the change in the independent variables explains a rate of the items for each factor and their prevealing opinion, in order to define their impact on the organizational performance within the companies' case study.

Table 3 illustrates the statistical measures of 8 factors of TPM adopted within the selected companies.

Table (3) The statistical measures of the 8 factors of TPM within the selected companies

Pillar	Weighted Mean	Prevealing Opinion
Autonomous Maintenance	3.3533	Low
Focussed Improvement	3.1021	Low
Planned Maintenance	3.4474	Low
Quality Maintenance	3.5069	Acceptable
Training and Development	2.6636	Low
Office TPM	2.7295	Low
Safety, Health & Management	3.8609	Acceptable
Development Management	3.0522	Low

The next part of this analysis is to test the research hypothesis, which measure the impact of the independent variables; which are Autonomous Maintenance, Focused Improvement, Planned Maintenance, Quality Maintenance, Education & Training, Office TPM, Safety, Health and Management, and Development Management on the dependent variable, which is the performance rates within the organization case study. This can be achieved using the simple regression method, in order to determine the significance of the effect, as well as determining the interpretation percentage of the variance in the dependent variable arising from the independent variable. It can be very clear as shown in Table 4.

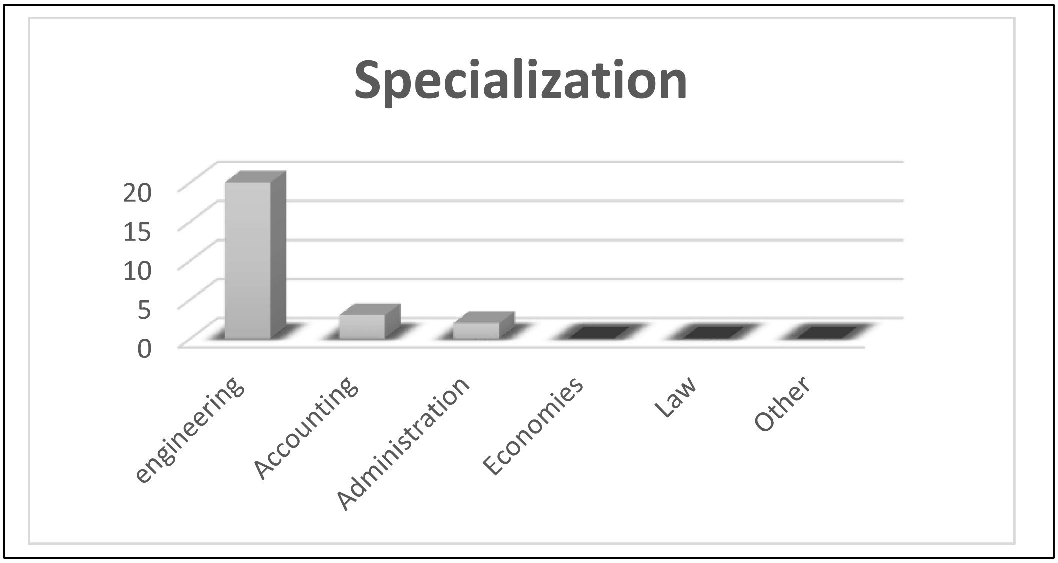

Figure (5) The distribution of the sample according to specialization.

Regarding the following question: *Does the company plan, in the short term, have any of the modern maintenance systems?*
The participants' answer of this question was (11) with Yes, and (14) with No.
With reference to those who answered (Yes); they mentioned some systems, including:

1. Preventive maintenance system.
2. Software applications.
3. Maximo data system.

4.2. Pillars of TPM

This section investigated the implementation of eight TPM pillars; they included autonomous maintenance, focused improvement, planned maintenance, quality maintenance, education & training, office TPM, safety, health and management, and development management.
To sum up, all of the eigth factors are analyzed using the Statistical Package for Social Sciences (SPSS) program to determine the mean

Figure (4) The distribution of the sample according to years of scientific experience

4.1.5. Specialization

The findings of the scientific specialization of the sample members are shown in Figure 5. It is obvious that the majority of the sample members are engineers, covering a percentage of 80%. Then, the accounting field represents a 12% of the total sample. Finally, the management area covers a rate of 8%. Based on this, the research sample has a strong relationship with the research topic, giving this research different points of view, according to their scientific specialization.

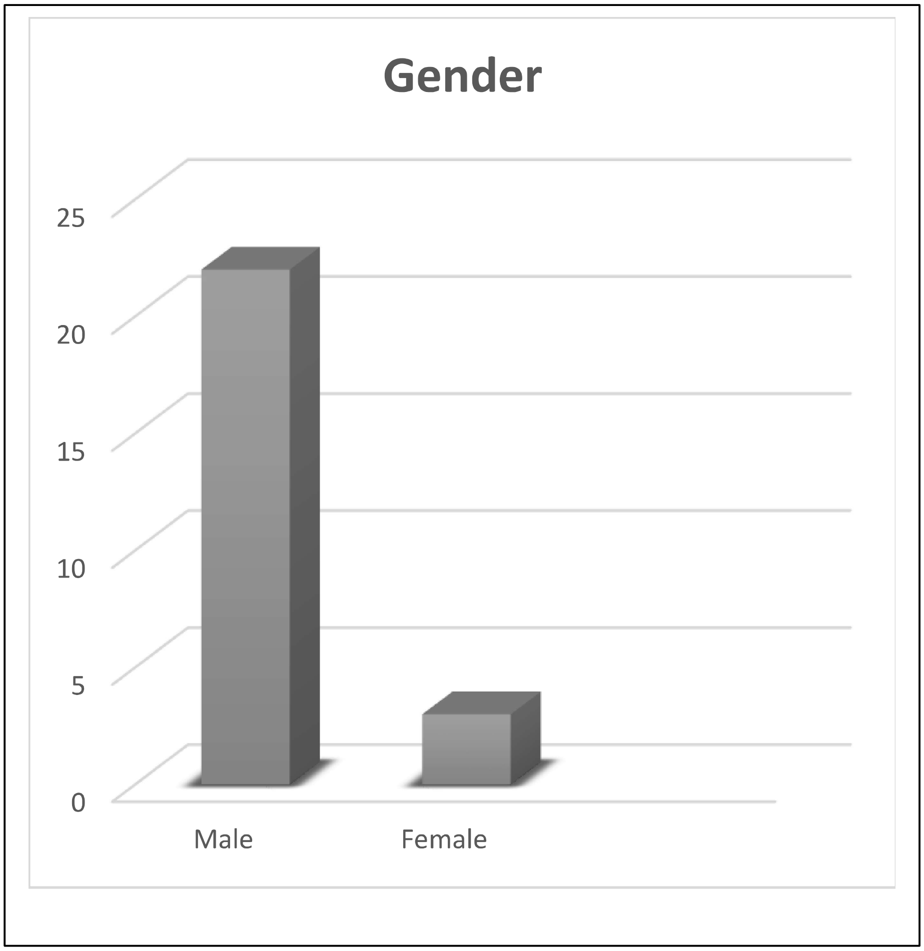

Figure (3) The distribution of the sample according to Gender.

4.1.4. Work Experience

Figure 4 demonstrates the results of the number of years of work experience possessed by the sample members. From Table 4, we find that the participants who have a work experience from 26 years or more represent a percentage of 28%; followed by those who have an experience from 16 years to 20 years with a rate of 24%; then, followed by those with an experience of 6 years to 10 years, 11 years to 15 years, and 21 to 25 years with the same rate of 16%. Therefore, the research sample has a good experience associated with the research topic.

4.1.2. Career Position

Figure 2 show the results of the job position of the research sample. It is clear that the highest percentage of job positions holders as a coordinator, specialist, management specialist, electrical maintenance, drilling management, employee, and management observer are with a percentage of 40%. Then, department heads represent a percentage of 24%. Then, the supervisors are with a percentage of 16%. Next, the directors of the administration are with a 12%. Finally, the position of the General Manager represents a rate 4%.

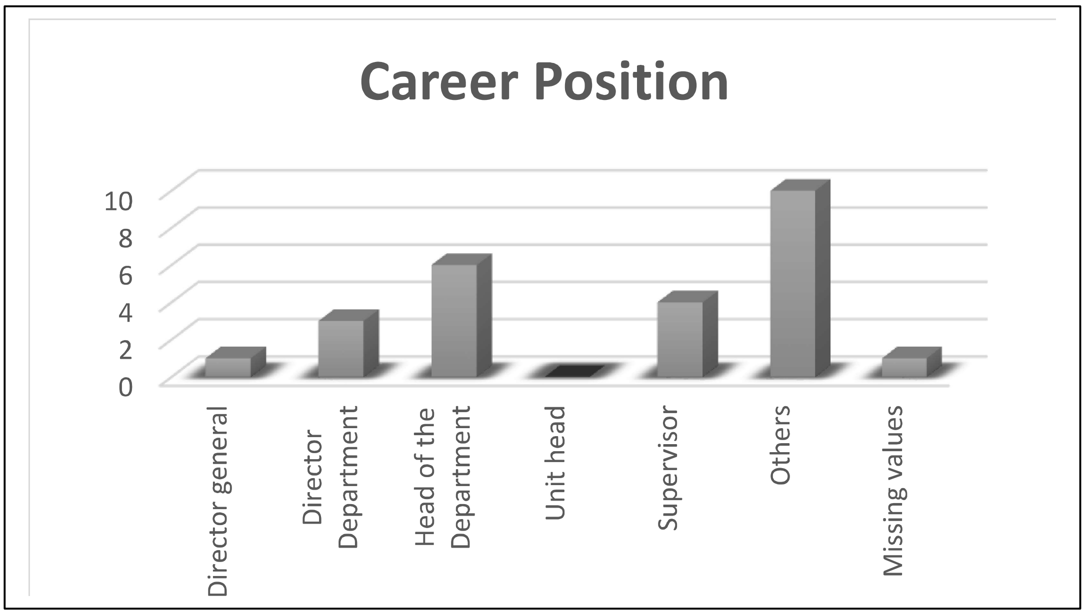

Figure (2) The distribution of the sample according to the career position.

4.1.3. Gender

Figure 3 demonstrates that the results of the research sample according to the participants' gender. From Table 3, it is clear that most of the study sample are males, which represents a percentage of 88%; and only 12% of them are females.

This section was used to gather demographic information from participants, including their qualification, position, gender, work experience and specialization.

4.1.1. Qualification

Figure 1 illustrates the results related to the scientific qualification of the research sample. It is noted that the highest percentage of a Bachelor's degree holders, with a percentage of 48%; followed by those they hold a Master’s and Doctorate degree with a 32%; then, followed by whom they hold a higher diploma with a 16%; finally, followed by whom they hold a high school diploma and Intermediate diploma with a 4%. The results indicate that the research sample is mostly from the Higher education levels holders.

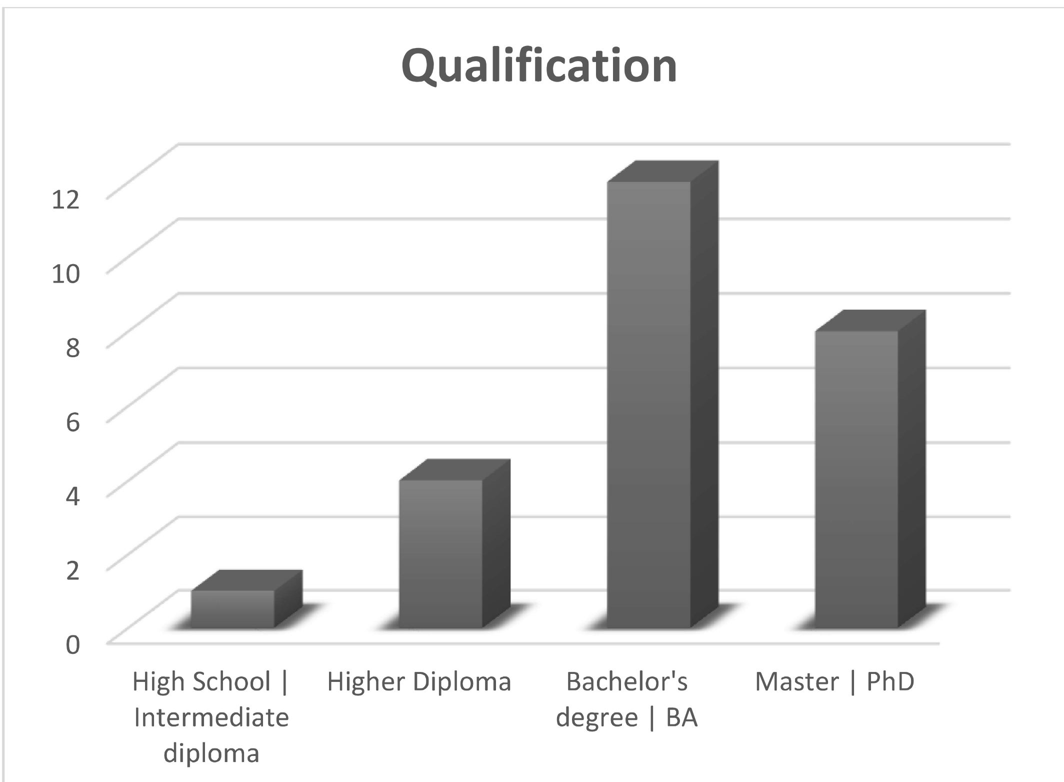

Figure (1) The distribution of the sample according to academic qualification

Table (2) The results of Alpha Cronbach for the validity and reliability of the statements of the factors of the questionnaire

No.	Factor	Number of items	Stability Index	Honesty Index
1	Autonomous Maintenance	9	0.946	0.973
2	Focused Improvement	8	0.840	0.917
3	Planned Maintenance	7	0.835	0.914
4	Quality Maintenance	6	0.797	0.893
5	Education & Training	8	0.932	0.965
6	Office TPM	7	0.895	0.946
7	Safety, Health and Management	6	0.966	0.983
8	Development Management	5	0.967	0.983
Total Alpha Cronbach		56	0.979	0.989

4. Results Discussion and Analysis

The information collected by the questionnaire included: 1) the demographic information (Section 1 of the questionnaire), and 2) the implementation of TPM pillars (Section 2 of the questionnaire).

4.1. Demographic Information

Table (1) Correlation coefficients between the sub-degree for each factor with the total score for all factors

Factor	Factor	Correlation Coefficient	Indication level
1st	Autonomous Maintenance	0.767**	0.000
2nd	Focused Improvement	0.732**	0.000
3rd	Planned Maintenance	0.781**	0.000
4th	Quality Maintenance	0.843**	0.000
5th	Education & Training	0.794**	0.000
6th	Office TPM	0.773**	0.000
7th	Safety, Health and	0.879**	0.000
8th	Development Management	0.871**	0.000

**** Correlation is significant at the 0.01 level (2-tailed).**

The current study has a total of eigth scales that were presented in the survey questionnaire to measure the factors presented in the TPM performance as shown in Table 2, namely Autonomous Maintenance; Focused Improvement; Planned Maintenance; Quality Maintenance; Education & Training; Office TPM; Safety, Health and Management; and Development Management. In order to ascertain that the scales in the present study has been consistently and accurately constructed, a scale reliability was assessed using Cronbach's alpha. Scale reliability was assessed using SPSS for each of the constructs in the study that presented in Table 2. The results reveal that the Cronbach's alpha value for each variable was over the required 70%. This illustrates that the instrument used in this study are reliable.

Reliability estimates the consistency of the measurement or more simply, a degree to which an instrument measures the same way each time it is used under the same conditions with the same subjects. It is a matter of whether a particular instrument applied repeatedly to the same object yield the same result each time. In other words, a reliable questionnaire item is an item that will constantly convey the same meaning. That is, if an item is measured many times and the result is always the same, it can be said that the measuring instrument is reliable.

Reliability is essentially about dependability and consistency. The most practical and extensive approach to reliability is the approach that defines reliability in terms of the relative absence of measuring errors in a measuring instrument. Reliability is therefore the relation of error variation to the total variation as obtained by the measuring instrument deducted from 1.00. The index 1.00 indicates perfect reliability. In other words, when the outcome of the measuring process is reproducible, the measuring instrument is reliable.

The concept of the internal consistency of the questionnaire questions is the relevance of each dimension and factor of the questionnaire to the overall degree of all factors. Table 1 illustrates the coefficient of correlation between the sub-degree for each factor with the total score for all factors.

Due to the results review of the internal consistency of all factors shown in Table 1, it is clear that the cases of correlation of the factors with the total degree of all factors are high. Also, the correlation coefficients are a function at a significant level (0.01). in addition, the probability value for all of its paragraphs is less than (0.01). This means that the sub-factors have common elements that make them homogeneous with each other, which indicates the strength of the structural validity of the questionnaire.

By adding the length of the period to the lowest value in the scale, which is one; the upper limit for the first period will be determined and so on for the rest of the periods.
where the item is acceptable when it is equal to 3.49 or greater according to the measures shown in Table 1.
Before piloting the questionnaire, it was sent to three colleagues for evaluation. They made some recommendations for improvement to ensure relevance, objectivity and effectiveness and that was done. In addition, it is not usually essential that the pilot subjects comprise of a representative sample; one could use people to whom the questionnaire is at least relevant (Babbie 2010). The results of the pilot study were analysed and the necessary changes achieved before the questionnaire were distributed to the main subjects of the study.
The population study covers 4 oil manufacturing companies: Arabian Oil Gulf Company, Mellitah Oil & Gas Company, Akakus oil Operation, and Zueitina Oil Company. The population for this study consisted of individuals who work in the area of production and maintenance. To get an accurate information, the population sample was focused on the managers of these departments.
Once the researchers had collected all the completed questionnaires, they were prepared for processing by a PC Intel® Core™ i5-3210M processor working at speed 2.5 GHz and RAM of 4GB. The data was captured in a Statistical Package for Social Sciences (SPSS) program. All data was coded from the completed questionnaire on standard capturing forms thereafter it was captured. The information required was also discussed with the consultant from the company to clear uncertainties in order to ensure correct interpretation of exactly what the researcher wanted. Once the questionnaire had been processed, a data set was obtained. The results of the answers to all the questions were integrated with one another and analyzed. The SPSS statistical packet includes the frequency analysis, correlation matrices and multiple regression analysis.

The questionnaire included two sections:

Section 1: the first section addressed the demographic information of companies. It related to the academic qualifications, career position, gender, work experience, and specialization.

Section 2: the second section evaluated the extent of TPM pillars (the independent variables) within the Libyan oil and gas companies. It is a questionnaire form that included (60) items; in addition to two open-ended questions, where (25) questionnaires were distributed. It comprises eight factors: the first factor (Autonomous maintenance), which includes (9) items; the second factor (focused improvement) and includes (8) items; the third factor (planned maintenance) includes (7) items; the fourth factor (quality maintenance) includes (7) items; the fifth factor (education & training) includes (8) items; the sixth factor (office TPM) includes (8) items; the seventh factor (safety, health and management) includes (7) items; and the eighth factor (development management) includes (6) items. The validity of the scale has been verified and there is an appropriate amount of internal consistency between the items of the form, and we will go over all of these steps in detail:

In order to come up with accurate scientific results for this research, weights were given from (0-5) using the Likert 6-Point Scale to answer the expressions (none, very low, low, acceptable, high, very high) these estimates are translated Descriptive numbers are based on numerical estimates based on assigning numbers (0, 1, 2, 3, 4, 5) respectively.

Before presenting the results of the analysis of the research sample answers, the range of the answers was calculated, and reaching the length of the category for each degree of weighting, as follows:

$$\text{Range} = \text{Maximum Value} - \text{Minimum Value} = 5 - 0 = 5$$

$$\boldsymbol{Length} = \frac{\textbf{Range}}{\textbf{Categories}} = \frac{\mathbf{5}}{\mathbf{6}} = \mathbf{0.83}$$

effectiveness, product quality, on-time delivery, and volume flexibility.

3. Research Methodology

This study followed a descriptive survey research method to measure the personnel beliefs and opinions regarding the application of TPM pillars. According to Neuman (2006), social measures provide data about social reality. In addition, measurements allow researchers to observe things that were once unknown but were predicted by theory. Data are empirical representation of concepts, and measurements links data to concepts. Surveys are mainly used in studies that have individual people as unit of analysis.

A descriptive survey method is regarded as a type of quantitative research which incorporates careful description of a phenomenon in question beginning with a theoretical or applied research problem and ends with empirical measurements and data analysis. Its main purpose is to collect original data for describing or measuring the attitudes and orientation in a large population. This method is relevant for this study in order to establish the extent of awareness and current application of TPM pillars within the Libyan oil and gas organizations to enhance organisational performance. The method is used because it allows a researcher to ask many questions at one time, measure many variables, and test hypotheses in a single survey. A survey research method can also facilitate the collection of detailed factual and accurate primary data describing the situation within productive and service organizations.

The population study covers 4 oil manufacturing companies: Arabian Oil Gulf Company, Mellitah Oil & Gas Company, Akakus oil Operation, and Zueitina Oil Company. The population for this study consisted of individuals who work in the area of production and maintenance. To get an accurate information, the population sample was focused on the managers of these departments.

Transfer and adaptation will necessarily require a change in the organization's processes such as a change in work and change in the formal structures.

In addition, Krishnamoorthy (2014) proposed a TPM model for integrating with Equipment Communication Standard (ECS) and Generic Equipment Model (GEM) which enables data acquisition and keeps track of data between the operator and the equipment. The proposed model uses Semiconductor Equipment and Materials International (SEMI) Standards which facilitate real-time data collection from the production equipment. The study suggested the three key elements of the TPM model: Asset Productivity (AP), Autonomous Maintenance (AM) and Planned Maintenance (PM)) for implementing TPM systematically and successfully. The main findings showed that TPM pillars, and SECS/GEM standards, together with labour and cost, can decrease losses in the production process and have a positive impact on manufacturing performance, while SECS/GEM standard integration with Autonomous Maintenance does not. The study confirms that focusing on a few TPM pillars will have a substantial impact on equipment performance. Owing to their impact on equipment performance, the autonomous and planned maintenance pillars will be the first two pillars selected for our proposed TPM approach.

Wickramasinghe and Perera (2016) conduct a study to examine the total productive maintenance pillars impact on the manufacturing performance of textile and apparel manufacturing firms. Data was collected by a survey questionnaire. The authors analysed the collected data by Correlation and regression technique. It was performed using SPSS program to identify the TPM impact on manufacturing performance. The findings show that all the TPM pillars have a positive and significant relationship with manufacturing performance and significantly improve cost-investigated by using some foundations of TPM with a basic message to avoid any kind of waste through continuous improvement of the entire company.

An effective TPM model at a chemical manufacturing company was proposed, in order to improve the company performance by reducing the six most common causes of efficiency loss in chemical manufacturing. The main objectives of the study were to evaluate the current maintenance system, to calculate the overall equipment effectiveness, and to identify key performance indicators and success factors of TPM. An evaluation of the existing maintenance system presented in their study shows that production lines were facing several problems such as less availability and reliability of equipment, machine downtime, frequent failures of equipment, and low production output (Mwanza & Mbohwa, 2015).

In another study, Monica (2014) presents a case study to investigate if TPM can be copied from one location to another. The researcher used a broad TPM approach to optimize the elements of productivity of equipment, teamwork, the involvement of employees, and continuous improvement activities. The implementation cannot achieve its targeted results without collaboration between maintenance and production departments. The case study is related to a company that has two production plants, one is in Norway and the other in Canada. Both have similar technology, equipment, products, and consumers. The outcome of the study showed that the implementation of the TPM program in one location or the other, with the same production and organization systems, could be successful. However, the implemented TPM program proposed some modifications which have led to a translation with better results. Different techniques such as interviews, group discussions, written documentation, and observation from both plants in Norway and Canada were used to determine the impact of teamwork, maintenance, participation and technology on the transfer process.

Today's increasingly competitive global marketplace places a constant pressure on organisations to adopt more effective and efficient business strategies that will ultimately lead to an increase in their performance levels. This can be achieved by the continuous improvement and optimisation of their processes and operations, cost reduction of their services and products, and an increased output capacity with satisfactory product quality and production rates. Organisations need to implement new techniques for managing their businesses in order to dramatically increase their revenue and reputations. One of these techniques which can be adopted by industries to achieve their goals is total productive maintenance (TPM).

There are several empirical studies that have been conducted on TPM implementation, and their impacts on companies' performance have been assessed. TPM and maintenance strategy is considered by many researchers to be the most important elements to improve manufacturing efficiency and effectiveness (Sharma & Singh, 2015). Wireman (1991) states that one-third of maintenance expenditure is unnecessary or wasted.

TPM can be described as a management philosophy,which promotes the change of the organizational culture towards quality and productivity at all levels of the company under a contributing scheme from top to bottom (Nakajima, 1989). Moses (2017) states that the core of the TPM pillars is autonomous and planned maintenance that may reduce maintenance costs and increase productivity. Also, Chlebus, et al., (2015) suggest that TPM implementation in a mining industry should be based on three main pillars: improvement of the environment of work, autonomous and planned maintenance, and standards in development. To adopt such a TPM system in this industry, it is necessary to consider two important factors: analyzing the failure rate and selecting a group leader. They illustrated that TPM approach as lean production at the copper mine was firms to cope with the challenges posed by global competition. The role of TPM success factors are also investigated to improve the performance within manufacturing industries. This study focuses on some success factors such as top management leadership and involvement for achieving its objectives. It discloses that these initiatives have a significant impact on manufacturing performance improvement when compared with traditional maintenance practices. TPM efficiency can be measured by a self-directed work team (SDWT) using data envelopment analysis (DEA) considering the overall process of TPM implementation. This process has been done in a three-stage model. The results can offer productive implications for managing and implementing TPM more efficiently (Jeon, Kim & Lee 2011).

There are very few studies that have focused on assessing the stages of short-term TPM implementation according to JIPM guidelines and evaluating the impact of implementation on equipment performance (Prabowo, 2018). Therefore, the problem of this study can be concluded as a lack of modern systems implementation within organizations may reduce the control of maintenance plans, which has a negative impact on their productivity. In addition, TPM approach have not been received substantial attention within organizations. Based on this, the main objectives of this research is to investigate to what extent TPM has been implemented within production & service organizations, and to assess and verify the effectiveness of TPM pillars within production & service organizations.

The rest of this paper is organised as follows: Section 2 reviews some of the literature on TPM approach. The study methodology is described in section 3. Section 4 discusses and analyzes the findings from implementing the TPM in the selected case study. Finally, section 5 summarizes and concludes this paper.

2. An Overview of TPM

In 1971, TPM started in Japan through Nippon Denso Company which is a part of the Toyota group. It can be considered as an evolution of preventive maintenance, which was essentially conceived in the United States in the 1950s. The TPM concept is an attempt to deploy certain approaches, which can assist organisations to achieve cost-effective benefits such as eliminating waste, consistently obtaining the best performance from the equipment and decreasing stoppage (Lazim & Ramayah 2010). It is a stratagem for improving productivity and achieving safety requirements with the end result of producing high quality goods by minimising wastages and thereby reducing costs through three zeroes: zero breakdowns, defects and accidents at work (Poduval, Pramod & Jagathy 2013). By motivating participating employees within organisations, TPM looks at increasing the effectiveness of the equipment during its lifetime by maintaining it in optimal working-condition so as to avoid any unexpected breakdowns and quality defects in products (Teeravaraprug, Kitiwanwong & SaeTong 2011). In addition, it tends to increase employees' efficiency by improving their skills and knowledge and distributing responsibility (Chong, Chin & Hamzah 2012).

Poduval et al. (2013) mention that there are many barriers which may face organisations in the case of implementing TPM such as lack of top management commitment, manpower costs, lack of TPM knowledge, maintenance management process, need for training, attitude towards manufacturing process and keeping large inventories. The impacts of TPM as a lean manufacturing tool on an organisation's effectiveness is defined by working out the correlation between its pillars, in order to analyse the significant structures, and to identify the most proper policy arising from implementing this technique (Thun, Jörn - Henrik 2006). The use of different initiatives of TPM implementation in Indian manufacturing industries by Ahuja and Khamba (2008) resulted in strategic benefits which helped these

the companies' case study. The findings illustrate the efficacy of this tool, and confirm that the designed decision variables have a significant impact on the objective function of the proposed tool.

Keywords: Total Productive Maintenance (TPM), Performance rate, Oil and Gas sector, Questionnaire.

الملخص

يسعى العملاء في الأسواق العالمية التنافسية اليوم إلى تقليل إمداداتهم، بغض النظر عن مكان إنتاجها. ولتحسين قدرتها التنافسية، حيث يمكن استخدام أدوات التصنيع الهزيل مثل الصيانة الإنتاجية الشاملة. الصيانة الإنتاجية الشاملة هي نظام صيانة يعزز الصيانة الإنتاجية. يعتبر الهدف الرئيسي من هذه الورقة هو تحديد ما إذا كان بإمكان الصيانة الإنتاجية الشاملة، استنادًا إلى ركائزها الرئيسية تقليل الخسائر في عملية الإنتاج، وما إذا كان لها تأثير إيجابي على أداء التصنيع. لذلك، فإن هذه الدراسة تعمل على تسهيل تنفيذ الصيانة الإنتاجية الشاملة بنجاح داخل المنظمات الإنتاجية والخدمية، حيث تم تصميم استبانة بناءً على عوامل الصيانة الإنتاجية الشاملة المحددة، وإرسالها إلى الشركات لجمع آراء العاملين حول نظام الصيانة الإنتاجية الشاملة. حيث تم تجميع البيانات من 4 شركات لتصنيع النفط وهي شركة الخليج العربي للنفط، وشركة مليته للنفط والغاز، وشركة أكاكوس للعمليات النفطية، وشركة الزويتينة للنفط. كما تم إجراء الاختبارات باستخدام برنامج الحزمة الإحصائية للعلوم الاجتماعية (SPSS) للتحقق من فعالية الصيانة الإنتاجية الشاملة على الأداء التنظيمي في الشركات محل الدراسة. حيث تُبَين النتائج فعالية هذه الأداة، وتؤكد أن متغيرات القرار المصممة لهذا الغرض لها تأثير كبير على دالة الهدف للأداة المقترحة.

Introduction