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Modification Of Measurement Tools On Cmm Machine To Increase The Accuracy Of The Sport Type K64 Production Process

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Abstract. New technological innovations in the design and production of motorized vehicles continue to be carried out to maintain product quality and have high-priority safety factors. The tool used by the CMM (Coordinate Measuring Machine) to measure product dimensions must have a very precise level of accuracy. The disadvantage is that it must be measured while still, so it requires tools. The limitation of the problem only focuses on modifying the measuring tools on the CMM machine for the Swing Arm Motor Sport Type K64 product. The aim of this research is to develop measuring tools to achieve tighter dimensional tolerances, increase the accuracy of the production process, and make recommendations for tools to increase measurement accuracy. The method used is a quantitative method. The results obtained show that the simulation and implementation of the K64 swingarm measuring jig show positive and satisfactory results. By modifying the measuring tools on the Coordinate Measuring Machine (CMM), it has succeeded in increasing the accuracy of measuring the K64-type sports motorbike swingarm components. These modifications have a significant impact on improving the accuracy of the swingarm production process in endpiece distance (average deviation percentage 0.05%) and collar distance (average deviation percentage 0.05%), and apart from increasing accuracy, this modification also helps in speeding up the production process and changing the cycle. Time, which was originally 12 minutes, became 8 minutes per unit.

Keywords: Coordinate Measuring Machine, Swing Arm, Safety

INTRODUCTION

The automotive industry continues to experience rapid development with the emergence of new technological innovations in the design and production of motor vehicles, with high standards in determining geometric tolerances. This is done to maintain the quality of the products produced, which indeed have a high priority as a safety factor because they concern human lives. Apart from that, a high level of precision is required in making automotive products. This is related to the assembly process, which requires tight fittings (small clearance). Therefore, after the manufacturing process, the product usually goes through quality control. This quality control section will measure product dimensions precisely according to the dimensions in the design drawing. The tools used to measure product dimensions must have a very precise level of accuracy. The CMM (Coordinate Measuring Machine) machine is a high-speed, multi-function measuring tool that produces high measurement accuracy and efficiency. The method used is to touch the probe to several parts (at least two points) of the product. The probe that is touched will form a coordinate or contour through the program so that its dimensions can be known. As previously explained, the CMM machine has the advantages of a high level of precision and accuracy and requires a short measurement time, making it more efficient. However, the drawback is that the product to be measured must be still or static, so it requires tools. Products in the automotive sector in general are not simple and large in size. This problem then requires a tool in the form of a jig, so that the object remains static. Tools are generally rectangular (4 sides). Generally, objects that have a high level of complexity will require a tool that has more than four sides. The brand that provides tools with more than four sides, namely Renishaw, has a price that is quite expensive. Therefore, this research contains modifications to CMM machine measuring tools. This is done because, in order to modify the CMM machine's measuring tools, the tools must be of the same size as the designed size (precise and accurate). Through this research, it is hoped that concrete steps can be taken towards developing more efficient and accurate measurement techniques, which in turn will have a positive impact on the quality and competitiveness of automotive products, especially the K64 type sports motorbike.

The Coordinate Measuring Machine (CMM) is a precision measuring tool used to measure the dimensions and geometry of objects with a high level of accuracy. A CMM machine usually consists of a work table that can move freely in three axes (X, Y, and Z) and is equipped with a measuring probe that can be moved automatically. There are five stages in the measurement process using CMM, including programming, object placement, measurement, data processing, and results analysis. The Coordinate Measuring Machine consists of parts that affect the accuracy of measurements, namely the working table, support, air bearing, axis guideways, motor, joystick, controller, probe head, sensors, linear scale, and software.

a. Bridge type CMM

This type of CMM has a bridge-like structure, with the probe moving on a platform supported by two columns.

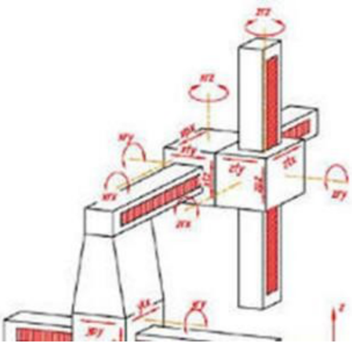

Figure 1. CMM Bridge Type

b. Gantry type CMM

This type of CMM has a gantry-like structure, with the probe moving on a platform supported by two horizontal beams.

Figure 2. CMM Gantry Type Source: Hexagon Manufacturing Intelligence

c. Portable type CMM
This type of CMM has a compact structure and is easy to carry, so it can be used to measure objects in different locations.

Figure 3. CMM Tipe Potable
Source : Hexagon Manufacturing Intelligence

There are two types of coordinate systems in the world of measurement. The first is called the Coordinate System Machine. In a machine coordinate system, the X, Y, and Z axes refer to the movement of the machine.

When viewed from the front of the machine, the X-axis is from left to right, the Y-axis is from front to back, and the Z-axis is up and down in a direction perpendicular to the other two axes.

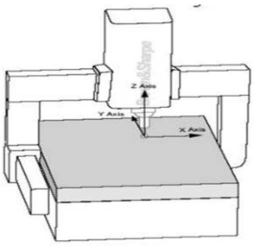

Figure 4. Machine Coordinate System Source: Hexagon Manufacturing Intelligence
Part Coordinate System

The second coordinate system is called the Part Coordinate System, where the three coordinate axes relate to the reality number (datum) or pattern of the workpiece. Before using computer software for coordinate measurements, components were physically placed parallel to the machine axis so that the position of the machine was parallel to the Part Coordinate System. This method is very time-consuming and not very accurate. When the part being measured is round or contoured, the measurement cannot be carried out.

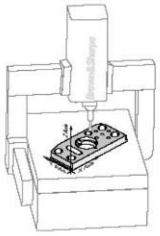

Figure 5. Part Coordinate System Source: Hexagon Manufacturing Intelligence

METHODS

The research aimed at increasing the accuracy of the Sport Type K64 production process through the modification of measurement tools on a CMM machine. The methodology followed a structured approach as outlined in the flowchart: Preliminary Study, Literature Review, Problem Formulation, Data Collection, Sampling, Normality Test, Data Processing, Analysis, Conclusion and Recommendations This systematic approach ensures that the modifications to the measurement tools are thoroughly evaluated, providing a clear understanding of their impact on the accuracy of the Sport Type K64 production process.

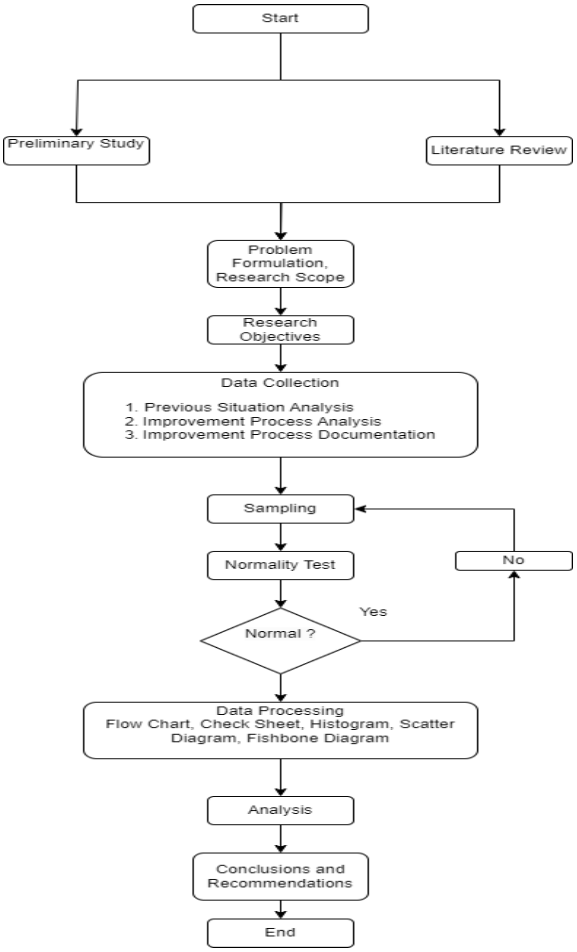

Figure 6. Process Flow Diagram

Data Collection Procedures

The data collection procedures used to support completing this research are as follows:

1. Observation, namely making direct observations of the PT AHM to see the production process carried out to produce the K64 type sports motorbike swing arm.
2. Conduct interviews with employees who work to find out the production process for the K64 type sports motorbike swing arm, the quality measurement process, and other information.
3. Data collection through the documentation method is carried out to retrieve data and activities carried out by employees when measuring the swing arm of the K64 type sports motorbike, as well as improvements that will be made in this process.
4. Searching for secondary data is used as a reference through literature studies originating from library sources and previous research.

Process of Modifying Measuring Tools on CMM

The work steps carried out in modifying the measuring aids on the CMM are redesign of the K64 Swingarm Jig/Measurement Tool, Prepare the necessary materials and tools, Component Manufacturing, Finishing and Inspection and Final result.

1. Calculating Deviation Per ItemData processing
   For each measurement item and parameter (e.g., Collar Distance, Endpiece Distance, Sleeve Hole Height), calculate the deviation between the actual value and the standard value. Deviation is calculated by the formula:

Deviasi = Nilai Aktual - Nilai Standar. dan $\frac{\Sigma(X-\bar{x})^2}{n-1}$

- Calculate the square of each deviation, then square the results of the calculation of point (1).
- Adds the squares of the deviations, using the formula $\Sigma(X-\bar{x})^2$ $\frac{\text{Measurement 1 + Measurement 2}}{\text{Total Parts}}$
- Calculating variance (S)
- Calculate the standard error $(SE\,\bar{x})$ $SE_{\bar{x}} \frac{s}{\sqrt{n}}$
- Calculate the Percentage Deviation Per Item $\frac{Deviasi}{Nilai\ Standar}\ x\ 100\%$
- Calculate the Average Percentage Deviation $\frac{deviation\ percentage\ values\ for\ all\ items}{total\ sample\ parts}$

2. Production Process Time

   $cycle\ time = \left(\frac{24\ jam}{28\ pcs}\right) = 0{,}857\ jam/pcs\ atau\ 51{,}4\ menit/pcs)$

3. Production Targets/Shifts

   $Production\ Targets/Shifts = \left(\frac{28\ pcs}{3\ shift}\right) = 9{,}33\ pcs/shift$

4. Production Process Costs
   Comparison of production cost calculations for the K64 swingarm before and after improvements. To compare the production costs of the K64 swing arm before and after improvements, we must analyze the cost components involved.
5. Production Process Efficiency

Calculation

Modification of the K64 type sports motorbike swing arm measuring tool on the Coordinate Measuring Machine (CMM) in order to increase product accuracy and increase the efficiency of the K64 type sports motorbike swing arm production process, the following is a table of calculation results before and after modification.

Table 1. Calculation results before and after modification

Item	Before	After
Calculating Deviation	-0.32%	0.05%
Production Process Time	12 minutes	8 minutes
Production Targets/Shifts	9 parts/shift	10 parts/shift

Production Process Costs	IDR 968,181/unit	IDR 930,303/unit
Production Process Efficiency	90.79%	92.72%

RESULTS AND DISCUSSION

Fishbone Analysis

The fishbone diagram or Ishikawa diagram in this image is used to identify the causes of problems in the K64 Swingarm measurement process on CMM machines that are less than optimal. This diagram groups the causes of problems into several main categories: Material, Man, Machine, Method, and Measurement.

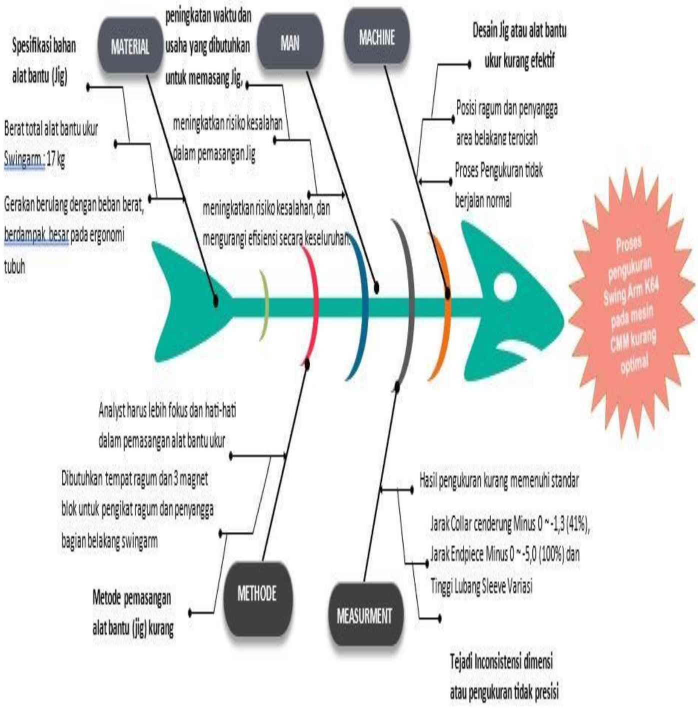

Figure 7. Fishbone

Measuring tools are too heavy, Use of tools is ineffective, Design of tools is less practical, and Dimensional inconsistencies occur or measurements are not precise and accurate

Simulation and Implementation Results

Simulation and implementation of the K64 swingarm measuring jig/tool show positive and satisfactory results. Here is the summary:

- Jig Weight: The Swingarm Jig weighs 9 kg as measured using a scale. This weight is quite light and easy to carry anywhere.
- Precision: The position of the jig and swingarm is precise, so that the resulting measurement results are accurate and reliable.
- Strength and Precision of the Fastener: The jig and measuring table fasteners are strong and precise, so that the jig does not easily shift during the measurement process.
- Prevent Jig Shifting: The design of the jig and its fastening is able to prevent the potential for the jig to shift during the measurement process, so that measurement results are more accurate and consistent.

Before Improvement	After Improvement
	

Figure 8. Before and After Improvement

Simulation Analysis and Implementation

Interpretation of Measurement Results Before and After Modification

There are deviations in several K64 swingarm measurement parameters compared to the established standards as seen in bold 3.11. The largest deviations in measurements before modification were carried out were in the endpiece distance (average deviation percentage -1.37%) and collar distance (average deviation percentage -0.32%). From the results after modification, the largest was the endpiece distance (average deviation percentage 0.05%) and collar distance (average deviation percentage 0.05%).

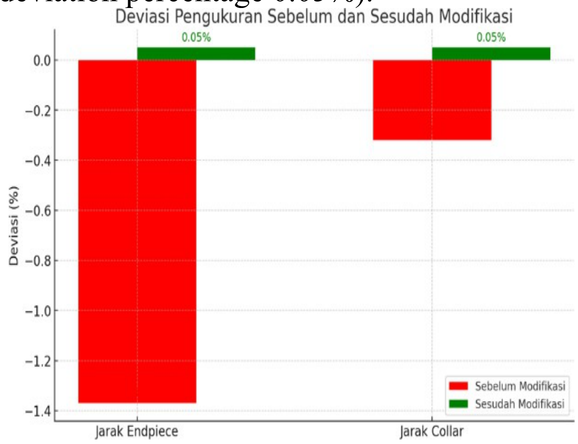

Figure 9. Differences in Calculation Result Before Modification and after Modification

Reduction of required Measurement Time

After conducting a trial on the modified CMM machine measuring tool, at the Quality Control stage, namely checking the quality of the finished swingarm to ensure there are no defects and in accordance with standard specifications, and carrying out measurements via the CMM machine to experience changes in Cycle Time. which was originally 12 minutes became 8 minutes. With optimized cycle time and using a CMM machine to reduce quality inspection time.

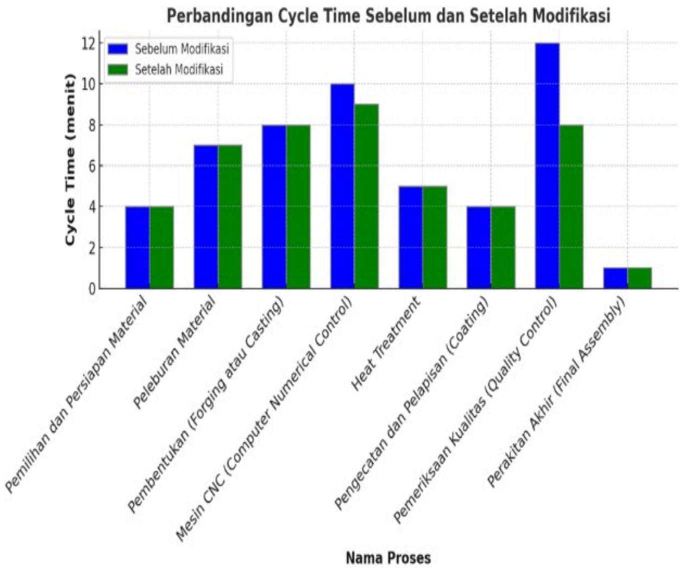

Figure 10. Cycle time reduction

Impact on Production TargetsFigure

After modifying the CMM machine measuring tools, production efficiency increased to 30 parts per day with a production target of 10 parts per shift. This modification significantly increases daily production capacity and overall process efficiency.

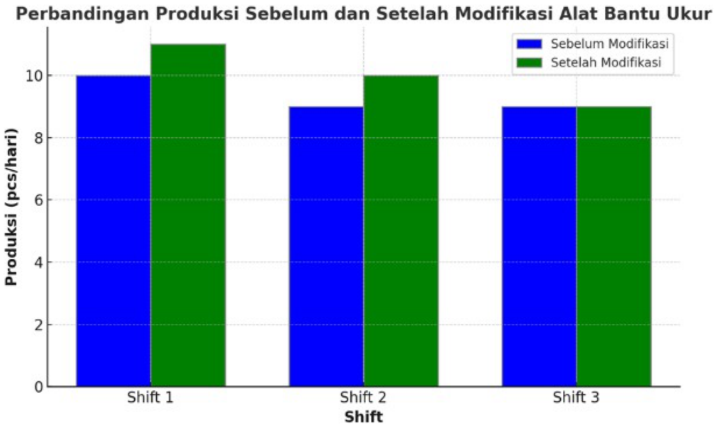

Figure 11. Production Targets Before and After Modification

Increased Production Cost Efficiency

After improvements were made, the production cost of the K64 swing arm decreased from IDR 968,181/unit to IDR 930,303/unit, resulting in savings of IDR IDR 37,878/unit or around 3.92%. This shows that increasing efficiency has had a positive impact in reducing production costs. These improvements can include reduced production time, improved overhead management, and other additional cost reductions. These savings can be used to increase profit margins or reinvested in the production process to continuously improve efficiency and quality.

Figure 12. Increased Production Cost Efficiency

Increased Production Process Efficiency

After modification of the measuring tools, OEE increased from 90.79% to 92.72% showing an increase of 1.93% in the efficiency and productivity of the machine or equipment.

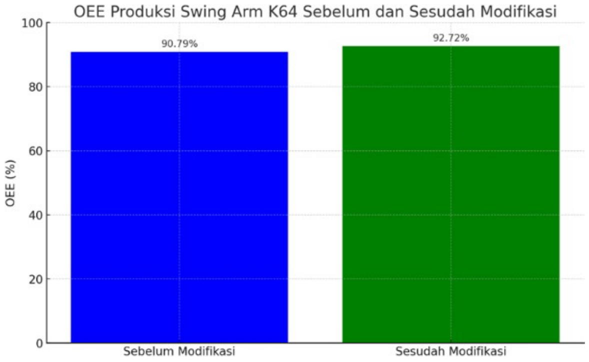

Figure 13. Increased Production Process Efficiency

Analysis of the situation and condition of measuring tools before and after modification

Modifications to the measuring tool (Jig) for the K64 swingarm measurement process on CMM machines have been carried out to overcome various problems previously identified which are factors that cause the measuring tool (Jig) for the K64 swingarm measurement process on CMM machines to be less than optimal. The following is an analysis before and after modification :

Analysis of the Situation and Condition of Measuring Tools Before Modification:

Less Effective Jig Designs:

- Design that does not consider Swingarm geometry: Jigs must be designed with complex Swingarm geometry in mind, including shape, dimensions and tolerances.
- Improper position of the measuring point: The position of the measuring point on the Jig must be determined precisely to ensure accurate measurements.
- Lack of adequate clamping features: Jigs must be equipped with adequate clamping features to ensure the Swingarm is mounted stably and securely during measurements.

Material specifications for tools (jigs) are less efficient

- The measuring tool is too heavy: Total weight of the Swingarm measuring tool: 17 kg
- Lack of ergonomics when used: Repetitive movements with heavy loads have a big impact on body ergonomics.
- Material Stiffness and Stability: The material used to make the jig must have sufficient stiffness and stability to ensure that no distortion or dimensional changes occur during the measurement process. The analyst must be more focused and careful in installing the measuring aids
- Installation Complexity: Requires a vise holder and 3 magnetic blocks for attaching the vise and supporting the rear of the swingarm. This can slow down the overall measurement process. Operators may need to spend extra time setting up the jig correctly before they can begin measuring.

Analysis of the Situation and Condition of Measuring Tools after Modification:

More effective Jig Design:

- Design that considers swingarm geometry: The jig design has been refined to take into account the shape, dimensions and tolerances of the swingarm. Jigs are now specifically designed to accommodate complex geometries, which increases measurement accuracy.
- More precise measuring point positions: The measuring point positions on the jig have been optimized to ensure more accurate measurements. Measuring points are now more precisely placed according to measurement needs.
- Improved clamping feature: The jig is now equipped with an improved clamping feature, ensuring the swingarm is mounted stably and securely during measurements. This reduces the risk of shifting during measurement, which can cause inaccuracies.

More Efficient Jig Material Specifications:

- Reduction in measuring aid weight: The total weight of the swingarm measuring aid has been reduced from 17 kg to 9 kg, making it easier for operators to handle and use.
- Better ergonomics: With a lighter weight, operators now experience lower physical stress, which improves ergonomics and reduces the risk of injury from repetitive movements.
- Material stiffness and stability: The material used, namely hollow steel, for making the jig has been selected for greater stiffness and stability, ensuring that there is no distortion or change in dimensions during the measurement process.

More Practical Method of Installing Jigs:

- Reduced installation complexity: The vise holder and block magnet have been replaced with bolt thread locks cut to 20mm, and the 2 bolt heads are installed with steel stirrups which function as manual bolt twisters and a simpler and faster installation mechanism, so the operator does not need to spend time extra to install the jig correctly.

CONCLUSION

Modification of Measuring Tools: By modifying the measuring tools on the Coordinate Measuring Machine (CMM), we have succeeded in increasing the accuracy of measuring the K64 type sports motorbike swingarm components. This modification includes additions and improvements such as improvements to the shaft adjuster jig swing arm, the addition of a spring to the shaft adjuster cylinder and improvements to the bolt thread lock which was cut to 20mm and 2 bolt heads installed with steel stirrups which function as manual bolt swivels and a simpler installation mechanism and fast.

Increased Accuracy of the Production Process: Implementation of these modifications had a significant impact on increasing the accuracy of the swingarm production process in terms of endpiece distance (average deviation percentage 0.05%) and collar distance (average deviation percentage 0.05%). This is evident from the reduction in measurement tolerance deviations which previously frequently occurred, so that the quality of the final product is more consistent and in accordance with the quality standards.

Production Process Efficiency: Apart from increasing accuracy, this modification also helps speed up the production process and changes the Cycle Time from initially 12 minutes to 8 minutes per unit. This result resulted in an increase in cycle time efficiency of 33.33%. with optimized cycle time and using a CMM machine to reduce quality inspection time. the time required for inspection and quality control can be reduced, thereby increasing production capacity from 28 pcs/day to 30 pcs/day. The OEE percentage also increased from 90.79% to 92.72% showing a 1.93% increase in machine or equipment efficiency and productivity.

Increased Production Cost Efficiency: The results of improving product quality and production process efficiency contribute to increasing the efficiency of production costs per unit. K64 swingarm production costs decreased from IDR 968,181/unit to IDR 930,303/unit, resulting in savings of IDR 37,878/unit or 3.92%. This shows that increasing efficiency has had a positive impact in reducing production costs. By making modifications, you can produce products that are more consistent and of high quality and have efficient production costs.

REFERENCES

Diakses dari https://www.renishaw.com.

Kamaruzaman, M. F., Selamat, A., Mohamed, Z., & Abu Bakar, S. A. R. (2019). *A review on coordinate measuring machine (CMM). Procedia Manufacturing, 2, 458–467.*

Mitutoyo. (2021). "Coordinate Measuring Machine (CMM) Overview." Diakses dari https://www.mitutoyo.com.

Nawi, M. N. M., Bahari, M. F., & Saharudin, M. S. (2018). *A review on coordinate measuring machine (CMM). IOP Conference Series: Materials Science and Engineering, 342(1), 012064.*

Renishaw. (2020). *"Advancements in CMM Technology for Automotive Manufacturing."*

Saluja, S., & Sooch, T. (2020*). A Review on Coordinate Measuring Machine (CMM). International Journal of Engineering Research and Applications, 3(3), 1712–1716.*

Santoso, E. (2019). *Peningkatan Akurasi Pengukuran dengan Modifikasi Alat Bantu pada Mesin CMM. Disertasi, Universitas Gadjah Mada.*