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Development of a Special Tool for Prefilter Glass Removal on Excavator PC400-8

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ABSTRACT

Periodic maintenance of hydraulic excavators, such as the PC400-8, is essential to ensure optimal performance in tasks like loading materials such as soil, rocks, and others into dump trucks. One of the challenges during periodic maintenance is the removal of the prefilter glass, which is often difficult due to the hardness of the material. The tool currently used, a standard filter wrench, lacks precision and frequently slips, increasing the risk of breaking the prefilter glass and causing potential injury to mechanics. To address this issue, this study develops an innovative prefilter glass removal tool using the 7 Ups++ method, an approach that involves evaluating aspects such as usability, efficiency, ergonomics, safety, sustainability, precision, and quality. The innovation aims to reduce the risk of glass breakage and enhance the safety of mechanics. The research results indicate that the designed tool can significantly reduce difficulties and is estimated to reduce the risk of prefilter glass breakage by approximately 90% during use, while also saving 50–105 seconds per operation. This leads to a performance improvement of 83%–87.5% and enhanced occupational safety, and has the potential to make a positive contribution to periodic service procedures and workplace safety in the heavy equipment industry.

Keyword: *Prefilter, tools innovation, Periodic service.*

ABSTRAK

Servis berkala pada unit hydraulic excavator, seperti PC400-8, penting untuk menjaga kinerja optimal dalam tugas memuat material seperti tanah, bebatuan, dan lainnya ke dump truck. Salah satu tantangan dalam servis berkala adalah pembukaan prefilter glass yang sering sulit karena kerasnya material tersebut, di mana alat yang digunakan saat ini, kunci filter standar, kurang presisi dan sering meleset, sehingga meningkatkan risiko pecahnya kaca prefilter dan potensi cedera bagi mekanik. Untuk mengatasi masalah ini, penelitian ini mengembangkan inovasi alat pembuka prefilter glass dengan metode 7 Ups++, sebuah pendekatan yang mencakup evaluasi aspek penggunaan, efisiensi, ergonomi, keamanan, keberlanjutan, presisi, dan kualitas. Inovasi ini bertujuan untuk mengurangi risiko pecahnya prefilter glass dan meningkatkan keselamatan kerja bagi mekanik. Hasil penelitian menunjukkan bahwa alat yang dirancang secara signifikan dapat mengurangi kesulitan dan diestimasikan dapat mengurangi risiko pecahnya kaca prefilter glass sekitar 90% saat digunakan, sekaligus menghemat waktu sebesar 50 – 105 detik setiap kali pengerjaan sehingga terjadi peningkatan kinerja sebesar 83% - 87,5% dan keselamatan kerja, serta berpotensi memberikan kontribusi positif terhadap prosedur servis berkala dan keselamatan kerja di industri alat berat.

Keyword: Prefilter, inovasi tools, servis berkala.

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1. Introduction

Heavy equipment refers to mechanical machinery designed to facilitate various types of construction and industrial work, making processes faster, more efficient, and producing results that meet expectations. The use of heavy equipment varies widely, from excavation and material handling to earthworks and other construction activities. To ensure that heavy equipment operates optimally, its use must be tailored to the specific conditions and situations on-site, considering the different nature of tasks and the need for adjustments based on the type of material and terrain involved.

One of the most important types of heavy equipment, particularly in the mining and plantation industries, is the excavator [1]. Excavators are used for a variety of heavy-duty tasks, such as digging, material handling, and other operations that require strength and high maneuverability. Due to their intensive use, excavators require periodic maintenance to ensure that all components function properly and that the unit continues to operate at maximum efficiency [2]. This periodic maintenance involves replacing and removing various components that are worn or damaged [3].

However, the maintenance process does not always proceed smoothly. One common challenge encountered is the removal of the prefilter glass, an essential component responsible for filtering debris before it enters the engine system [4]. The removal of the prefilter glass often becomes problematic due to its tightness and difficulty in being detached. In practice, the removal of the prefilter glass is typically performed using a chain or belt-type filter wrench. These tools often lack precision and can slip, potentially causing the prefilter glass to crack or even break [5]. This poses additional risks, both in terms of the safety of the mechanics performing the maintenance and in terms of costs, as broken glass must be replaced, thereby increasing overall maintenance expenses. Furthermore, this issue affects not only costs but also time efficiency [6]. An inefficient process for removing the prefilter glass can extend the duration of maintenance, reduce productivity, and result in longer equipment downtime. This is particularly detrimental in operational contexts where speed and timeliness are critical. Therefore, innovative solutions are needed to address this problem by creating a special tool that is more precise, safe, and effective for removing the prefilter glass [7][8].

Based on this background, this study aims to design and develop a special tool specifically to improve the efficiency of the prefilter glass removal process. This tool is expected to address common challenges in the field, such as precision issues and the potential for glass damage, while also enhancing workplace safety and reducing maintenance costs [9]. The specifications of the designed tool and the steps for its development will be detailed in the following chapters, with the goal of providing a precise solution to improve productivity and reduce time and cost losses in heavy equipment operations [10].

2. Method

Figure 1 illustrates the Seven Up++ method as a guideline for innovation. This method is designed to make the innovation process more structured, easier to monitor, and well-documented, thereby facilitating continuous innovation [11]. With this approach, the results of innovation can be used as effective solutions when facing similar processes in the future. The first step before starting any improvement or innovation project is to conduct an analysis phase, followed by a solution phase, to achieve the desired outcomes [12][13].

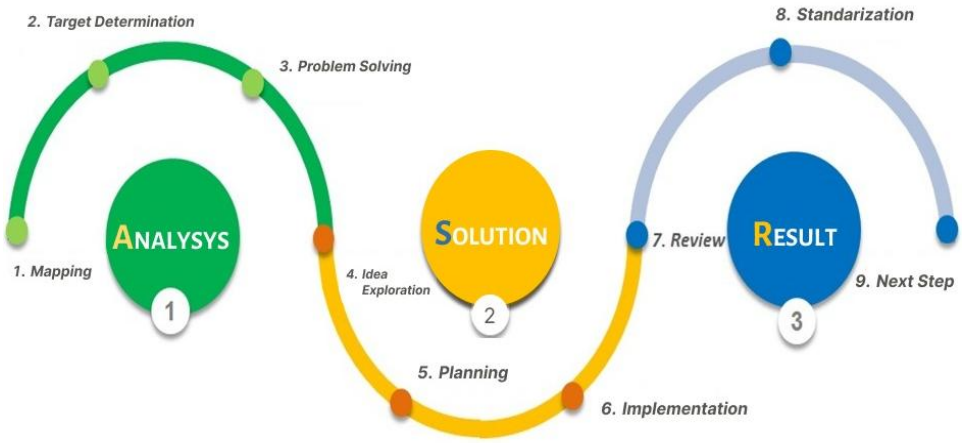

Figure 1. 7Up++ Method

This statement serves as the basis for the author to design and develop a special tool for the removal of the prefilter glass during periodic maintenance on the PC400-8 unit [14]. This innovation aims to provide an effective solution and improvement in the maintenance process to ensure the unit remains free from

productivity issues, reduce high costs due to glass damage, and lower safety risks identified in the hazard analysis and risk assessment for the PC400-8 unit [15].

3. Result & Discussion

3.1 Analysis

Analysis is the process of breaking down a complex problem into smaller parts, making it easier to understand. During Periodic Service (PS) activities [16], there will always be certain challenges, particularly with the prefilter glass component when attempting to remove it. According to the method described in the Operation & Maintenance Manual (OMM) for the PC400-8 and the actual conditions in the field, the process for removing the prefilter glass outlined in the Operation & Maintenance Manual [17]

Figure 2. Prefilter

There are issues such as the tightness of the glass and the continued use of a filter wrench, which creates problems for the mechanics. The filter wrench often slips due to its lack of precision, leading to potential glass breakage. Additionally, the cost of replacing the glass is quite high.

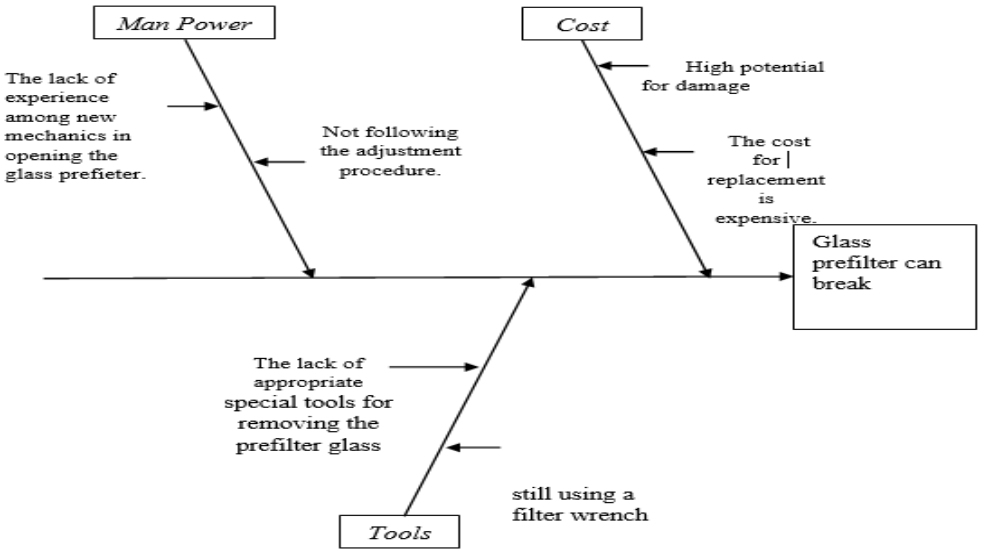

Figure 3. Fishbone Diagram

The fishbone diagram is used to identify the root causes of the limitations of the tools used for periodic service, which impact the prefilter glass. There are several factors contributing to the suboptimal removal of the prefilter glass, including: mechanics (manpower), tools, costs, and other factors.

3.2 Solution

The next step after carrying out the analysis process is to look for solutions to existing problems, to find an idea for the problem. In the planning process for making Special Tools for Glass Prefilter Remover on Excavator PC400-8 using the observation method (field survey) and library research [18], namely by reviewing the target object and looking at the dimensions in the shop manual [19]. and determine the steps in making tools. The next stage is to create a design plan for the Special Tools for Glass Prefilter Remover on Excavator PC400-8 which is shown in Figure 4. Designing a Special Tools for Glass Prefilter Remover on Excavator PC400-8 requires being able to visualize and know the function of the tool. The ideas of the problems carried out in this research can be seen from the table as follows. The materials used include a 108 mm diameter steel

pipe and a 0.3 mm thick steel plate [20].

Table 1. Idea Planning

	Root Cause Dominant	***Solution***	***Benefit***	***Final***
Cost	Potential for cracks or scratches on components, leading to very high replacement costs	Recycle components in the workshop	Rp.0-,	Creating special tools by utilizing available items in the workshop
Tools	The lack of appropriate tools to remove the glass prefilter in the workshop	Making a special tool for prefilter glass removal	Safer working processes and leftover fuel in the prefilter or glass can be collected in tools and reused	Creating a tool to replace the filter wrench with a glass prefilter remover
Man Power	During periodic service, it is common for there to be hard resistance when opening the glass prefilter	Socialization and training on special tools for mechanics	Rp.0-,	Providing socialization and training to mechanics on the correct use of special tools

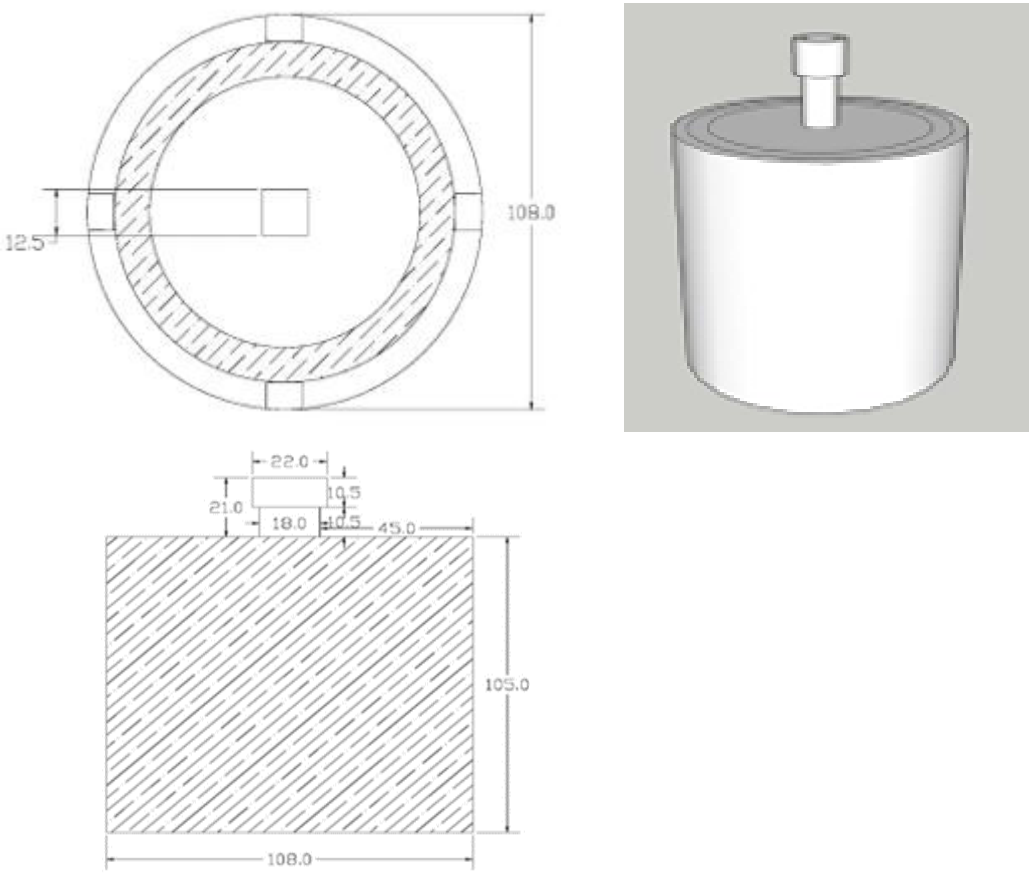

Figure 4. Special Service Tools Design

3.3 Result

During the application of removing the glass prefilter using this specialized tool, it is essential to focus on enhancing safety and efficiency in terms of time, effort, and protection of the workpiece. The use of this special service tool ensures a more streamlined and effective removal process. It significantly reduces the amount of time and physical effort required to complete the task, making the operation more efficient. Moreover, the tool is designed to minimize the risk of damage to the workpiece, thereby protecting both the component and the surrounding areas from potential harm. By employing this tool, the overall procedure becomes safer and more

controlled, leading to improved operational outcomes and a reduction in the likelihood of errors. Enhanced precision and reduced manual handling contribute to a more efficient and secure work environment. This approach not only optimizes the workflow but also promotes a higher standard of safety and quality in the task at hand. For a visual representation, refer to Figure 5, which illustrates the process of using the special tools.

Figure 5. Special Service Tools Testing

The results of this study demonstrate that the developed special tool for prefilter glass removal provides significant improvements in efficiency, safety, and operational reliability during periodic maintenance of the PC400-8 excavator. The evaluation was conducted by comparing the conventional method using a standard filter wrench with the proposed special tool through direct application during maintenance activities. The performance assessment focused on time efficiency, safety level, and component integrity. Based on repeated field trials, the average time required to remove the prefilter glass using a standard filter wrench ranged between 60–120 seconds, depending on the tightness of the glass and the operator's experience. In contrast, the use of the special tool reduced the removal time to approximately 10–15 seconds, resulting in a time savings of 50–105 seconds per operation, equivalent to an efficiency improvement of approximately 83%–87.5%.

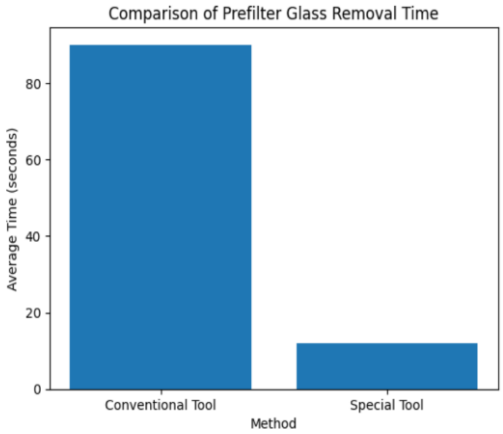

Figure 6. Comparison Table

The results of innovative ideas and research ideas that were obtained before improvements were made and after improvements were made using Special Tools for Glass Prefilter Remover on Excavator PC400-8 are discussed in table 2 below.

Table 2. Before & After Comparison

Aspect	Before project	After project
Cost.	The potential for cracking is quite high, and the cost of components is relatively expensive.	The potential for cracks can be minimized, and component replacement is not required
Morale.	The customer lacks confidence in the mechanic due to the damage to the glass component.	Customers have more trust and mechanics are safer in their work

Aspect	Before project	After project
Productivity.	When the glass breaks, the productivity of the unit decreases	The productivity of the unit remains uninterrupted.

The introduction of the special tools has significantly simplified the mechanic's task of removing the prefilter glass. These tools have proven to make the process considerably more efficient, allowing the job to be completed approximately 10 to 15 seconds faster than before. This reduction in time is substantial, considering that the previous method required 1 to 2 minutes for the same task. Moreover, the special tools have enhanced the safety of the operation. Previously, using a standard filter wrench often resulted in the prefilter glass breaking, which posed a risk of damage and necessitated additional repairs or replacements. In contrast, the special tools have been designed to handle the prefilter glass more delicately and securely, significantly reducing the likelihood of breakage. This advancement not only streamlines the workflow and increases productivity but also ensures greater safety and reliability when dealing with fragile components. The improved efficiency and safety offered by these tools contribute to a more effective and dependable maintenance process, ultimately benefiting both the mechanic and the overall operation.

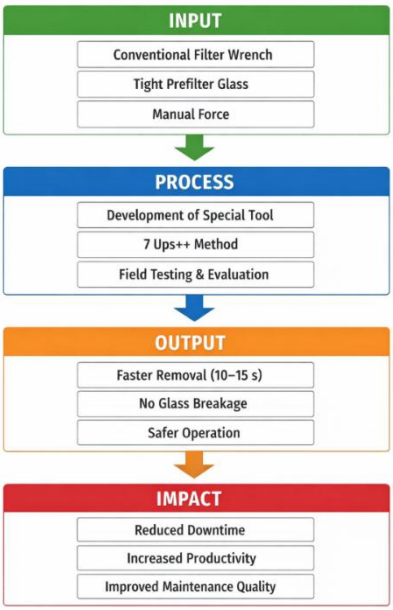

Figure 7. Conceptual Framework and its Impact

Figure 7 illustrates the IPOI framework highlighting the quantitative impact of the developed special tool on maintenance performance. The conventional method requires high manual force and is associated with tool slippage and glass breakage risk, leading to longer task duration and increased maintenance cost. Following systematic tool development and field validation, the proposed tool reduces prefilter glass removal time to approximately 10–15 s, representing a time efficiency improvement of more than 70% compared to the conventional approach. Glass breakage incidents were eliminated, corresponding to an estimated ~90% reduction in operational risk, while operator physical strain was significantly reduced. These improvements result in lower replacement costs, reduced unplanned downtime, improved work efficiency, and enhanced operator safety and morale, providing a quantitative basis for future durability, scalability, and standardization studies.

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