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Reducing reject cotter valve skyrocketing cylinder head parts in retainer press machine process in the automotive industry

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ABSTRACT

The automotive industry is an automotive company that produces various types of motorcycles, such as automatic, sport and cub. One of the processes is machining. This process is very important because quality is highly considered. In the machining process, the products produced are crankcase R, crankcase L, cylinder comp, cylinder head, crankshaft. Based on initial observations, this process found reject goods. In the cylinder head line machining area, especially the retainer press machine, there is a problem of reject cotter valve soaring and resulting in the repair process. This will have an impact on the addition of time to repair and product quality is reduced. PT XYZ is facing a problem with cotter valve soaring on the cylinder head product with daily report data for the last 3 months, the percentage of cotter valve soaring problems reaching 1.5% exceeding the maximum defect target of 0.5%. This study aims to reduce the level of reject cotter valve soaring during the retainer press machine pressing process. The method used is eight steps. One solution is to modify the punch size to adjust the urethane punch to work optimally. This process will have an impact on reducing the number of rejects. In addition, this repair also does not cause a repair process on the cylinder head part. The results of this study are very significant with the reduction in cotter cases soaring to 0.2%

1. Introduction

The automotive industry is a company engaged in the automotive industry in Indonesia (Aprianto et al., 2022; Setiawan & Setiawan, 2020; Suratno & Ichtiarto, 2021). Since its inception, this industry has been committed to continuing to innovate and develop technology in making quality and environmentally friendly motorcycles. This company always provides products that meet the needs of the Indonesian people with high quality and are equipped with sophisticated technology (Abhilash & Thakkar, 2019; Irwanto et al., 2020; Praharsi et al., 2020). This company produces several types of motorcycles including sports motorcycles, cub motorcycles, automatic motorcycles. This company carries out various big part manufacturing processes for motorcycles such as crankcase R, crankcase L, cylinder head, cylinder comp, wheel, farme, and body. One of the manufacturing processes carried

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out is the machining process. Machining is an important manufacturing process where cutting tools are used to remove material in the form of chips, which can be varied in size depending on the method used, after the product has been cast (Murray et al., 2024). The company applies this machining process to several of their main products, such as crankcases, cylinder heads, cylinder comps, crank shafts.

This automotive industry has various problems faced. The problem currently being experienced is the occurrence of reject goods which results in the repair process in the machining area on the cylinder head line. Cylinder head is one of the components in a motorcycle engine that functions as an air and fuel inlet to the engine (intake) and also as an exhaust outlet for combustion residue which is processed by casting the Low Pressure Die Casting type. The cylinder head in the machining line undergoes several processes, including rotary milling, drilling, milling-reaming, tapping, boring, valve boring, leak testing for material, seat ring and valve guide installation, chamfering-reaming, washing, sub-assembly, retainer pressing, and valve leak testing. The process carried out on the cylinder head line has a problem that arises, namely when the operator carries out the process on the retainer press machine using the product, it is found that there is a problem in the in and ex valve areas, namely the problem of the cotter valve which skyrockets during the pressing process which results in rejects on the cylinder head product and this results in a time-consuming repair process for the operator to carry out the next pressing process on other cylinder head products and also makes the quality of the product less good. Based on the report data obtained, it is known that 3132 products experienced a sharp increase in reject cotter for 3 months in January 2023-March 2024. Therefore, it is necessary to conduct an analysis of the indications of the causes of the sharp increase in cotter valve and make improvements.

To ensure the final product meets company standards, product quality control needs to be implemented throughout the manufacturing process, from initial machining to the finished product (Nurjaman et al., 2024); Gandara & Hasibuan, 2020). This system helps maintain product quality and reduces the occurrence of defects. Based on previous research by (Darmawan et al., 2018), product quality cases can be improved using the eight-step method. Research (Sulaeman & Gusniar, 2023) also uses the eight-step method as a method to resolve customer complaints. This study aims to reduce the level of sharp increase in reject cotter valve during the retainer press machine pressing process

2. Methods

This data analysis uses the eight steps method on the retainer press machine, there are a series of steps that must be followed to achieve optimal results (Khamaludin & Respati, 2019; Suratno & Ichtiarto, 2021). The eight steps methodology can be seen in Fig. 1.

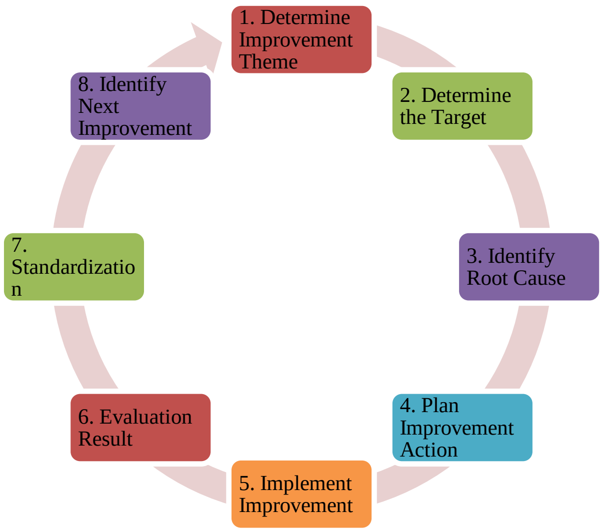

Fig. 1 Eight steps methodology.

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The first step is to determine the theme by identifying and setting clear objectives of the study. The next step is to set targets to be achieved in the study. This step will help in directing the focus and research efforts in the right direction. Based on the initial steps completed, the next step is to analyze the existing conditions on the retainer press machine. Based on this analysis, aspects such as performance, reliability, and problems that may occur on the machine will be evaluated in depth. Based on the analysis of existing conditions, an appropriate improvement plan can be formulated. This step involves designing strategies and tactics to overcome problems found on the retainer press machine. The next step is the improvement plan and implementation stage. This step includes the implementation of the previously designed improvement plan. Based on the results of the implementation, an evaluation of the results of the effectiveness and success of the improvements that have been made will be carried out. The next step is to standardize. The last process is to carry out the next improvement plan.

3. Results and Discussion

The results and discussion sections are one of the challenging sections in your article. The purpose of the Results section is to present the key results of your research. Results and discussions can either be combined into one section or organized as separate sections depending on the journal's requirements to which you are submitting your research paper. Use subsections and subheadings to improve readability and clarity. Number all tables and figures with descriptive titles. Present your results as figures and tables and point the reader to relevant items while discussing the results. This section should highlight significant or interesting findings along with P values for statistical tests. Be sure to include negative results and highlight the potential limitations of the paper. The reviewers will criticize you if you don't discuss the shortcomings of your research. This often makes up for a great discussion section, so do not be afraid to highlight them.

Determine the Theme

A company's Key Performance Indicator (KPI) aims to reduce the reject rate as part of its target-setting process. In this study, the KPI for machining production is established, with a target reject rate of 0.3% from the total machining production conducted over three months (January–March 2024), amounting to 204,600 products. The acceptable reject limit for machining is 0.5%. However, in this case, the product experienced an increasing reject rate over the three-month period. In January, there were 843 rejected products out of 68,200 produced, resulting in a rejection rate of 1.23%. In February, the number of rejected products increased to 929 out of 68,200, bringing the rejection rate to 1.35%. The highest rejection rate occurred in March, with 1,360 rejected products out of 68,200, reaching 2.1%. On average, the reject rate for the three-month period was 1.5%. As a result, the company incurred a cost of quality amounting to IDR 38,496,000, which includes both unusable rejected products and rework expenses. Based on initial observations, it can be seen from the Pareto diagram showing data from the 4 largest rejects on the cylinder head product machining line, the most data is the case of soaring cotter, which is 3132 pcs for 3 months. This problem contributes 88% of rejects on the cylinder head product. The results of this observation identify that the soaring cotter case requires improvement actions to solve the problems on the cylinder head product machining line. Pareto data can be seen in Fig. 2.

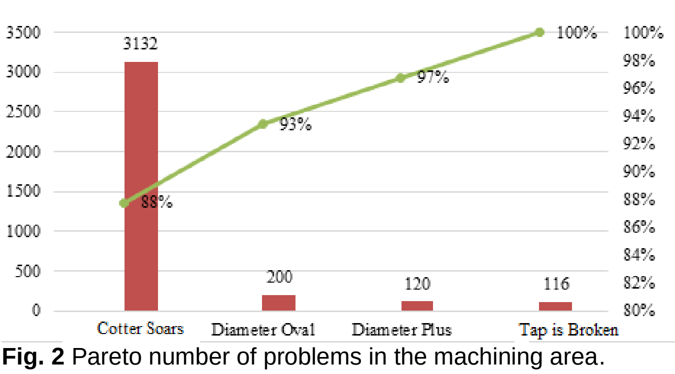

Fig. 2 Pareto number of problems in the machining area.

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Setting Targets

The target setting stage of the research requires Key Performance Indicators (KPI) for machining production. As a reference, the target set is to reach 0.3% of the total machining production carried out during the 3-month period of January 2024 - March 2024 amounting to 204,600 products, because the allowed machining rejects are 0.5%. The target setting graph can be seen in Fig. 3.

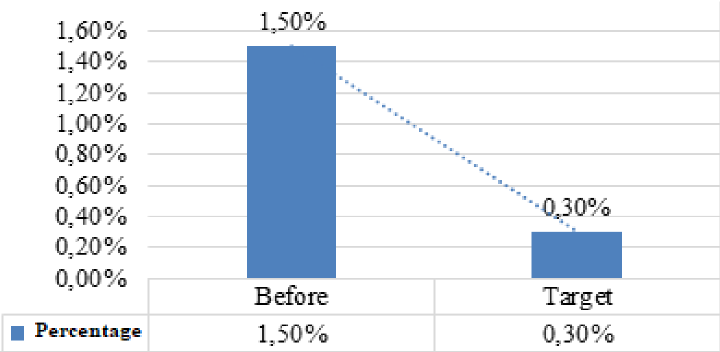

Fig. 3 Target decrease graph.

The purpose of setting these targets is to direct improvement efforts in a specific and measurable direction. Comparing the targets set with the current condition of the cotter valve jump allows for an assessment of the extent of improvement needed and a design of an appropriate strategy to achieve it. This step allows for a clear focus and targeted planning in an effort to reduce the number of cotter valve jumps and improve overall production quality. Based on the determination of these improvement targets, it is expected that the steps to be taken can successfully reduce the percentage of cotter valve jumps during the pressing process on cylinder head products by 1.2%.

Condition Analysis

This cause and effect diagram or fishbone analysis is conducted to find out the root cause of the soaring cotter valve problem which resulted in the repair process in the work process and overtime. The analysis factors in this fishbone are machines and humans which can be seen in Fig. 4.

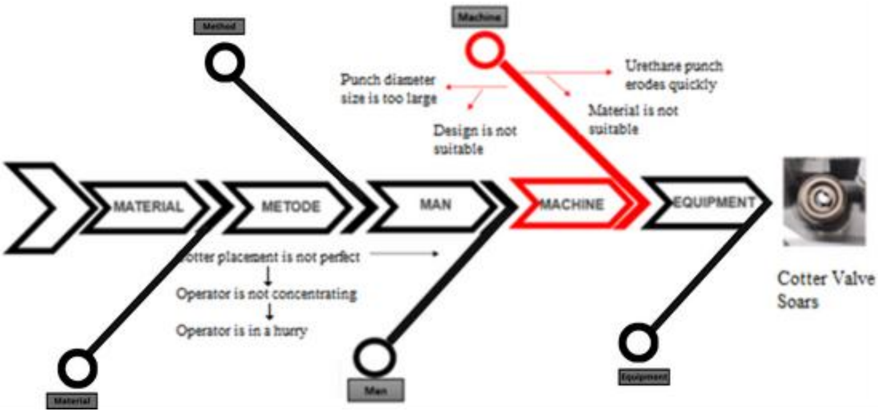

Fig. 4 Fishbone cotter valve soaring.

a. Machine Factor Analysis

The first factor is when the pressing process is carried out, the size of the inner diameter of the punch is not appropriate, this causes the service life of the urethane to be faster and results in the pressing process being imperfect and a part repair process must be carried out. According to (Lucky & Takim, 2015), that manufacturing defects can stem from inappropriate material selection and variations in process conditions, which significantly affect product quality. The second factor is the material used in the punch, namely urethane material, the service life of this material when used for the pressing process is quickly eroded and this is also the cause of the problem of the cotter jump case. This factor

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in the machine factor is an important factor that needs to be considered in efforts to improve and increase the quality of the pressing process on the cylinder head product. Identifying and overcoming this problem is expected to reduce the number of cotter valve jumps and increase the efficiency and quality of the manufacturing process as a whole.

b. Human Factor Analysis

Based on human factors, it was found that there is a potential for the cotter valve to jump due to imperfections in carrying out the initial process of pressing the retainer part and cotter valve using manual hands. This process is carried out before the pressing process which causes the cotter valve to be slightly uneven. The function of this emphasis is before the pressing process is carried out, the retainer part and cotter valve are in a straight position against the valve, the imperfection in this emphasis is caused by the lack of concentration of the operator working. This lack of concentration can be analyzed because of the factor of being too hasty during the pressing process, to the operator doing the work.

Looking for Ideas and Improvement Plan

Based on the analysis, several factors were found that caused the cotter valve to skyrocket, including machine and man factors. Then, a search for improvement ideas was conducted to overcome the problem and the result was an improvement idea using the 5W + 1H method (What, Why, When, Where, Who, and How). The following explanation is a table presenting the 5W + 1H method in Table 1.

Table 1 5W+1H

Factor	What	Where	Why	How	Who	When
Machine	The diameter of the urethane punch is too large and causes the punch to have a short service life, the urethane punch is quickly eroded.	Cylinder head machining line process	Design is not suitable	Modifying the size of the urethane punch and implementing it on the retainer press machine	Team	Jan24 - Jun24
	The diameter of the urethane punch is too large and causes the punch to have a short service life, the urethane punch is quickly eroded.	Cylinder head machining line process	Material is not suitable	Replacing the punch with a harder, more wear-resistant material	Team	Jan24 - Jun24
Man	Cotter placement is not in perfect position	Cylinder head machining line process	The operator is not concentrating due to being in a hurry when carrying out the work process	Conduct outreach to operators so that they do not rush the work process	Team	Jan24 - Jun24

Based on Table 1, several solutions have been identified to address this issue comprehensively. One of the key solutions is modifying the size of the urethane punch by making the hole in the punch diameter smaller. This aims to make the punch not easily eroded during the pressing process and also make the pressing process more perfect because the inner diameter of the punch is tighter and implement it on the retainer press machine. The steps of the repair plan that are carried out are by modifying the size of the urethane punch and making the urethane punch by giving the inner diameter of the punch to be smaller and longer in order to make the pressing process more durable and optimal because the diameter given to the urethane punch is smaller in diameter. In addition to modifying the punch size, further measures have been implemented to address other contributing factors. A Standard Operating Procedure (SOP) has been established to ensure a more structured and precise

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pressing process, thereby maintaining consistency and extending the punch's service life. Fig. 5 is a design image before and after improvement.

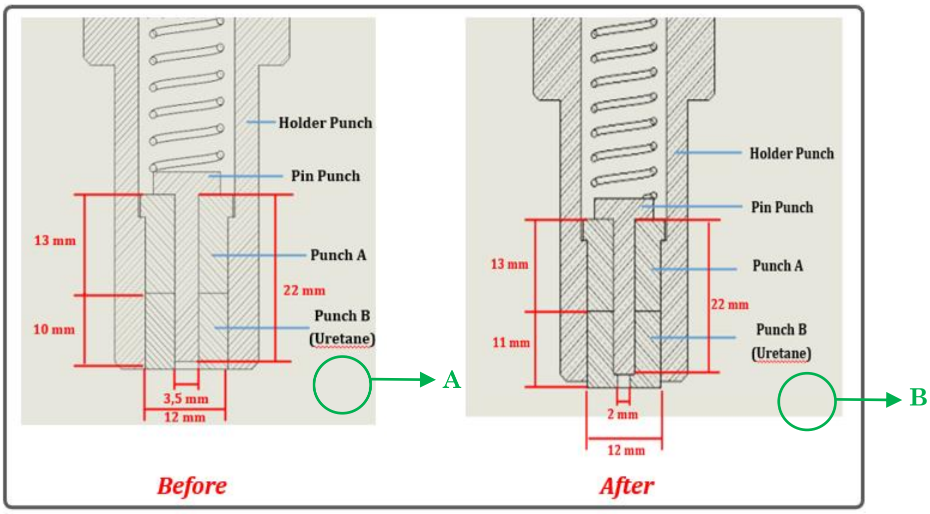

Fig. 5 Dimensions of the design plan before and after improvement

Based on Fig. 5, the main improvement is observed in the area marked with circles labelled A (Before) and B (After). Initially, in the "Before" condition, the hole size at point A was 3.5 mm. After the improvement, the hole size was reduced to 2 mm at point B. This modification enhances the precision and strength of the punched area, leading to better material integrity and reduced deformation.

Implementation of Improvement

The repair was carried out in accordance with the previous repair plan that had been prepared. The next step after discussing with the maintenance team, several steps were found that needed to be taken in this repair. Based on the analysis, one of the repairs made was to modify the size of the length of the urethane punch and also after that provide a larger diameter according to the valve size, which is 4.5 mm so that during the pressing process, the valve fits easily into the urethane punch. The following is a picture of the urethane size before the repair in Fig. 6.

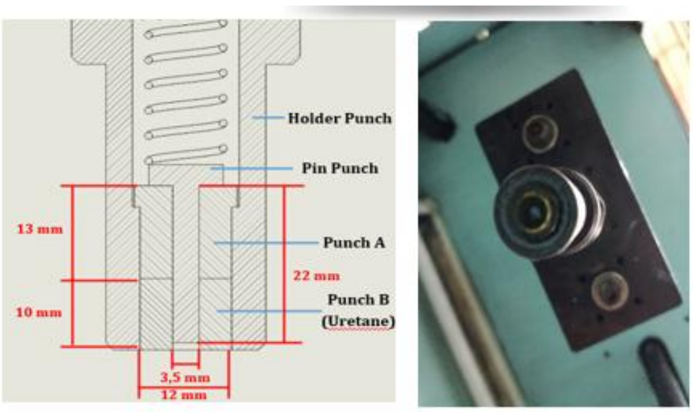

Fig. 6 Urethane punch size before improvement.

Based on Fig. 6, before the repair, the condition of the urethane punch in the factory experienced several problems that had an impact on the problem of the cotter valve soaring when the pressing process was carried out on the retainer press machine on the cylinder head product. Based on the main problem, the lack of appropriate punch size in the previous design, this caused sub optimality when the operator carried out the pressing process and caused the problem that arose, namely the

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cotter valve soaring. In addition, the large pressure zone on the punch can creates high pressure on the inner wall of the work piece, leading to cracks at the top due to transition thinning (Yang et al., 2022). Based on the problems experienced, improvements to the size of the urethane punch by adjusting the current size conditions have been analyzed in actual conditions in the field so that the pressing process is optimal, this is very important to reduce cases of cotter valve soaring and improve the quality of the pressing process.

The application of a new size modification on a more optimal urethane punch by providing a smaller diameter size of the urethane punch to make the urethane punch not quickly eroded during the pressing process and also make the pressing process more optimal. Operators are now more comfortable in carrying out the pressing process. The size of this new urethane punch is a reliable reference in carrying out the pressing process on the retainer press machine for part accessories on the cylinder head product. The new size modification on this urethane punch can reduce the risk of problems that cause part reject cotter valves to soar and cause repairs to the pressing process for cylinder head product part accessories. The following Fig. 7 is a picture of the urethane punch.

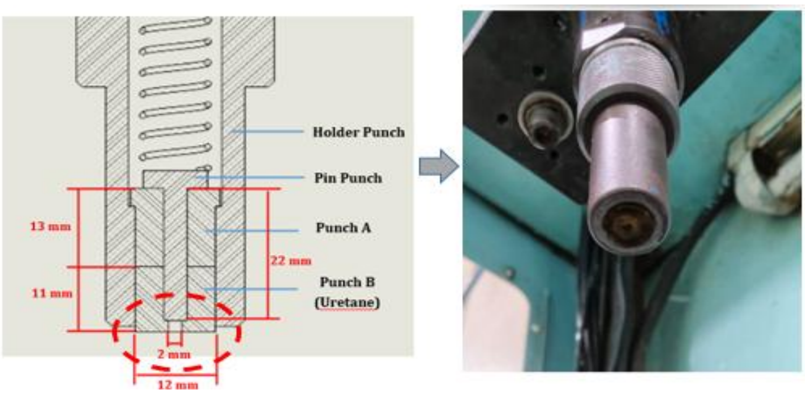

Fig. 7 Urethane punch size before improvement.

To further enhance process reliability and reduce errors in cotter placement, a Standard Operating Procedure (SOP) has been developed. The SOP ensures that operators follow standardized steps when performing the pressing process, minimizing variations caused by human error. This SOP, which is illustrated in Fig. 8, provides clear guidelines on proper cotter placement and operational best practices to maintain process stability and improve efficiency.

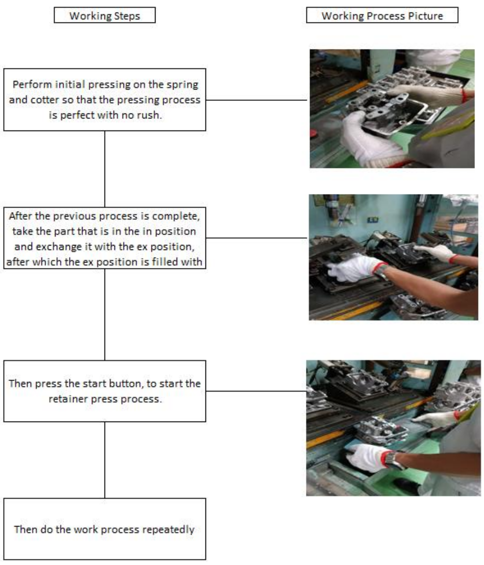

Fig. 8 SOP implementation to ensure proper cotter placement and process consistency.

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This improvement has significantly increased the efficiency and accuracy of the press. Operators no longer have difficulty in carrying out the pressing process and operators are more comfortable working because the repair process that occurs has been reduced. Another benefit that is obtained is the cost of the machine cost per production is reduced from before against the repair process that occurs.

Evaluation of Result

Evaluation of the repair results obtained from the graph of the repairs made to the urethane punch size. The following Fig. 9 show the repair results from January to June 2024.

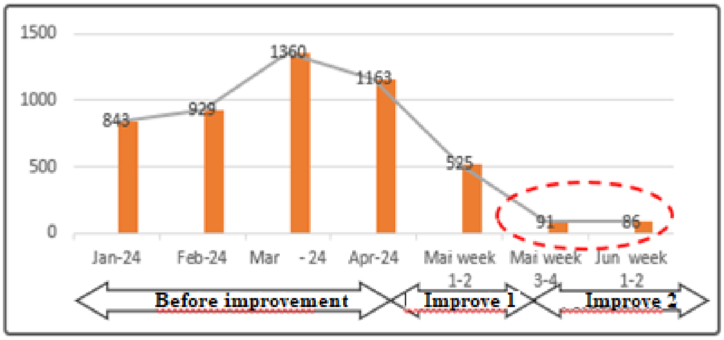

Fig. 9 Graph of improvement results.

It can be seen in January - March is the graphic data from monitoring the cotter valve soaring cases that occurred, namely if the total cotter valve soaring cases were 3132 parts. In April is a graph of the repair action period on the size of the urethane punch that has been determined. It can be seen in the graph in May week 3-4 and June the cotter valve soaring cases experienced a very significant decrease with the modified urethane punch size. This improvement shows that modifying the size of the urethane punch has a positive impact in efforts to reduce the problem of cotter valve soaring on the retainer press machine. This improvement is also to get a decrease in the permitted reject machining of 0.5% while previously the reject reached 1.5% and now it has obtained quite optimal results of 0.2%.

Based on efforts to improve the efficiency and consistency of the production process, the next standardization plan is to update the new size of the urethane punch in the drawing. This standardization aims to provide clear and detailed guidance for the engineering process in making punch sizes on retainer press machines. The standardization drawing of parts on the updated punch size is shown in Fig. 10.

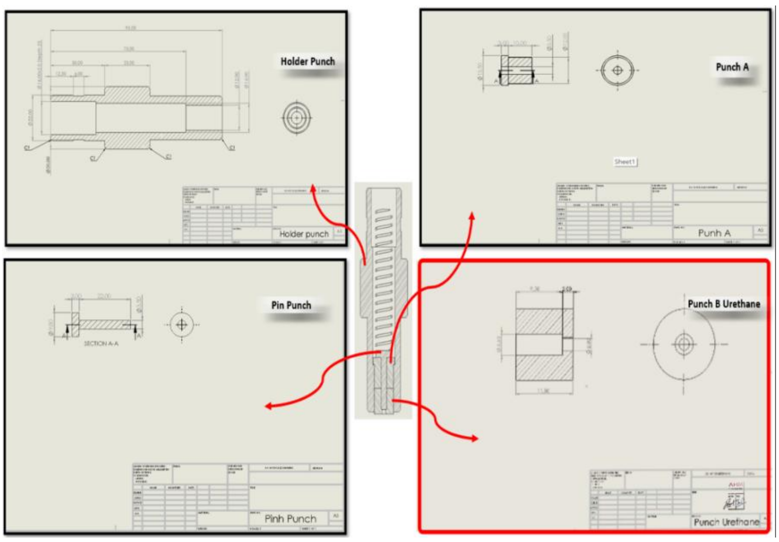

Fig. 10 Punch size standardization.

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The image presents a technical drawing breakdown of a punch assembly, detailing its individual components: Holder Punch, Punch A, Pin Punch, and Punch B Urethane. A central cross-sectional diagram illustrates how these components fit together, with red arrows indicating their positions within the assembly. Each part is represented separately with precise dimensions and specifications, suggesting their roles in a manufacturing or tooling system.

Further Improvement Plan

The next step in order to continue the improvements that have been made, the next plan is to carry out an analysis process on materials that are suitable for replacing urethane punch materials in order to provide more durable, long-lasting service life strength and are not easily eroded by parts on the cylinder head product components. Examples include carbon steel and solid aluminium because these materials are resistant to wear. This is consistent with (Mott et al., 2018) statement that high-carbon steels (with 50 to 95 carbon points) have high hardness that provides good wear resistance, making them suitable for tools, chisels, and components subject to abrasion. In addition, (Zhang & Xu, 2022) found that aluminium has a high strength-to-weight ratio and good corrosion resistance and is widely used in the automotive industry. If a replacement material other than urethane has been found that is suitable for punch, do not forget to re-standardize it again to be a guide for analyzing the next press process if a problem arises.

4. Conclusion

After the analysis and improvements that have been explained in the previous chapter, it can be concluded that the problem of the cotter valve case soaring when the retainer press machine process is carried out is by modifying the size of the urethane punch. From the results of the improvements made, quite significant results were obtained. Improvements were made by providing a urethane length of 11 mm and a urethane diameter of 2 mm, the results of the improvement of the cotter valve problem soaring down to 177 parts/month. The final result of the change in size resulted in a cotter case soaring down from 1.5% to 0.2%. In addition, this improvement contributed to achieving the company’s Key Performance Indicator (KPI) by significantly reducing rejection rates and leading to a cost savings of IDR 36,351,500 from reduced reject-related expenses. Moving forward, it is recommended to conduct a material analysis to determine the most suitable punch material for the pressing process of the retainer and cotter. This step is essential to optimize the press process and enhance the punch’s durability against wear. The selected material should be harder than the previously used material, with the punch hole diameter precisely adjusted to match the cotter valve's diameter. Suggested materials include solid aluminium and carbon steel, as these materials offer high resistance to wear and ensure a more efficient pressing process.

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