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Bibliometric Analysis Of Overall Equipment Effectiveness (OEE)

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Abstract: Overall equipment effectiveness (OEE) is a key performance indicator used to measure equipment productivity(Overall equipment effectiveness 2008). The purpose of this study is to review and analyze the scientific papers written on OEE(Tang Ho Hwa, Yeo Chiew Tiam, and Ding See Kong 2020). 1377 documents were obtained in the general search; after eliminating duplicates and applying certain inclusion and exclusion criteria, 1308 papers were used for this review. This study provides three main conclusions: During the period 2000-2022, academic interest in this topic has increased and the keywords are maintenance and production, related to the six major losses, lean manufacturing and optimization; a list of authors who have conducted scientific work on the basis of OEE is compiled; and the top 10 countries that conducted scientific work based on OEE are presented based on geographical analysis. VOS viewer software was used to investigate the bibliometric research method and bibliographic display maps(Vinodh 2022; Wudhikarn 2012; Yeo, Chang, and Liu 2021). There are three phases to the bibliometric research process, they are search criteria and source identification, software and data extraction, and then data analysis and interpretation. To our knowledge, several bibliometric comparative reviews on OEE and maintenance have been published. This study serves as a continuation of the above related studies.

Keywords: Bibliometrics, Overall Equipment Effectiveness (OEE) Manufacture, Maintenance, Productivity, Total Productive Maintenance, Efficiency, Equipment, Scopus.

1. Introduction.

Overall Equipment Effectiveness (OEE) is a calculation made to determine the level of efficiency of an existing machine or piece of equipment. OEE is one of the techniques available in Total Productive Maintenance (TPM)(Yadav, Gupta, and Kumar 2019, 2020; Yahya 2017). Generally, the performance of a machine or equipment can be evaluated through OEE. The purpose of OEE is to measure the performance of the technical service system, using this method it is possible to see the availability (availability) of machines or equipment, the production efficiency (performance) and the production quality of machine equipment (quality). Overall Equipment Effectiveness (OEE) is a measure introduced by Nakajima (1988). OEE was developed as part of Total Effective Maintenance (TPM) to measure the performance of equipment in a manufacturing system. OEE is the productivity ratio between actual output and ideal output(Sharma et al. 2021; Singh et al. 2021; Teran et al. 2011). This metric is widely used by companies, as a means of monitoring the actual performance of equipment in lean manufacturing or useful in implementing maintenance programs. OEE identifies six major losses that reduce equipment efficiency. Six Big Losses Eliminated Through OEE:

1) Unscheduled shutdowns - periods of time when the equipment is scheduled to operate, but is not working due to an unplanned event.
2) Planned downtime - periods of time when equipment is planned for production, but is not working due to a planned event.
3) Minor Stops - Occurs when the equipment stops for a short time (usually a minute or two) before the stop is resolved by the operator.

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4) Slow Cycles - Occurs when equipment is running slower than the ideal cycle time (the theoretically fastest possible time to produce a part).
5) Production defects - defective parts produced during the stable (stationary) production process.
6) Start-up defects are defective parts produced from start-up until stable production is achieved(Kopf, Sommer, and Lanza 2015; Krachangchan and Thawesaengskulthai 2018; Mugwindiri and Mbohwa 2013; Muñoz-Villamizar et al. 2018).

Method. The Scopus search engine was used to find a comprehensive literature on the oee of the theory. Scopus is one of the most comprehensive databases of citations and abstracts for peer-reviewed literature. Based on Figure 1, there are three steps in the bibliometric research process, which are search criteria and source identification, software and data acquisition, and then data analysis and interpretation. Step 1, source identification with search criteria and bibliometric analysis, consists of scientific database retrieval and publication information collection from the Scopus database. In the search process, we initially identified documents with the terms "oee". As a result of the bibliometric search, 1377 documents were found, and when we synthesized them for the years 2000-2022, 1308 documents were identified. Bibliometric analysis was performed on the basis of 1308 documents(Abramova and Abramov 2018; Abreu, Alves, and Moreira 2019; Buchmeister et al. 2012).

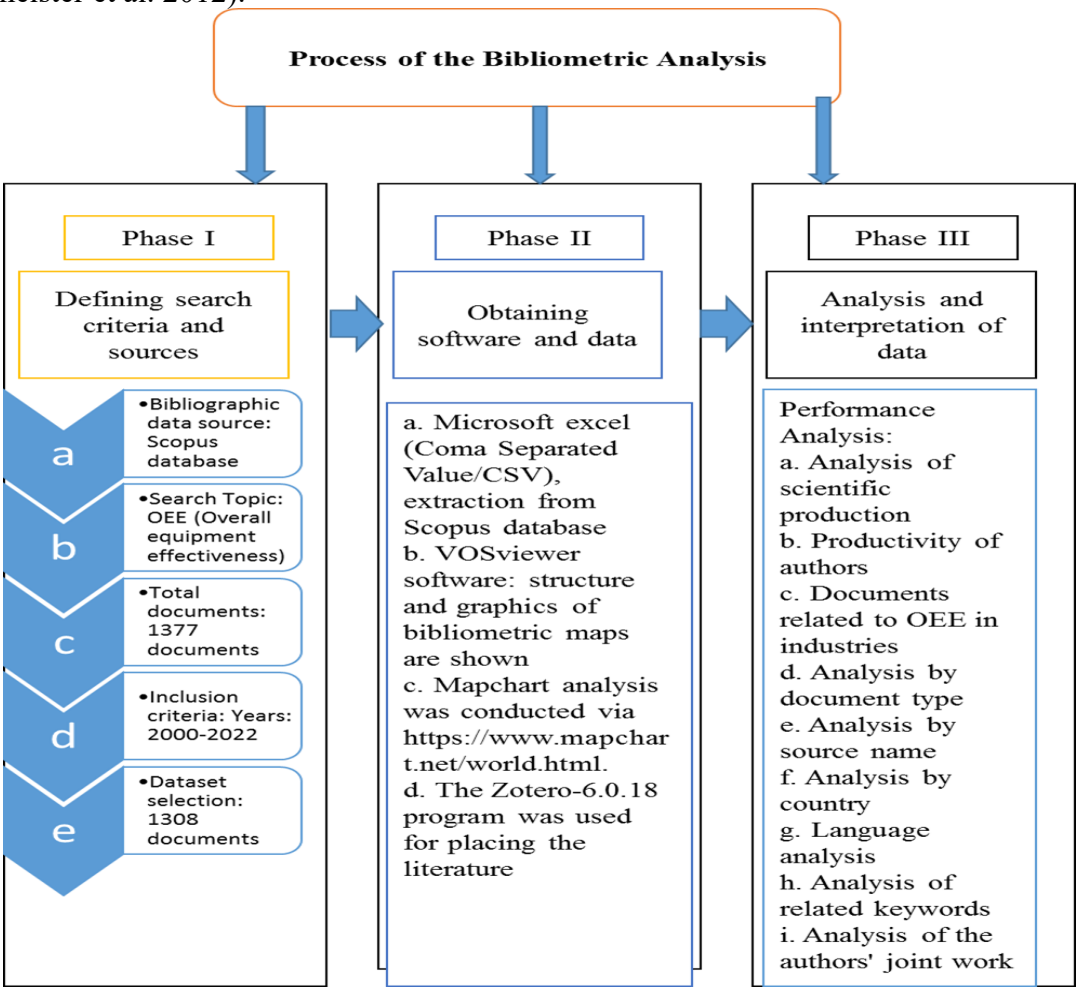


Figure 1. Process of the Bibliometric Analysis

In Phase 2, the results were downloaded from the Scopus database in three different formats. The following data was received in CSV format for data viewing through Microsoft Excel: Authors, affiliations, titles, publication years, cited publications, abstracts, author keywords and other important bibliographic information are included in the downloaded metadata, which must be examined and improved. The use of bibliometric approaches to describe the knowledge structure of oee project is illustrated. The outcome of VOS viewer software analysis, such as Bibliometric coupling; includes co-citation analysis and keyword co-occurrence.

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The site www.mapchart.net was effectively used in the formation of analyzes by countries. Zotero software was used to compile the list of references. The results obtained in the Phase 3rd stage were analyzed.

Result and Discussion

We can see the development dynamics of scientific research on determining overall equipment effectiveness (OEE) between 2000 and 2022 through Fig.2.

Between these years, 1308 scientific researches were conducted, and these indicators are growing year by year. In particular, the maximum increase point of the indicators is 132 in 2020-2021(www.scopus.com).

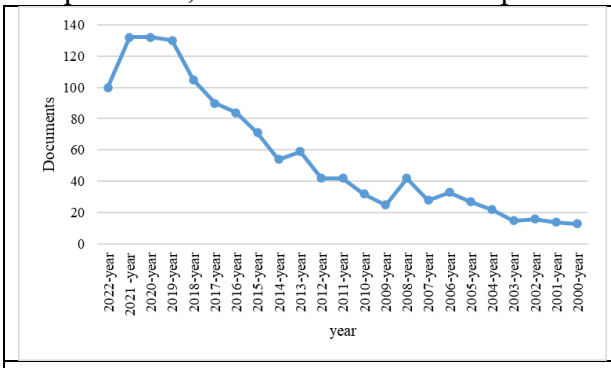


Figure 2. Growth of scientific production relating to OEE.

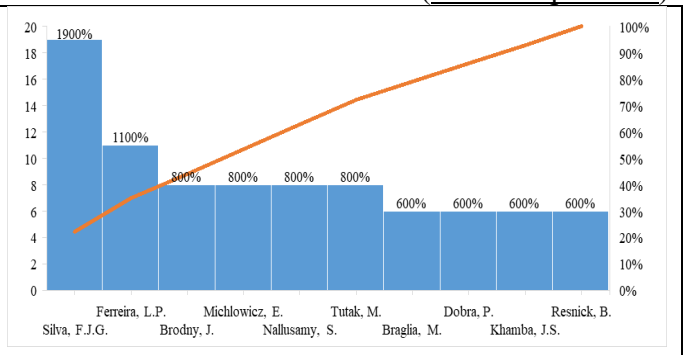


Figure 3. Top-10 authors (www.scopus.com)

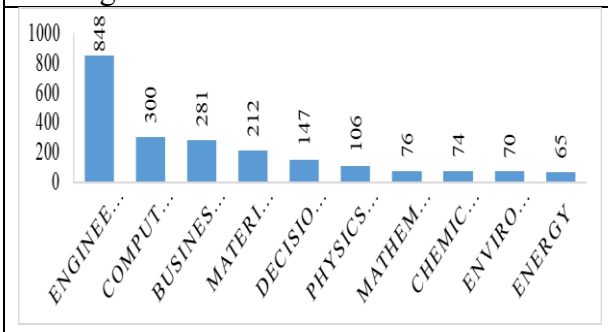


Fig. 4. Analysis of OEE research by subject area.

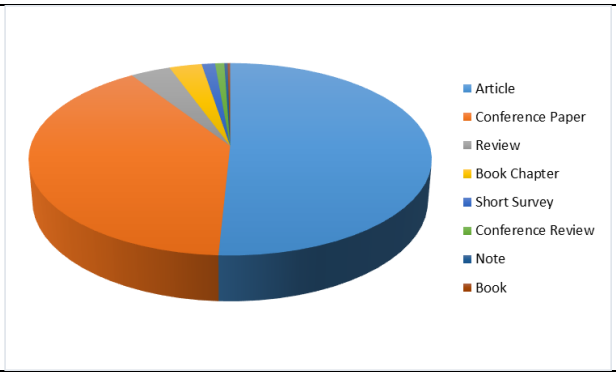


Fig.5. Analysis by document type.

In the Scopus database, 159 authors conducted scientific research on the overall efficiency indicator of the equipment "OEE", and the top 10 authors were determined by Fig. 3.

Fig. 3 is built on the basis of the Poretto diagram, and we can see the obtained results at the same time in percentages.

Fig.3 shows us that "Silva, F.J.G" is considered to be the most effective among the authors who conducted research on OEE, and he is on the first place with 19 indicators.

The last 10th place was taken by "Resnick, B" with 6 results, which is equal to the 30% result of "Silva, F.J.G".

In the Scopus database, scientific works were carried out in 27 directions on the equipment efficiency indicator "OEE", and Fig. 4 shows the top 10 of them.

33% of the total scientific research was carried out in the direction of Engineering, 12% in the direction of Computer Science, 11% in the direction of Business, Management and Accounting, 8% in the direction of Materials Science, 6% in the direction of Decision Sciences, 3% in the direction of energy.

Through Fig.5, we can see how the work done on OEE in the Scopus database is distributed by source. The main place in this is occupied by articles (51%), conference papers (40%), reviews (4%), book chapters (3%).

Results by document type	
Article	663
Conference Paper	521
Review	48
Book Chapter	39

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Short Survey	16
Conference Review	11
Note	4
Book	3
Editorial	1
Erratum	1
Undefined	1
Number of results : 1308	

Fig.6. Results by document type.

We can get information on source type through Fig.7. It can be seen that 667 scientific works published in journals contain 51% of the total amount of information.

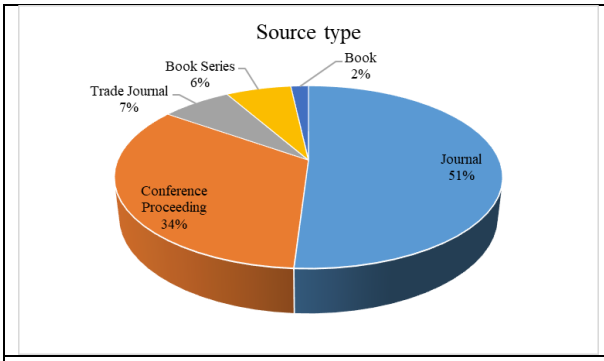


Fig.7. Analysis by source type.

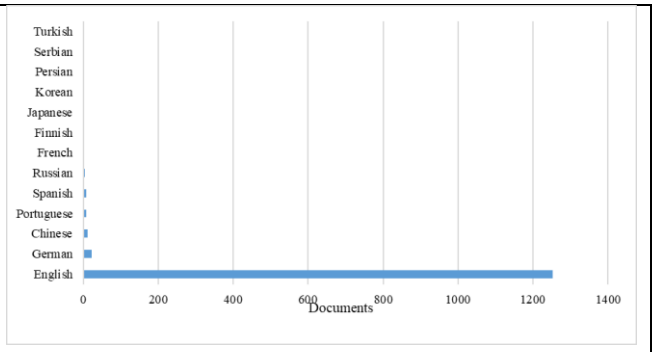


Fig.8. Language analysis

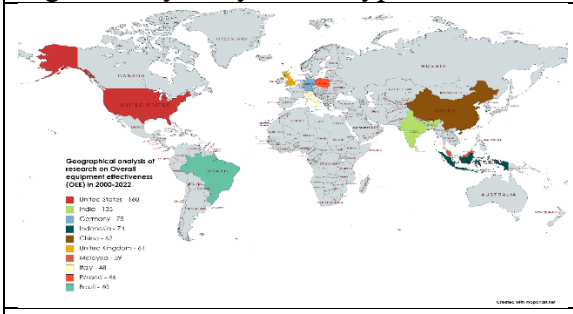


Fig.9. Geographical analysis of research on OEE in 2000-2022. (www.mapchart.net)

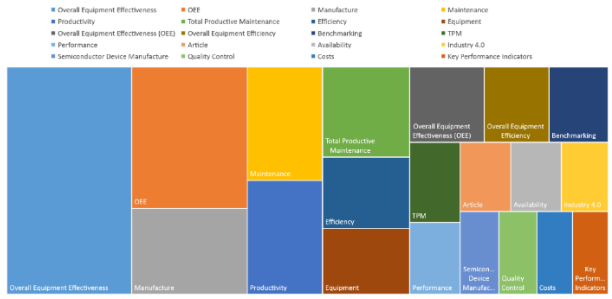


Fig.10. Keyword analysis

The main reason for learning foreign languages around the world is to exchange information and learn new knowledge. 95% of scientific research on OEE was published in English, 2% in German, 1% in Chinese. This shows that the authors in this field mainly write in English.

Fig. 9 was formed based on the information obtained from the Scopus database. The site www.mapchart.net was used to create a world map and place data.

Fig. 9 shows which country is active in OEE research. Nearly 90 countries have conducted research on OEE. When we determined the top 10 in this regard, the United States took first place with 10%, India with 9%, and Germany with 5%.

The Scopus database contains 160 keywords related to the evaluation of the efficiency of the device, and Fig. 10 shows the top 20 of them according to the indicator of their frequent use in scientific works.

The calculation of the OEE indicator is included in the Total Equipment Maintenance (TPM) clause of the IATF 16949:2016 standard, which is one of the main calculation parameters of TPM.

I used the VOSviewer program to visualize statistical data related to keywords. I saved information on keywords from the Scopus database in "Ris" format. The total number of keywords is 7881, and when the keywords with the minimum number of repetitions five times were selected, 444 keywords were selected. Fig.11-a and Fig. 11-b show the results divided into clusters. The 444 used keywords were divided into 8 clusters, the clusters are shown in colors.

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Color	cluster	number of
	1-cluster	95
	2-cluster	74
	3-cluster	73
	4-cluster	58
	5-cluster	49
	6-cluster	42
	7-cluster	37
	8-cluster	16

Fig.11-a. Separation of keywords into clusters

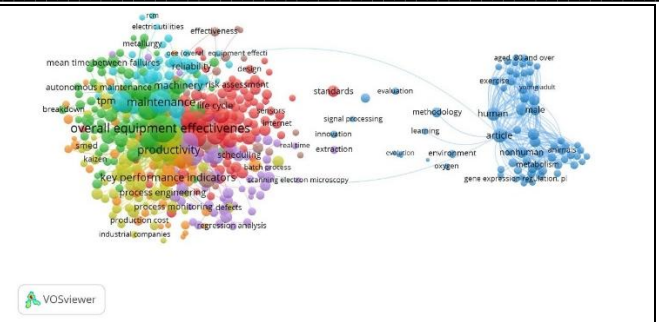


Fig.11-b. Keyword correlation (by clusters)

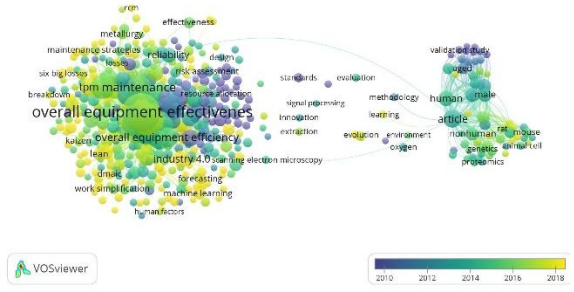


Fig.11-c. Correlation of keywords (in series of years)

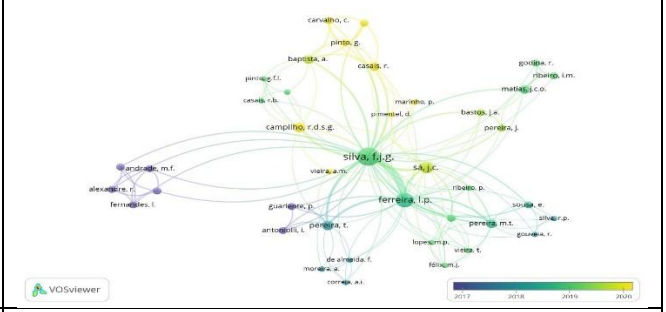


Fig.12. Analysis of the interaction of authors in scientific research.

Fig. 12 shows the analysis of the interaction of the authors in scientific research, and with the help of this analysis, we can see the citations given by the authors to each other on OEE(Bengtsson, Alm, and Tjulin 2022). According to the analysis, the authors' relationship in scientific works began in 2017, and by 2018, "Silva,F.J.G" achieved high results.

Conclusions

Using bibliometric and network analysis, this paper provided an overview of the distribution of publications on Overall Equipment Effectiveness (OEE). By querying the Scopus database with predefined keywords, a collection of 1,308 published papers was retrieved. There are three phases, first search criteria and source identification, second software and data acquisition, and third data analysis and interpretation. In summary, research findings on OEE using VOS Viewer have been identified.

As a matter of fact, the assessment of the efficiency of the device is important in every field. For example, by controlling the efficiency of equipment in industrial enterprises and continuously improving this indicator, poor quality products and possible losses are prevented. And in the field of medicine, by constantly improving this parameter, it is possible to improve the health of patients.

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