



Design and Construction of Special Tools for Rear Seal Removal and Installation on Komatsu Engine Flywheel Housing

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Abstract

This research focuses on the innovation of mechanical work aid design in the form of special tools specifically used to remove and install the rear seal on the flywheel housing of Komatsu diesel engines type SAA6D107E-1 and SAA4D95LE-3. One of the procedures that is still done manually and has high risk is the replacement of the rear seal on the flywheel housing. The purpose of using special tools is to gain efficiency in the removal and installation of the rear seal on the flywheel housing. The research method includes field observation, component measurement, 2D and 3D design, and direct field trials. The test results show that this tool can reduce the processing time from 55 minutes to 20 minutes. The use of these special tools helps technicians in increasing the work speed in removing and installing without causing damage to other components.

Keywords: *Rear Seal, Flywheel Housing, Diesel Engine, Heavy Equipment*

Abstrak

Penelitian ini berfokus pada inovasi rancang bangun alat bantu kerja mekanik dalam bentuk *special tools* khusus digunakan untuk melepas dan memasang rear seal pada *engine* pada *fly wheel housing diesel engine komatsu* tipe SAA6D107E-1 dan SAA4D95LE-3. Salah satu prosedur yang masih dilakukan secara manual dan berisiko tinggi adalah penggantian rear seal pada *flywheel housing*. Tujuannya penggunaan alat special tools adalah untuk mendapatkan efisiensi waktu pengerjaan *remove and install seal rear* pada *fly wheel housing*. Metode penelitian meliputi observasi lapangan, pengukuran komponen, perancangan 2D dan 3D, serta uji coba langsung di lapangan. Hasil uji menunjukkan bahwa alat ini dapat mengurangi waktu pengerjaan dari 55 menit menjadi 20 menit. Penggunaan special tools ini membantu teknisi dalam meningkatkan kecepatan kerja dalam melakukan *remove and install* tanpa mengakibatkan kerusakan pada komponen lainnya.

Kata kunci: *Sil Kruk As Belakang, Rumah Roda Gila, Kunci Spesial, Efisiensi Waktu, Mesin Diesel, Alat Berat*



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1. Introduction

A seal is a machine component that functions as a barrier to keep lubricant in the working area. Lubricants are applied to friction points to reduce the coefficient of friction, maintain mechanical stability, and increase component durability. Oil seals are specifically designed to prevent lubricating fluid leakage through bearing clearances in parts experiencing rotational or translational movement [1]. The seal receives a significant amount of stress, which in turn reduces its durability [2] [3].

This component requires maintenance and care. Conventional rear seal replacement carries a high risk of damaging other components and requires a long time for technicians to remove the component. Therefore, innovation in the form of special tools is needed to speed up the process and improve the safety of heavy equipment technicians. The tools used by technicians in carrying out maintenance, care, and repair work can include general tools and special tools or special service tools (SST) [4].

Difficult work in repair technicians can use special service tools called special service tools (SST). With the use of these tools, repair work can be completed quickly, precisely, and efficiently without damaging the parts being worked on [5]. In the process of removing and installing components, special service tools are very necessary to provide ease in removing components that are difficult to remove with ordinary hand tools [6]. Innovation in product remove and install components on heavy equipment units has several significant benefits in labor efficiency and increasing work productivity and labor resources can be optimized by using innovation in product remove and install [7]. In making improvements to simplify and increase safety in removing components that are done manually and using special service tools (SST), the time efficiency obtained is very significant in use to reduce loading and unloading time [8].

Repairing and replacing the rear flywheel housing seal on the crankshaft is crucial to prevent oil or lubricant leaks. However, conventional methods often used by technicians are still inefficient and require significant processing time. Therefore, this research aims to design an innovative work aid. This tool is designed to increase technician efficiency and productivity in the removal and installation of components, thereby speeding up cycle times on heavy equipment diesel engine units and minimizing the risk of damage to other components.

2. Method

This research uses the trial process stages as shown in the following flowchart. The research methodology is conducted through a systematic workflow that begins with the Start phase, followed by an Observation stage to identify field conditions and existing challenges. This is followed by an Analysis phase to determine technical requirements, which then informs the Design Planning and the more technical 2D–3D Planning stages to ensure precise tool modeling. Once the design is finalized, the process moves into Testing, where the tool's performance is empirically evaluated. A critical decision point, Tools Appropriate?, determines the next step; if the tool meets the required standards (Yes), it proceeds to the final Finish stage. If the tool is not found to be appropriate (No), the flow directly bypasses further testing to conclude the current cycle at the Finish point.

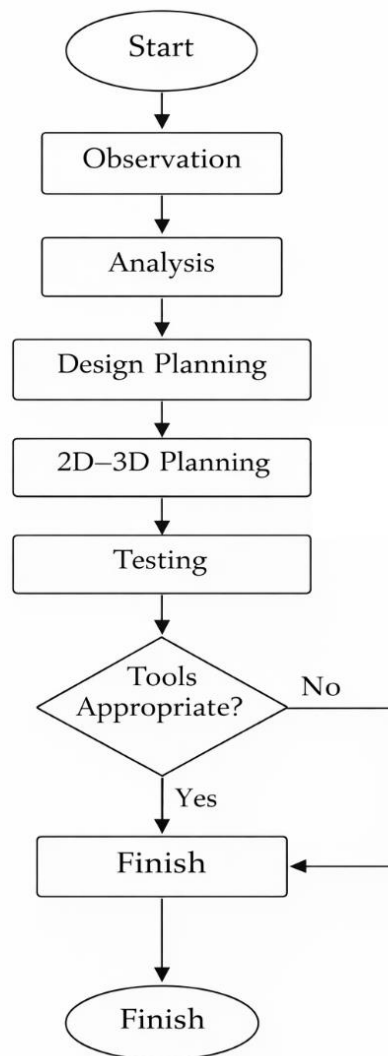


Figure 1. Research Flowchart

2.1 Observation

The initial step in the research was to conduct observations, map the problem, and measure the components on the rear seal flywheel housing of the diesel engine. Data collection techniques were used to obtain supporting data for the research. Data collection was conducted through direct field observations of the SAA4D95LE-3 diesel engine on a Komatsu excavator.



2.2 Analysis

The damage condition of the rear seal flywheel housing on a diesel engine was analyzed based on its age, material type, and seal specifications. This required measurements of its dimensions and mounting conditions.

2.3 Design Planning

By optimizing the design through Computer-Aided Design (CAD) engineering drawings, the flywheel rear seal housing removal and installation process can be designed and simulated using CAD software to find the best solution for efficiently implementing special tool designs. In every stage of tool or engine planning, material selection is a crucial aspect to consider. As a first step in tool or engine planning, it is essential to first determine the type of material that best suits the design characteristics of the tool or engine to be used [9] [10].

2.4 2D-3D Design

The purpose of the design is to determine the dimensions and component standards required for the component. Testing is carried out to determine whether the tool can be used, functions, and conforms properly. Dimensional measurement analysis is performed on SolidWorks components.

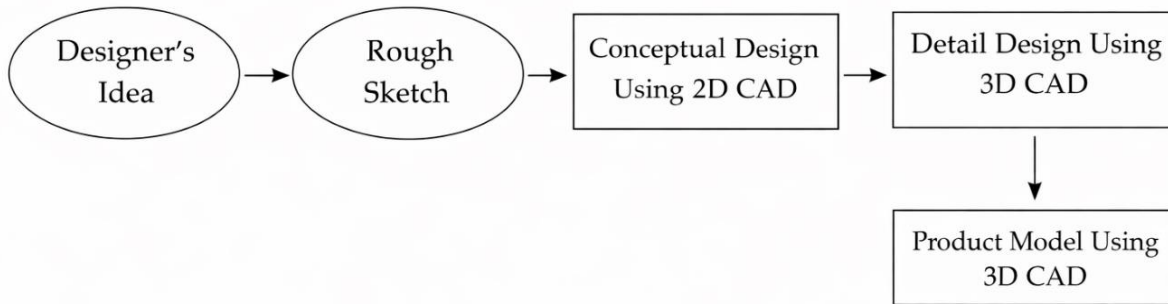


Figure 3. Design optimization model using CAD techniques

A Computer-Aided Design (CAD)-based design optimization method is applied to the design and manufacturing stages of tools through a product design flow integrated with Computer-Aided Engineering (CAE), starting with conceptual design. The primary focus of optimization lies in formulating design problems accurately and evaluating the resulting solutions to achieve the most optimal design results [11].

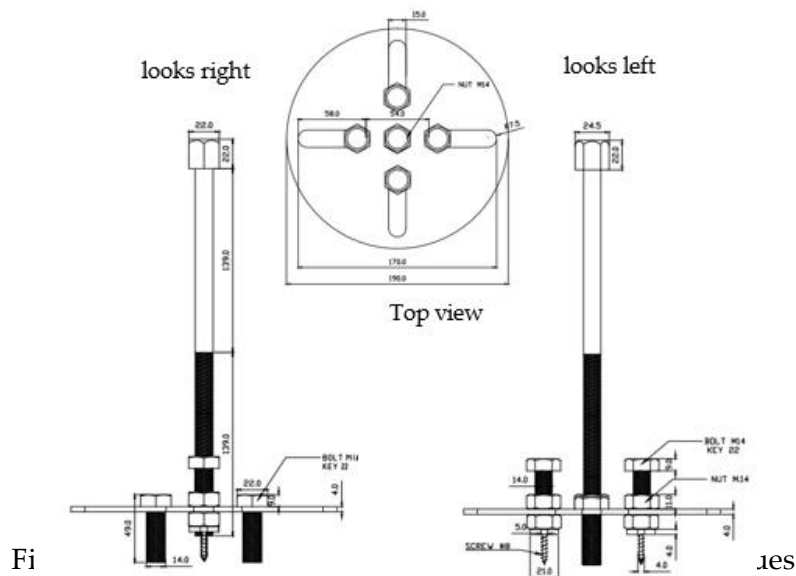




Figure 5. 3D Design Tools

3. Design Implementation

S45C steel is a medium carbon steel with a carbon content of 0.45%, providing strength and hardness [12]. This type of steel is the material of choice for making special service tools for removing and installing rear seals on Komatsu engine flywheel housings. The tool manufacturing process involves creating a pattern on a plate from the material used [12]. The prepared plate is patterned according to the 2D design. The special tool is made from 4 mm steel plate, 14 mm round steel rod, and equipped with an M14 and M12 thread system. The tool manufacturing process involves cutting, machining, welding, and drilling. In designing a tool or machine, material selection is a fundamental aspect that must be determined from the initial planning stage, because the suitability of the type of material with the design characteristics greatly determines the performance and reliability of the tool being designed [13] [14].



Figure 6. Pattern making and material cutting & machining



Figure 7. Threading & welding of bracket nut



Figure 8. Drilling bracket screw

The development of an ergonomic Flywheel Holder tool was carried out to improve comfort and safety at work and speed up the work process of maintenance technicians. This special tool designed serves as a solution in improving the efficiency and ergonomics of the workshop work system. Design efforts were carried out through modeling using CAD software and CAE-based analysis to obtain an accurate, effective, and efficient design, so as to be able to meet functional needs and operational technical demands in the field [15].

4. SST Testing Process

Testing is conducted on diesel engines using conventional methods and innovative special service tools, as shown in the following figure.



Figure 9. Working using conventional methods



Figure 10. Work with innovative work aids

5. Test Results and Discussion

The average processing time obtained using the two methods is shown in the following table.

Table 1. Conventional processing time

Work Items	Trial			Average Processing Time (minutes)
	Processing Time (minutes)			
	I	II	III	
Remove Seal Housing	25	30	35	30
Install Seal Housing	30	35	38	34
Remove & Install Seal	45	65	60	61

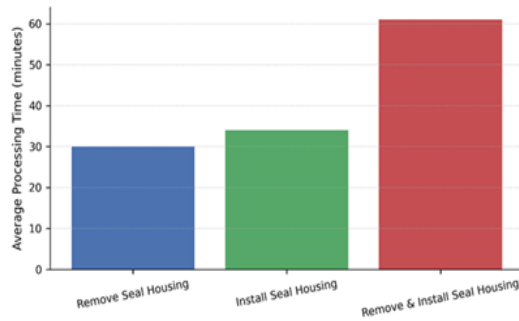


Figure 11. Conventional processing time

Based on the data presented in Table 1 and Figure 11, the conventional processing time for rear seal housing operations was evaluated through three work items: *Remove Seal Housing*, *Install Seal Housing*, and *Remove & Install Seal*. Each work item was tested through three experimental trials, and the average processing time was calculated to represent typical operational duration. The results show that the *Remove Seal Housing* process required an average processing time of 30 minutes, while the *Install Seal Housing* process took slightly longer at 34 minutes, indicating higher precision and alignment requirements during installation. The *Remove & Install Seal* process exhibited the longest average processing time at 61 minutes, reflecting the cumulative workload and increased operational complexity of sequential removal and installation activities.

Overall, the table and graph clearly indicate that the combined remove and install operation is the most time-consuming process. This finding demonstrates the limitations of conventional methods and emphasizes the need for process optimization or the implementation of specialized tools to improve efficiency and reduce maintenance time.

Table 2. Work time using innovative work aids (SST)

Work Items	Trial			Average Processing Time (minutes)
	Processing Time (minutes)			
	I	II	III	
Remove Seal Housing	7	8	8	8
Install Seal Housing	12	13	10	12
Remove & Install Seal	19	21	18	19

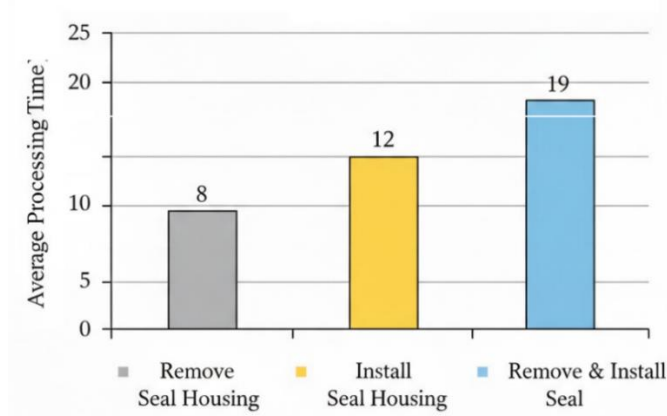


Figure 12. Work time using innovative work with Special Service Tools (SST)

Table 2 and Figure 12 present the work time performance using innovative work aids in the form of Special Service Tools (SST). The experimental results show that the average processing time for the *Remove Seal Housing* operation is 8 minutes, while *Install Seal Housing* requires an average of 12 minutes, and the combined *Remove & Install Seal* process takes 19 minutes. The consistency of processing times across three trials indicates that the application of SST provides stable and repeatable performance during each work stage. As illustrated in Figure 12, the shortest processing time is observed in the seal housing removal process, whereas the combined removal and installation process requires the longest duration due to the integration of multiple work steps. In conclusion, the implementation of SST contributes to improved operational efficiency and process reliability, making it a suitable and effective solution for supporting seal removal and installation activities in heavy equipment engine maintenance.

3. Conclusion

Based on the design and manufacture of a technician's work aid, a special service tool innovation for removing and installing the rear seal housing on the SAA4D95LE-3 diesel engine flywheel, it can be concluded that the developed tool has proven effective in increasing work efficiency. The use of this special tool reduced the average time for removing and installing the rear seal housing to 19 minutes, compared to the conventional method, which requires an average

of 60 minutes. This increased efficiency demonstrates that the tool design meets the functional and operational requirements for engine maintenance and care.

The alignment of special tool designs with job functions not only increases efficiency but also improves technician safety and security by reducing the risk of errors and potential component damage. Based on the resulting performance, safety, and operational effectiveness, this tool is deemed suitable for widespread implementation in heavy equipment engine maintenance and repair activities.

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