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3D Model Autocad Of The Piston Displacer Cup For A Gamma Stirling Engine Using The API Method

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ABSTRACT (10 PT)

When producing a perfect product, design process namely 2D modeling and 3D drawing, are closely related. The purpose of this study is to design a 3D model of a gun mastering machine product as a fan drive using CAD applications. The method of this study is decision data on API production (analytical product inspection). Measurement of sterling machine degradation using CPK (deviation) received results of -0.97, -0.22, 0.86, 0.11, 0.11 between zero and what indicates this specification. On average, the results of the stirling fluid fluorescent agent measurement are red numbers indicating that the survey dimensions are absent, especially from the basic dimensions of point 4, with samples 2, 3, and 5 exceeding the specified tolerance limits.

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1. INTRODUCTION

The sterling engine can theoretically achieve the highest efficiency of all heat engines for maximum engine efficiency . Due to its high efficiency, the Stirling engine design process must be very precise so that the efficiency does not decrease (Rahmat, 2024). Perfect Product Production is a design process that is inseparable from 3D modeling and 2D drawings. In the world of mechanical engineering, the development of a new technology that has emerged is the use of software in drawing designs, utilizing computerization (Jokanan et al., 2022). For precise manufacturing, using the CAD method will be more effective than hand drawing in order to achieve the level of accuracy, neatness, adjustment of drawing tasks, presentation of materials, modification of drawings, saving drawings for later review and the overall quality of the drawing (Fakhry et al., 2021).

The use of software such as Auto CAD 2D can help the design process because this software allows us to draw techniques with high precision according to industry standards (Pujiastuti, 2025). Auto CAD acts as an important communication tool in the world of engineering (Yonas Prima Arga

Rumbyarso, Gali Pribadi, 2024) . Along with time and technological developments, this certainly has a good impact. Technological developments have a major impact on the speed of research projects (Rahmat, 2025). The introduction of the Auto CAD application is very helpful in the process of improving designer skills (Suwaji et al., 2024). The use of video simulations in Auto CAD is also very helpful for research (Sarif, M, 2024). The use of the Auto CAD application can also increase researcher confidence (Hijriyah, R, D, 2024).

AutoCAD is a CAD (Computer Aided Design) software produced by Autodesk. In general, CAD is an application used for designing, especially in making or drawing technical drawings using a computer or laptop, and is currently being expanded to mobile devices such as cellphones, with the aim of creating design results with a high level of accuracy and planned in a short time (Dawolo et al., 2024). Using digital techniques in drawing provides the ability to create quality artwork in an easier and faster way (Andy Satria et al., 2024).

In this study, the issues that arise are decisions regarding the status of the product taken by researchers during the presentation stage and data processing which is still done manually, resulting in errors in data processing, both addition and division, which often occur, and require re-measurement. In addition, the absence of a registration number for the inventory and calibration of measuring instruments leads to the same treatment of all measuring instruments (Rahmat & Isdaryanto Iskandar, 2023). The measuring instrument should have one deviation of its own and this has the potential to fail, which will have an impact on the machining process which can delay the production process and result in losses for researchers so that the time needed to complete a component will certainly be long to complete this Stirling gamma engine. Therefore, the calibration process of measuring instruments should indeed be carried out to maintain the quality of a product that will be produced.

1.1 Auto CAD Software

Advances in information technology and communication, especially Computer-Aided Design (CAD) software such as AutoCAD, play a significant role in the education and industrial (Fajrinia & Budiati, 2025). Among the various technologies that affect various aspects of human life, CAD Applications (Rendi, 2023). Auto CAD is one of the CAD applications released by the American software company, Autodesk Inc, which is most commonly used worldwide. This application is increasingly used because it has many conveniences in use, complete facilities and is universal, flexible, and can be added with a program to support a particular application because Auto CAD has the Visual LISP programming language, VBA (Visual Basic Application). In this program, there are basic commands and advanced image modification commands (Vitri, 2020). Soft skills in the era of the Industrial Revolution 4.0, can improve the abilities and achievements of students, so that graduates can compete in global competition (Nasution et al., 2020).

The latest CAD software that is widely used today is designed using the main C module along with its special API, providing precise planning and calculations by designers (Reza et al., 2024). With the presence of automatic skills, designers can use computers to design everything they need, and manual design designs with regular sketches on paper so that the results of product design are more attractive and accurate. Family Car - All CAD products are the most commonly used CAD software worldwide. Auto CAD is used by civil engineers, national developers, architects, mechanical engineers, interior designers, and many more. The DWF format, which is currently automatically CAD, is a support format that has been published and advertised by Autodesk to publish CAD (Rafiuddin & Khursatul Munibah, 2016). To be able to run the Auto CAD program, the most basic thing that must be mastered is knowledge of the Auto CAD screen display (Surya & Rochyat, 2014). CAD/CAM functions consisting of three basic technologies, namely:

1. Database Management.
2. Computer Graphics.
3. Mathematical Models (Analysis).
4. Data Acquisition and Control (physical prototypes, production processes).

CAD/CAM applications often use four basic technologies: CAD/CAM providers. CAD/CAM Controls the production process with numerical control and robot programming. Another example is MRP (Material Requirements Planning). It only uses basic CAD/CAM technology: Database Management. In addition, the CAD/CAM sign "/" indicates integrated skills. The alphanumeric database created in the design is an application for raw material demand in the production industry. In general, Auto CAD is an application that supports the production of drawings in design technology design. This application can design floor

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plans, author frameworks, and other objects in 2D (2D) and 3D (3D) sets (Akhmadi dan Hendrawan, 2019).

Auto CAD software itself has various features such as 2-dimensional and 3-dimensional visualization images as well as reading spatial dimensions such as length, area, and volume of objects. The features in Auto CAD can be used by educators as a learning medium to convey the concept of projection images, the volume of an object or the steps in operating the Auto CAD software itself effectively (Ndruru et al., 2023).

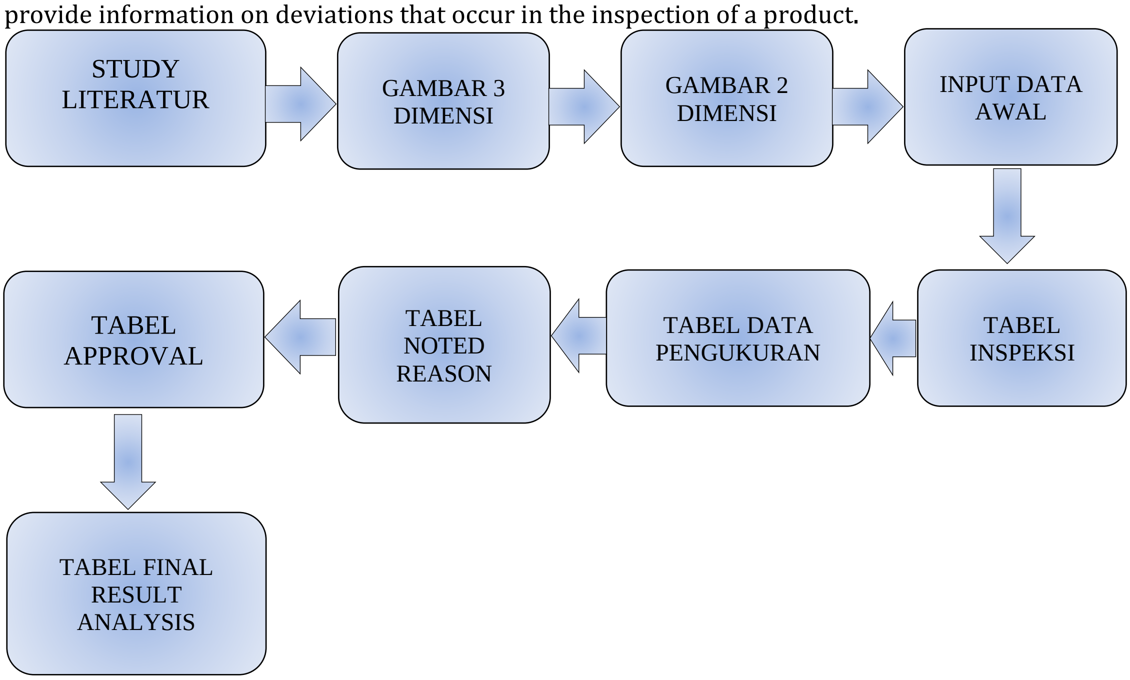
1.2 Working Drawing

Working drawings are illustrations that are used as guidelines in carrying out work in the field, so the drawings need to be arranged in a clear and understandable manner when the work is carried out. The drawing is a step in perfecting the existing design and has been adjusted to the conditions in the field. So that with the working drawings, both parties, both designers and others, can understand and comprehend what is represented.

The working drawings themselves are divided into 2, namely: 2-dimensional (2D) working drawings and 3-dimensional (3D) working drawings. 2-dimensional (2D) drawings are drawings that have two dimensions, namely length and width. This image has no depth, so its appearance is only visible from one side. In general, 2D images are used to visualize objects or data in a simpler form and can be easily understood, without involving the depth dimension. While 3D images are 3-dimensional (3D) images are images that have three dimensions: length, width, and depth, so that the objects depicted look more realistic, as if they can be seen from various angles. Here the presentation of 3D images is used to realize the image into a real form according to the original.

2. METHOD

The method used in decision making is using API (Analysis Product Inspection). API is a template with Microsoft Excel format which contains a formulation or formula that has been created so that it can provide direct information, if the product dimensions are written with actual data with conditions exceeding the standardized tolerance or less, then the color gradient can change to red and provide information on deviations that occur in the inspection of a product.



Pictures 1. Research Method

The API method can also be used to provide information about the average results of the product meter with automation. If the results are wrong, automation can answer the average and red mood and automatically correct your decision results.

3. RESULT DAN ANALYSIS

3.1 Creating API Template (Analysis Product Inspection).

Creating API formulas can be made as easy as possible, where a special formula is created with APK, AVG format and the final result is stored in a separate file with a lock so that the formulated formula does not change when the application is used. So that if this application file is used by someone else, the formula in it is certain not to change according to the initial creation.

ANALYSIS PRODUCT INSPECTION (API)

Date Inspection :
Drawing :
Item No :
Customer :

No	Dimension Tolerance	Upper Limit	Lower Limit	Exam p 1	Exam p 2	Exam p 3	Exam p 4	Exam p 5	Cpk	Avg	TRUE	FALSE

MEASURING TOOLS USED

No	Measurement	Long & Hight	Code Inventaris	Regular Calibration	Condition

NOTE REASON

Approval	Approval Analysis Product			Final Result Analysis
Name & Signature	Production Engineering	Riset & Development	Purchasing	Pass ☐ Reject ☐
Date	Date	Date	Date	

Picture 2. API Template (Product Inspection Analysis)

3.2 Piston Displacer Cap Modeling Results

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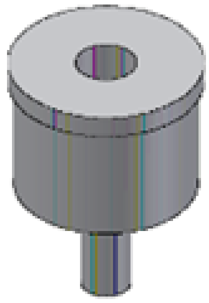
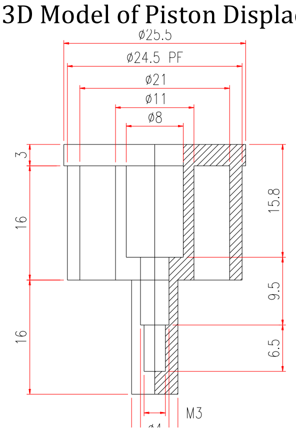
The model image using Autodesk Inventor 2018 Software takes part of the Piston Displacer Cap component. This component is taken as an example because this component has a function related to other components and the precision of the size will greatly affect the performance of the Stirling engine that will be made later.



Picture 3. 3D Model of Piston Displacer Cap



Picture 4. 2D Piston Displacer Cap Model

3.3 Data processing

Table 1. Piston Displacer Cap Measurement Results

Basic Dimension	Sampling 1	Sampling 2	Sampling 3	Sampling 4	Sampling 5
$\emptyset 8.0 \pm 0.10$	8.03	8.04	8.04	8.02	8.04
$\emptyset 11.0^{+0.00}_{-0.10}$	10.09	10.08	11.01	10.09	10.08
$\emptyset 21.0^{+0.10}_{-0.15}$	21.11	21.10	21.09	21.10	21.10
$\emptyset 24.5^{+0.20}_{-0.05}$	24.60	24.70	24.70	24.65	24.70
$\emptyset 25.5^{+0.20}_{-0.05}$	25.50	25.50	25.70	25.65	25.50

From the table above shows the measurement results of the Piston Displacer Cap carried out before the data presentation. It can be seen in points 2, 3 and 4 on the component there are red numbers which means that the inspected part is outside the previously set basic inspection limits. So the potential for measurement errors in that part is very likely to be imprecise with other components.

- API (Analysis Product Inspection) Results Perpoint CPK

From the CPK results, we can create an average inspection result per point that varies, depending on the initial measurement results that also vary. In principle, the measurements are not only carried out once because they take 5 measurement samples so that the results are also diverse, the goal is to ensure that the measurement results can be more varied so that the more samples are measured, the more data we can obtain that we can process. From the measurement results, an average measurement result is then created to obtain data as seen in the table below.

Table 2. Piston Displacer Cap Measurement Results with CPK

Basic Dimension	Sampling 1	Sampling 2	Sampling 3	Sampling 4	Sampling 5
$\emptyset 8.0 \pm 0.10$	8.03	8.04	8.04	8.02	8.04
$\emptyset 11.0^{+0.00}_{-0.10}$	10.09	10.08	11.01	10.09	10.08
$\emptyset 21.0^{+0.10}_{-0.15}$	21.11	21.10	21.09	21.10	21.10
$\emptyset 24.5^{+0.20}_{-0.05}$	24.60	24.70	24.70	24.65	24.70
$\emptyset 25.5^{+0.20}_{-0.05}$	25.50	25.50	25.70	25.65	25.50
Basic Dimension	CPK				
$\emptyset 8.0 \pm 0.10$	-0.97				
$\emptyset 11.0^{+0.00}_{-0.10}$	-0.22				
$\emptyset 21.0^{+0.10}_{-0.15}$	0.86				
$\emptyset 24.5^{+0.20}_{-0.05}$	0.11				
$\emptyset 25.5^{+0.20}_{-0.05}$	0.11				

Table 2 shows the results of the Piston Displacer Cup measurements using CPK (Deviation) at points 2 and 3. There are red values indicating deviations in the part.

- API (Analysis Product Inspection) Results Per AVG Point

Table 3. Piston Displacer Cap Measurement Results with AVG

Basic Dimension	Sampling 1	Sampling 2	Sampling 3	Sampling 4	Sampling 5
$\emptyset 8.0 \pm 0.10$	8.03	8.04	8.04	8.02	8.04
$\emptyset 11.0^{+0.00}_{-0.10}$	10.09	10.08	11.01	10.09	10.08
$\emptyset 21.0^{+0.10}_{-0.15}$	21.11	21.10	21.09	21.10	21.10
$\emptyset 24.5^{+0.20}_{-0.05}$	24.60	24.70	24.70	24.65	24.70
$\emptyset 25.5^{+0.20}_{-0.05}$	25.50	25.50	25.70	25.65	25.50
Basic Dimension	CPK				
$\emptyset 8.0 \pm 0.10$	8.03				
$\emptyset 11.0^{+0.00}_{-0.10}$	10.27				
$\emptyset 21.0^{+0.10}_{-0.15}$	21.10				
$\emptyset 24.5^{+0.20}_{-0.05}$	24.67				
$\emptyset 25.5^{+0.20}_{-0.05}$	25.57				

Table 3 above shows the results of the average Piston Displacer Cup measurement. At point 3, there is a red number, which indicates that the inspection section indicates that the inspection dimensions are outside the limits.

4. Conclusion

From the measurements that have been carried out and processed using the API (Analysis Product Inspection) method, the following conclusions can be drawn:

1. The results of the measurement of the Piston Displacer Cup of the Stirling engine using CPK (deviation) obtained results of -0.97, -0.22, 0.86, 0.11 and 0.11 between zero and one indicating that the average process is within the specification limits but the variation part is outside the specifications
2. The results of the measurement of the Piston Displacer Cup of the Stirling engine On average, there are red numbers indicating that the inspection dimensions are outside the basic dimensions, especially at point number 4, samples 2, 3 and 5 are all outside the tolerance limits that have been set.

The results of the study show that this study still uses the latest Auto Cad and Autodesk inventor applications so that there are still many shortcomings in the design that can be displayed due to limited facilities. There is still a lot to be developed in this study because the components used for the Stirling engine are very numerous and require high precision so that measurements and testing must be carried out on each component.

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