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Toward Learning Tools: Analyzing Precision of Tool Maker and Optical Comparator

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Abstract

This paper aims to provide a clear analysis to choose what is the best tool for their specific needs. This is a quantitative descriptive correlation study that determines the difference in terms of accuracy and precision of optical comparator and toolmaker. Two different materials were measured using an optical comparator and tool maker microscope at the Technological University of the Philippines Manila Campus. Technological University of the Philippines is one of the schools in the Philippines that uses the equipment. Two measuring machines can be located at the College of Industrial Technology (CIT), Mechanical Engineering Technology Department (MET). This location was chosen for its highly efficient and calibrated machines to come up with accurate result. Both machines are significantly useful to industry and companies. Toolmaker microscope is a bit complicated while optical comparator has very slight difference to its measurements. However, optical comparator is less costly than that of a toolmaker's microscope. This paper has navigated the complexity of both tool makers microscope and optical comparator that offer a great accuracy and precision in terms of measuring small components which are used in the manufacturing process to make products.

Keywords**:** Tool Maker, Optical Comparator, precision, workpiece point, Technological University of the Philippines

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Introduction

In industries where precision is important, the choice of measurement tools can substantially impact product quality and cost-effectiveness (Soori et al., 2024); (Achouch et al., 2022); (Javaid et al., 2022). The Toolmaker and the Optical Comparator has its unique features and capabilities in measuring how precise it is and how accurate it is. Optical comparator and toolmaker's microscope are both useful tools for accurate measurement. In machining, every micron matters to ensure the parts meet the exact specifications needed (Tuli et al., 2024); (Barrat et al., 2024). These machines offer highly accurate and repeatable data in seconds with the push of a button. Optical comparators are used for inspection and measurement in the manufacturing industry. The toolmaker's microscope on the other hand is used for measuring small delicate objects. Optical comparators and toolmaker's microscopes can be used in quality control. This enables the machinist to examine and inspect the workpiece measurements and tolerances. The precision can provide guarantees the quality of material it can deliver (Rita et al., 2019); (Aldoseri et al., 2023).

This paper aims to provide a clear analysis to choose what is the best tool for their specific needs. Both instruments the Toolmaker and Optical Comparator, the researcher examine the cost-effectiveness, justifiable for different tasks, accuracy, and precision. The guide is crafted to support enthusiasts in dealing with their measurement methods and improving overall capability (Faganel & Rižnar, 2023); (Nowell et al., 2017); (Da Silva et al., 2023). This study conducts an analysis with a toolmaker microscope and optical comparator to analyze the difference between those tools in terms of accuracy and precision. The researcher produce their measurements of the same specimen and compare it to one another to see how it differs and further tackle the factors affecting those differences. The researcher is discovering new factors that can solve and remove to lessen the differences between the two measurement tools or improve the tool itself for better use.

Methodology

This is a quantitative research anchored by descriptive correlation study to determine the difference in terms of accuracy and precision of optical comparator and toolmaker microscope two tool. Two different materials were measured using an optical comparator and tool maker microscope at the Technological University of the Philippines Manila Campus. Technological University of the Philippines is one of the schools in the Philippines that uses the equipment. Two measuring machines can be located at the College of Industrial Technology (CIT), Mechanical Engineering Technology Department (MET). This location was chosen for its highly efficient and calibrated machines that will bring positive results. The researcher used the gathered data from the materials that was measured using the optical comparator and tool maker microscope. The researcher compared the accurateness and preciseness of the two-equipment using numerical measurements including the margin of error that is included while measuring. Two different materials would have different comparisons for better analysis. The researcher employed a descriptive method which guide the researchers to analyze the data. The researcher utilizes four steps in determining the result. First, the collecting the materials, second is the data gathering or measuring stage, third is the data analysis and last was the presentation and evaluation of results.

Results

This section presents the data gathered from the respondents. The presentation is made using tables. Analysis and interpretation of data were performed through the figure and tabular presentation. The researcher provided two objects to be measured to have a clearer analysis of the difference between optical comparator and tool maker microscope measuring capabilities. The researcher measured both objects using both measuring tools and provided specific measurement of the objects and uses (maximum tolerance or margin of error) while measuring.

Figure 1. Aluminum plate cross-shaped workpiece

Table 1. Result of Aluminum plate cross-shaped workpiece

Workpiece Point	Optical Comparator	Actual Value	% Difference
A	50.1	50.32	0.44 %
B	47.34	48.83	.305 %
C	50.45	50.02	-0.86 %
D	47.9	47.98	0.17 %
E	8.78	8.9	1.35 %
F	19.65	18.91	-.391 %
G	30.27	30.54	0.88 %
H	39.62	39.20	-1.07 %
I	6.28	6.9	.896 %
J	15.03	15.5	3.03 %
K	24	24.1	0.41 %
Workpiece Point	Tool Maker	Actual Value	% Difference
A	50.34	50.32	-0.04 %
B	48.81	48.83	0.04 %
C	50.32	50.02	-0.60 %
D	48.18	47.98	-0.42 %
E	8.93	8.9	-0.34 %
F	18.94	18.91	-0.16 %
G	30.92	30.54	-1.24 %
H	39.11	39.20	0.23 %
I	7.17	6.9	-.391 %
J	15.71	15.5	-1.35 %
K	24.14	24.1	-0.17 %

The statistical data in the table 1 shows the measurements of an aluminum cross plate using an optical comparator and toolmakers microscope as well as their actual value. The highest different percentage from optical comparator is 1.35 percent from an actual value which still lands on the given tolerance that is 0.1-0.3 mm, while toolmakers microscope has 1.35 percent on a different part of the measured workpiece that also lands inside the given tolerance. Both toolmakers microscope and optical comparator are proven to have preciseness and accuracy for measuring the aluminum cross plate.

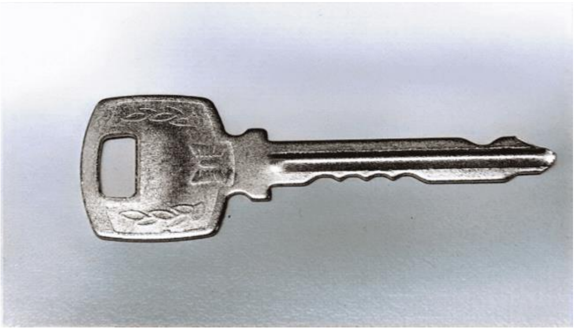

Figure 2. key-shaped workpiece

Table 2. Result key-shaped Workpiece

Workpiece Point	Optical Comparator	Actual Value	% Difference
A-B	16.6	17.1	0.43 %
B-C	18.88	19.15	.305 %
C-D	21.22	22.20	-0.86 %
D-E	27.3	27.19	0.16 %
E-F	29.57	31.33	1.34%
F-G	32.86	34.5	-3.91 %
G-H	36.04	37.3	0.88 %
H-I	40.23	41.77	-1.07 %
I-J	49.29	48.75	.898%
J-K	53.52	52.9	3.03 %
Workpiece Point	Tool Maker	Actual Value	% Difference
A-B	17.6	17.1	-0.03 %
B-C	19.41	19.15	0.04 %
C-D	22.84	22.20	-0.59 %
D-E	27.21	27.19	-0.41 %
E-F	30.33	31.33	-0.33 %
F-G	33.51	34.5	-0.15 %
G-H	37.72	37.3	-1.24 %
H-I	41.76	41.77	0.22 %
I-J	48.48	50.7	-3.91 %
J-K	52.22	55.2	-1.35 %

The statistical data in the table 2 shows the measurements of a key using an optical comparator and toolmakers microscope as well as their actual value. The highest different percentage from optical comparator is 3.91 percent from an actual value which still lands on the given tolerance that is 0.1-0.3 mm, While toolmakers microscope has 3.91 percent on a different part of the measured workpiece that also lands inside the given tolerance. Both toolmakers microscope and optical comparator are proven to have preciseness and accuracy for measuring the key. This indicates that both toolmaker microscope and optical comparator are both accurate and precise and their measurements landed inside the tolerance that is used which is 0.01-0.03 mm for every part that is measured. The data shows the difference of every measurement from actual value and its percentage. Some measurements fall out of tolerance but both tool makers microscope and optical comparator have measurements that are close to each other that indicates both measuring tools offer similar measuring capabilities. This proves that both toolmaker microscope and optical comparator are still great assets to industries, especially to machine shops for accurate and precise measurements. The researcher’s analysis concludes that toolmakers microscope offers modernity, yet the optical comparator is not that far behind despite being traditional.

According to (Bi et al., 2018), tool makers microscopes can magnify up to 1/100th mm of a component which makes it perfect for small parts of electronic devices and this tool is different to traditional optical comparators despite both being dependent on optics. This gives the toolmakers microscope an edge over optical comparator that can be seen from the data above in which the percentage difference of toolmakers microscope is closer to the actual value. Further, (Weber & Huisken, 2021); (Reigoto et al., 2021). microscopes can be fitted with a variety of attachments to suit various applications. These attachments include things like diaphragms, coatings, lens, filters, and more. These additional items ensure that you acquire more accurate information than an optical comparator.

Discussion

While the fundamental measurement goals of both systems are identical, some significant distinctions could make an optical comparator the better option in some situations compared to a vision system, and vice versa (Reinartz et al., 2019). Additionally, the optical comparator has some drawbacks. Further drawbacks include the fact that the setting up of the optical system is highly expensive. These comparators must be used in a darkroom to facilitate the measuring process. Typically, some of these optical comparators have bigger dimensions. For the light source to run continually, there needs to be an external power supply. Since the microscope's eyepiece is needed to examine the scale, it is not practical to use it continuously (Kuang et al., 2020). The Toolmaker's microscope is generally used as a measuring device. So, this device can go up to 20x, 50x, 100x, or more magnification of the sample that you want to measure. Toolmaker's microscope is suitable for magnifying and observing finer details and locating the coordinates of the sample with consistent precision and ease (Jouini et al., 2023). Electronic hardware is used in operating said device and can store data in its computer and even see what the lenses see by projecting it to the screen of the computer (Arena et al., 2022); (Kamińska et al., 2019).

As the setup is a bit complicated, once you get the sequence of operations, operating it will be easy. It also features a light that can be above or below the sample that you are measuring, unlike the conventional Optical Comparator lighting that is only available below the sample. Even though the Toolmaker's microscope is far more advanced than the Conventional Optical Comparator the Optical Comparator still has its uses. As you want to learn the basics of using the microscope, you can effortlessly measure by just putting the sample on the stage, turning the optical lights on, and lining it up to the measurement you want, showing its measurements right away without any complex set-up needed. Even though the Conventional Optical Comparator does lack the need for a computer, its measurement depends on the viewing angle of the operator. It will still be accurate, but the precision may vary depending on the Operator's Height angle and Optical Sight (Arafat et al., 2023); (Liu et al., 2023).

Conclusion

In conclusion, both toolmakers microscope and optical comparator offer great accuracy and precision in terms of measuring small components specifically. Their magnification capabilities are different and the way of measuring, However, produces measurements they are close to each other. Both machines are significantly useful to industry and companies. Toolmakers microscope is a bit complicated while optical comparator has very slight difference to its measurements. However, optical comparator is less costly than that of a toolmaker's microscope, this research paper has navigated the complexity of both tool makers microscope and optical comparator that offer a great accuracy and precision in terms of measuring small components which are used in the manufacturing process to make products. However, when it comes to measurements, they are relatively close to each other. A toolmaker's microscope is a bit complicated while the optical comparator has a very slight difference to its measurements. However, the optical comparator is less costly than that of a toolmaker's microscope. The effect of these findings is to go beyond this investigation. By focusing on both practical and observation, this research emphasizes the significance of industries and companies. As industry evolves, these insights develop practices and involvement of communities for the future of the manufacturing process.

Conflicts of Interest

The authors declare no conflict of interest.

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