

ANALYSIS OF DESIGN RESULTS OF AUTOMATIC TRIMMING PRESS MACHINE AT HPDC CASTING LINE

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Abstract

One of the manufacturing companies is engaged in aluminium casting which produces aluminium casting main products in the form of two-wheeled vehicle parts, four wheels, and several other types of machinery. One of the main products is rail rear grab, rail rear grab is a rear handle for two-wheeled vehicles, which requires high quality with a smooth surface and optimal strength. In the manufacture of rail rear grab, the previous manual trimming process posed various challenges, such as non-valuable manual work on the operator and a high product defect rate, which amounted to 9.89% in the last three months. This research aims to design and implement an automatic trimming press machine to replace the manual trimming process. The methods used include problem identification, design, tool making, testing, and tool performance analysis. The machine is designed using pneumatic and hydraulic systems controlled by a Programmable Logic Controller (PLC), allowing automatic and manual operation to improve efficiency and consistency of trimming results. The implementation results showed a decrease in the product defect rate from 9.89% to 3.34%. This decrease is due to the improvement of the trimming process from manual to automatic using an automatic trimming press machine. In addition, the use of this machine also reduces manual work on the operator, thus increasing the productivity and efficiency of the trimming process. The automatic trimming press machine proved to be an effective solution for making real grab rail.

Keyword: Aluminium casting, Automatic trimming, Productivity, Programmable logic controller, Non-valuable work.

INTRODUCTION

A manufacturing company engaged in the automotive sector, especially aluminium moulding (casting). The main production is automotive component products for 2-wheeled and 4-wheeled vehicles with production quantities based on order requests from customers. The company has several areas in the production process, such as Melting, Casting, Finishing, Machining, Painting and Assembly areas. The casting area consists of 3 lines, each line produces a variety of products and has 46 casting machines with a capacity of 250-1650 tons.

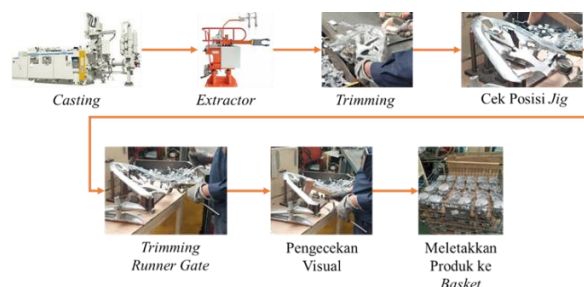


Figure 1 Process flow after the product exits the casting machine

In the Casting Area, the aluminium casting process is carried out using an HPDC casting machine. After the aluminium casting process on the high pressure die casting (HPDC) machine, products that still have scrap are removed with an extractor. In the initial process, a rimming process is carried out on the overflow attached to the product, the overflow is the scrap that is on the outer side of each product. Then after the overflow has been separated from the product, the product is checked on a predetermined jig to determine whether the product is bending or not. After checking the bending, then the product is trimmed again in the runner gate area. Runner gate is a scrap on the inner side which is the way out of alumina during the moulding process. After both trimming processes are carried out, the next step is to check the visual of the product whether the product has defects around the product or the product is in good condition without any defects.



Figure 2 K59J rear grab rail products

Scrap and runner gates that are attached are cleaned by hitting them manually using a wooden hammer. This process is quite time-consuming and difficult for operators because the location of scrap and runner gates is quite complicated. In addition, the amount of scrap in each product also lengthens this process.

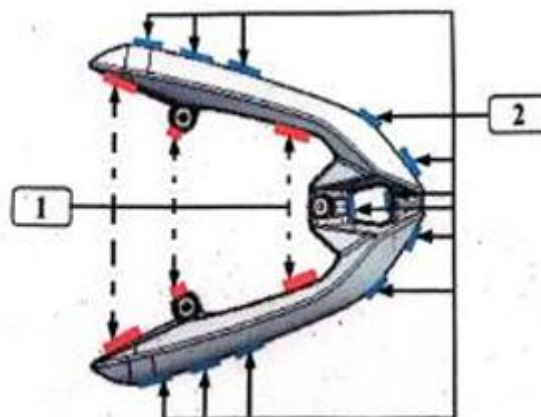


Figure 3 Product areas that should be trimmed

at number 1 is the runner gate part that must be trimmed, at number 2 is the overflow part that must be trimmed. However, the actual trimming that must be done first is at number 2 first because

it is easier than number 1 first. Number 1 is harder than number 2, because number 1 is the entry point for the molten aluminium in the mould.



Figure 4 Product after trimming

Figure 4 still leaves sharp fins after the trimming process, which is not a problem, because after the trimming process the product is sanded again and enters the machining area.

Based on the description of the problems that have been described, the trimming press tool is expected to reduce manual work by operators, make trimming results to be uniform and constant, so that product quality to increase. In addition, the trimming press is expected to reduce non-valuable work on the operator, namely in the process of checking the product into the jig which must be done one by one manually.

LITERATURE REVIEW

The research conducted by (Pirmansah *et al.*, 2020) discusses the results of the design related to trimming and piercing production aids in the process of working on the final stage of the refrigerator inner liner. The tool design measures 2016 mm x 1875 mm with a weight of 1.8 tons and an electric power of 8.25 kW. Then for the work process requires 1 operator and can operate 2 trimming and piercing operations in turn within one loading and unloading process for approximately 20 seconds per inner liner. The trimming process includes the removal of sprue, runner, riser, parting-line flash, overflow, and some other excess metal from the cast part. In the case of brittle alloy castings and when the cross section is relatively small, these appendages on the casting can be broken. Otherwise, hammering, shearing, sawing, grinding, or various cutting methods should be performed. According to (Rizza, 2014) press tool is a tool used for cutting work such as turning sheet plates into a product that can be produced quickly and with high quality and short time. Then the press tool is a simple press tool that has one station and one work process in one tool. The types of work that can be done by press tools are cutting tools and forming tools. Cutting is a process that is done by removing part of the material or cutting it into the desired shape, and one of the processes that can be done by cutting tools is trimming. Cutting and non-cutting are two categories of cutting tool categorization. Cutting operation means cutting a part of the main product. Some examples of cutting groupings include bending, piercing, and trimming.

RESEARCH METHOD

Research Methodology

This research aims to reduce non-valuable work on operators and reduce defective products in the trimming process. Non-valuable work is included in the category of activities that do not generate additional value, also referred to as waste, can be identified through various ways, such as overproduction, transportation, waiting, excessive inventory, and overproduction (Yunitasari, 2018). The process starts from problem identification through field studies and interviews with company resource persons. The next stage is a literature study to design the machine concept, including tool movement and 3D/2D design. Design analysis and optimization involved consideration of cylinder requirements, material selection, and cycle time analysis. Once approved, the manufacturing process was carried out by the machining vendor. Testing involved gripper testing, uniformity testing, quality testing, and yield testing. Test results were analysed to conclude the study.

Identification of Tool Requirements

Observing the HPDC casting machine. The HPDC machine used is the Toshiba CCT 650 T. The process on the HPDC machine is a repetitive process (cycle) automatically, but can still be controlled manually. The first process is the spray process, which is the process of applying lubricant (lubricant) to the surface of the cavity (mould) in order to cool, lubricate, as well as provide a thin layer of silicone on the surface of the mould so as to allow the product to come off the mould without any parts sticking and left on the mould. The lubricant used contains a mixture of lubricant, water, and wind. Where mixing occurs in the Die Lube Auto Mixing Machine.

Observing the extractor. Extractor is an additional device (modification) on the casting machine. Extractor is used to take products after the dies are open. This tool is the closest part to the operator, with this tool it can facilitate the operator in the process of taking aluminium moulds that are still very hot when after the printing process. In front of the extractor is equipped with a photosensor that shoots infrared light to detect products that have been taken by the extractor. The product sensor functions as a counter on products that have come out of the casting process, the results of this calculation will be used as a reference for total production. The extractor works using a PLC (Programmable Logic Control) control that is separate from the HPDC casting machine (in the Toshiba CCT 650T series). There is a need for integration between the HPDC casting machine and extractor conditions. Since they both use the same control system, the only modification that needs to be made is the sequence of each PLC (Programmable Logic Control) program of both the HPDC casting machine and the extractor. The integration will later create the movement of the two machines to be interrelated, without causing any errors when running both automatically. Of course, each movement of the two devices requires a kind of emergency and home base for the security system of each device. With the provision of observations made, it is intended to help in making tools for this research.

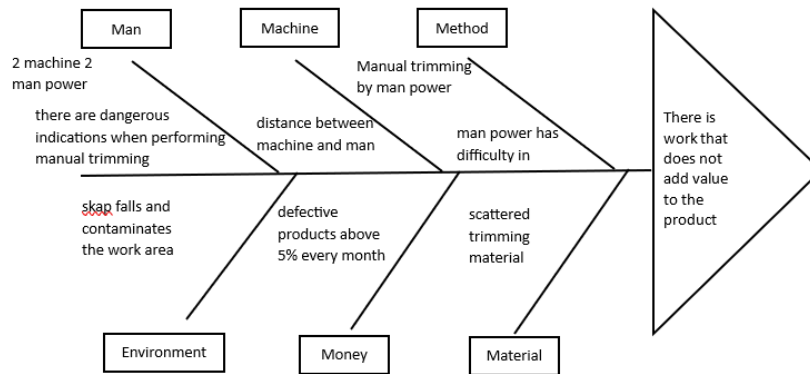


Figure 4 Problem analysis fish bone diagram.

- **Man Power**
Man power Operators in doing work have responsibility for one machine and operate only one machine. So that from this statement it can still be attempted to make modifications related to the number of existing operators. This modification will certainly not burden the work of the operator or the performance of the machine.
- **Machine**
Machine conditions on the HPDC casting machine were not included in this study, so it is considered that the machine is in a normal state. The focus is on the distance between the operator and the machine, which results in increased operator movement. On the other hand, the distance can also be used for product loading after exiting the casting machine.
- **Method**
The method of scrap removal (trimming) is done manually. The method used is to use a wooden hammer to beat each scrap on the product. From some of the scrap there are parts that are very hard and difficult to clean, this takes a long time. In addition to cleaning the scrap, the operator is also required to check the dimensions of the product with a tool in the form of a jig that has been prepared. Checking is done by putting the product into the jig and visually checking each surface of the product.
- **Material**
The problem that arises from the material factor is that the scrap in the trimming process becomes scattered due to the blows made by the operator on the scrap in each product. This resulted in some scrap falling to the floor and causing the scrap to become scattered.
- **Money**
The high level of defective products is the main problem in this factor. The target given for defective products is 5%, if in actual circumstances defective products reach above 5% then the company can be said to experience losses from the excess 5%. Because each defective product has used material that has been measured and should be a finished product, but with defective products, the material can be melted down again by mixing it using new aluminium bar material.

- **Environment**

Scattered scrap due to uneven scrap cutting makes scrap scattered and dirty the work area. This certainly makes the environment not neat or clean.

Design

The design concept is an outline of the design plan that will be made. made, which is then adjusted to the components that will be chosen based on the specifications available in the market. Tool design process the three-dimensional (3D) tool design process then begins with the concept and components that have been selected using Solidworks 2022 software. that have been selected using Solidworks 2022 software. Concept The design concepts include dies for laying out the product,trimming to fit the product shape, and also where the scrap will be disposed of. After the design is finished, the concept of tool movement is needed so that the realization of the design can work optimally and in accordance with what has been planned. How to determine the concept of tool work by looking directly at the field, how the operator works. By knowing the work of the operator, it will be easy to make the working concept of the automatic trimming press machine. machine. The simple concept is to drain the product from the casting machine and perform the trimming process. casting machine and perform the trimming process, then trimming process, then flowing the product close to the operator for check visually.

RESULTS AND DISCUSSION

Machine Design

The automatic trimming press works with pneumatic and hydraulic systems, and uses PLC as its control system. The working concept of the automatic trimming press is to cut the scrap on the product after going through the casting process. The product after exiting the HPDC casting machine will be removed by the extractor, then continued by the process of the automatic trimming press. The initial product holder with a pneumatic system moves closer to the point at the end of the extractor to pick up the product. After the product is pinched by the gripper on the initial product holder, the product will be brought into the jig. Then after the product is in the jig, the trimming press with a hydraulic system can cut the scrap on the product. After the scrap is cut, the trimming press can return to its original position so that the product can be taken by the final product holder.

Then the end product holder with the pneumatic system moves forward to a predetermined point, after which the end product holder descends to perform product retrieval. The product is taken by clamping method using 2 pneumatic cylinders on the right and left side of the product. After the product is clamped, the end product holder moves up and moves back again to bring the product to the shutter to the man power. After that, the man power can visually check the product.

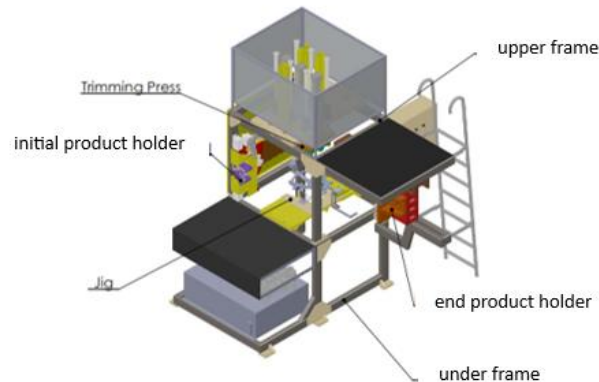


Figure 5 Design of automatic trimming press

Tool Working Concept

The automatic trimming press works with pneumatic and hydraulic systems, and uses PLC as its control system. The working concept of the automatic trimming press is to cut the scrap on the product after going through the casting process. The product after exiting the HPDC casting machine will be removed by the extractor, then continued by the process of the automatic trimming press. The initial product holder with a pneumatic system moves closer to the point at the end of the extractor to pick up the product. After the product is pinched by the gripper on the initial product holder, the product will be brought into the jig. Then after the product is in the jig, the trimming press with a hydraulic system can cut the scrap on the product. After the scrap is cut, the trimming press can return to its original position so that the product can be taken by the final product holder. Then the end product holder with a pneumatic system moves forward to a predetermined point, after which the end product holder descends to pick up the product. The product is taken by clamping method using 2 pneumatic cylinders on the right and left side of the product. After the product is clamped, the end product holder moves up and moves back again to bring the product to the shutter to the man power. After that, the man power can visually check the product.

Installation Process

The installation process took 2 days, 1 day to prepare the area for the entry of the automatic trimming press, 1 day for the installation process of the automatic trimming press. The area preparation includes sterilizing the entry area of the automatic trimming press, this area needs to be sterilized so as not to interfere with the process of entering the automatic trimming press into the HPDC casting line 1. Once the area is sterilized, the next step is to place the automatic trimming press into the designated area. The placement of the automatic trimming press also considers the condition of the HPDC casting machine, which is related to the synchronization of the extractor with the product holder on the automatic trimming press.



Figure 6 Automated trimming press insatalation process

After the automatic trimming press is installed properly, the next process is to carry out the electrical installation process and also the pneumatic air connecting hose to the air source in each HPDC casting line. After the power source and air source are installed, the PLC integration process on the automatic trimming press can be carried out with the PLC on the HPDC casting machine.

Integrasi PLC

PLC integration is done so that the commands in the PLC system of the trimming press can run and relate to the movement of the HPDC casting machine.

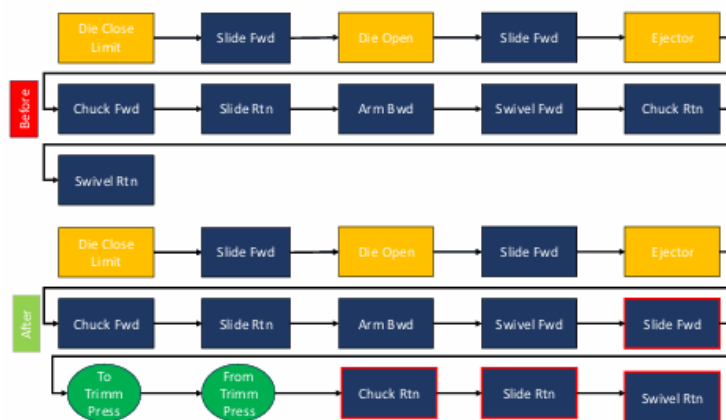


Figure 7 Process sequence diagram

The before condition is the initial condition of the sequence diagram on the PLC that controls the running of the HPDC casting machine extractor. The process sequence starts from the limit switch that marks the dies are closed until the position of the extractor is in the outermost condition and ready to release the product on the shutter table. Modifications are made to add movement and also provide time for the automatic trimming press to run. There are additional movements and also the giving and receiving of automatic trimming press signals.

Testing Process

After the PLC integration process is complete, the next step is to test the automatic trimming press. The test carried out is gripper testing, this test is carried out manually, the purpose of this test

is to ascertain whether the gripper position of the extractor can match the automatic trimming press gripper. Testing is carried out several times until it is certain that the product gripping from the extractor can be accepted and gripped properly by the automatic trimming press gripper. During the testing process, adjustments are made to the automatic trimming gripper, the trimming press gripper can be adjusted high and low according to the gripper from the extractor. By conducting experiments periodically, the fixed position of the gripper's grip on the product to be trimmed will be found. Thus, the right position is obtained for the process of placing the product into the jig. The yellow circle is the gripper of the extractor on the HPDC casting machine, while the blue square is the gripper on the automatic trimming press.



Figure 8 Casting machine gripper and trimming press

After the gripper is in the right position and can run properly, the next step is to test the trimming press running automatically from the beginning of the HPDC casting machine movement to the final process on the automatic trimming press. This automatic trial is also carried out many times until all processes can run well without any obstacles. After testing the condition that the trimming press can run automatically well, the next step is to test the uniformity of the automatic trimming press production process. This uniformity test is needed to see the uniformity of the products produced by the automatic trimming press because during the previous testing process the products produced still vary.

This uniformity test goes through several processes, namely the trial process of 5 samples, 10 samples, 30 samples, 100 samples, and mass production at the customer. The purpose of each process is that the automatic trimming press must be able to produce products that are in good condition in a predetermined amount, for example, such as 5 samples, so during the 5 production processes must produce 5 products in good condition. If during the 5 production processes there are still products with poor results, then improvements are made first and the trial process is repeated 5 samples. However, if you have reached a trial of 30 samples, you can continue to the next testing process if the good product results reach above 70%.

There are several criteria in the test, the first is an OK product. Products that are said to be OK are products that have passed and passed all tests, starting from visual physical testing, bending testing, and geometry testing with CMM tools. Then there are types of defects, namely bending and dent. Bending is a type of defect in products that look crooked judging from the placement of the product into the jig.



Figure 9 Examples of defects in products

Test Results

By using 2 specimens, quality testing is carried out using the CMM tool to determine the level of precision of each coordinate in the product. In the graph provided is the average result of both products 1 and 2 in product quality testing.

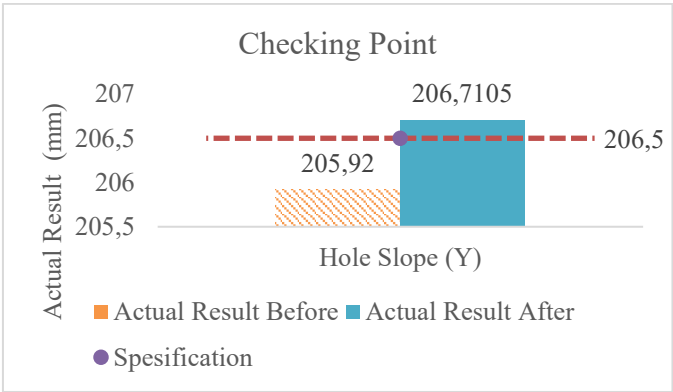


Figure 10 Hole slope check point (Y)

The figure above shows the actual results before manual trimming and after automatic trimming. With the orange dotted line as the specified specification which is 206.5 mm. The tolerance used is ± 0.500 mm. The difference from manual trimming is 0.469 mm, while the difference from automatic trimming is 0.2105 mm.

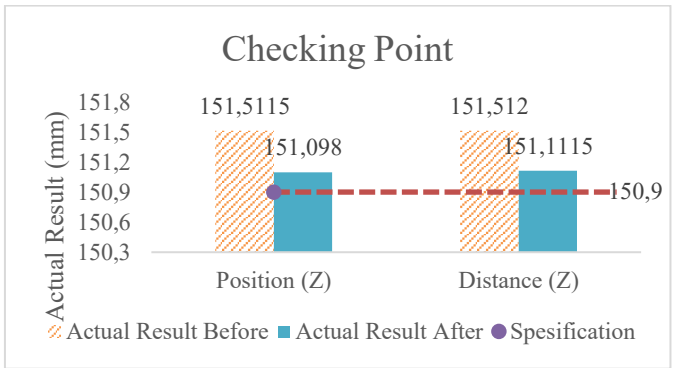


Figure 11 Check point position (Z) and distance (Z)

In checking the position (Z) and distance (Z), better results are obtained when using an automatic trimming press, namely in position (Z) a difference of 0.198 mm and at a distance (Z) a

difference of 0.2115 mm. While in the actual results before in position (Z) the difference is 0.6115 mm and at a distance (Z) the difference is 0.612 mm. These results exceed the given tolerance of ± 0.500 mm, so the use of an automatic trimming press can improve the product geometry.

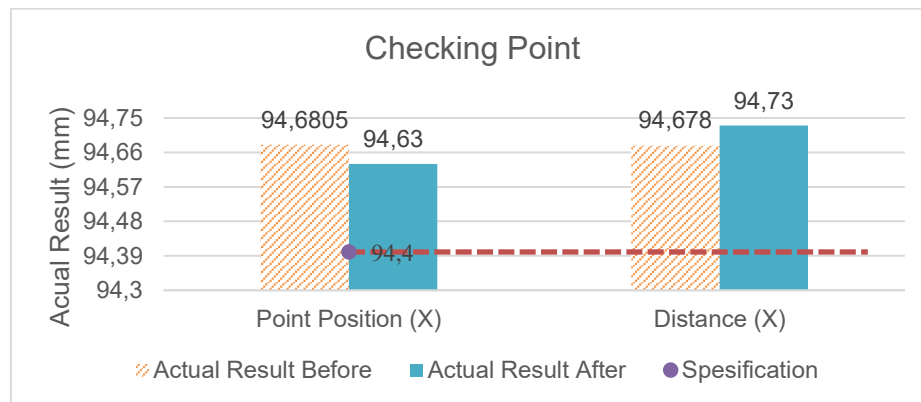


Figure 12 Checking point position (X) and distance (X)

The figure above shows that each checking point is still within the given tolerance, which is still below ± 0.500 mm. So it can be seen that the position of point (X) and distance (X) is not affected by the trimming process either manually or automatically. It's just that in the graph in Figure 4.17 at a distance (X) the actual results using an automatic trimming press exceed the actual results when trimming manually.

The results of rejects due to falling products were 6 products and rejects due to bending were 4 products. Of course, these results are data from rejection caused by the trimming process only, not the entire HPDC casting process. The average rejection in the last 2 months is 3.34%. So the decrease in rejection caused by the trimming process is 6.57%. The amount of rejection reduction caused by the trimming process.

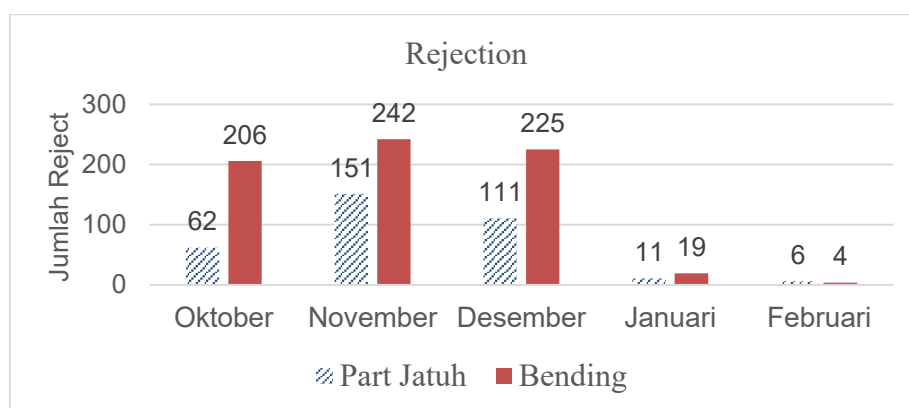


Figure 13 Rejection decline chart

The decrease in the number of falling and bending products is due to the improvement of the trimming process from manual to automatic using an automatic trimming press machine. The decrease in numbers is due to the difference in the accuracy of the trimming process which does not cause the product to fall or bend. The product cannot fall or bend because the automatic trimming

process is placed on a jig that can prevent the product from falling or bending due to the pressure exerted by the trimming press.

CONCLUSION

The development of this automatic trimming press successfully answers the problems in the manual trimming process which was previously less efficient and resulted in a high product defect rate. This automatic trimming press uses pneumatic and hydraulic drive with PLC control system. Specifications of the automatic trimming press: air pressure used is 3.5 bar, hydraulic pressure is 100 x 105 [N/m²], using rodless cylinder SRL3-LB-40B-60 CKD, and using hydraulic cylinder 140H-8-FY63 B400. By utilizing pneumatic, hydraulic, and PLC systems, this machine is able to improve product quality and consistency, while reducing the operator's manual workload. The implementation results show that the product defect rate was successfully reduced from 9.89% to 3.34%, a significant achievement in supporting the company's productivity. The automatic process trimming machine is designed to not only have a positive impact on improving the efficiency of the production process, but also offer a new approach to managing non-valuable work and reducing waste in the aluminium casting industry. With this machine, companies can continue to optimize their production processes, improve competitiveness, and maintain high product quality standards.

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