Design and Analysis of Autoloader Equipment to Assist the Loading Process of Polypropylene Plastic Seeds in the Injection Molding Machine: Study Case

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Abstract. This study focuses on the manual process of transferring plastic pellets into the plastic molding production machine, in which the operator brings the plastic pellets up to the top of the plastic molding production machine due to the high hopper on the plastic molding production machine. The goal of developing a plastic pellet autoloader tool is to automate the process of removing plastic pellets in order to shorten the process time for transferring plastic pellets into the hopper of a plastic molding production machine. The Root Cause Analysis method was employed in the research, which involves identifying difficulties that arise during the removal of plastic pellets and learning how to solve those problems. The result from the research conducted on the process of removing plastic pellets before improvement took 10,832.39 seconds to reach the target of 25 kg, while the results obtained after improvement were 467.32 seconds to reach the target of 25 kg. If the percentage can cut the cycle time by 95.68%.

Keywords: Autoloader, Cycle Time, RCA, Vacuum.

1. Introduction

Many product on the market are made from plastic as a substitute for metal items. The plastic molding production process has a workflow starting from the arrival of the plastic pellet material, processing the plastic material such as mixing the original material with dye, the process of feeding the plastic pellet material into the production machine until the product is finished and ready to be sent to consumers.

One of the important processes when a plastic molding machine is operating is the process of transferring plastic pellets into the plastic molding production machine. Manually, the plastic pellets are brought up to the top of the plastic molding production machine by the operator, this is because the hopper on the plastic molding production machine is high. This stage requires time, so production time is less than optimal. Apart from that, this manual stage has the potential to cause accidents for the operator due to its high position, as an illustration can be seen in Figure 1. This problem can be solved using a hopper feeder machine, where this machine will significantly help the process of moving plastic pellets from the source to the hopper.

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using a hopper feeder machine, where this machine will significantly help the process of moving plastic pellets from the source to the hopper.

Fig. 1. Manual feed plastic into hopper injection molding by operator [1]

Pranajaya, et al. [2] conducted research that discussed raw materials falling to the floor when being transferred to a mixing machine and the existing raw material storage container could not allow all the raw materials to be sucked into a machine that uses a vacuum autoloader. This problem can be solved by using a transfer platform to carry out the process of moving raw materials and a new container trolley so that all the raw materials can be sucked into a machine that uses an autoloader and also the tool has been designed based on the anthropometry of the Indonesian people so that it is comfortable to use. Pambudi, et al. [3] conducted research that discussed constructing an autoloading tool for plastic pellet raw materials using a universal motor as the main component, a dimmer as a speed controller and a TDR (time delay relay) as a working time controller. It can be concluded that the effect of torque on the suction power and filling time of the plastic pellet raw material is influenced by the power and input voltage. If the input voltage is greater, the power will increase as well as the torque will be greater, the influence of torque on the suction power and filling time will be faster, with varying voltages at the same load.

Currently, the plastic industry at PT Cosmetic Mirror Indonesia, which operates in the field of cosmetic packaging design and manufacturing, still uses plastic feeders manually. For the sake of operator safety and increasing productivity, it is very important to carry out research on plastic pellet autoloader machines to reduce the risk of accidents for operators and reduce production time at PT Cosmetic Mirror Indonesia.

The aim of this research is to determine the structural strength of autoloader equipment using finite element simulation and the cycle time values of plastic molding production machines.

2. Method

2.1 Material and Design of Autoloader

The design of the plastic seed autoloader machine uses a hollow iron frame with ASTM A36 material measuring 50 mm x 30 mm x 2 mm. The vacuum machine used is the

HB750W Rotor Ring Blower series. This design considers aspects of use that are compact and easy to move. Figure 2 is the design of a plastic pellet autoloader machine, where the specifications of the plastic pellet autoloader machine are shown in Table 1. The design in this research uses the rules described by Sigley [4] and also adopted the other researcher [5, 6].

Table 1. Specification of Plastic Seed Autoloader Machine

Item	Value
Length	470 mm
Width	500 mm
Height	755 mm
Main Frame	Hollow tube (50x30x2)
Top vacuum tube	*Stainless Steel Plate* (1100x 300x2)
Middle vacuum tube	*Stainless Steel Plate* (1100x120x2)
Bottom Vacuum tube	*Stainless Steel Plate* (1100x150x2)
Controller	TT-300G *Series Loader Control*
Engine	*Rotor Ring Blower* HB-750W
Locking	*Spring Loaded Toggle Clamp* – J111

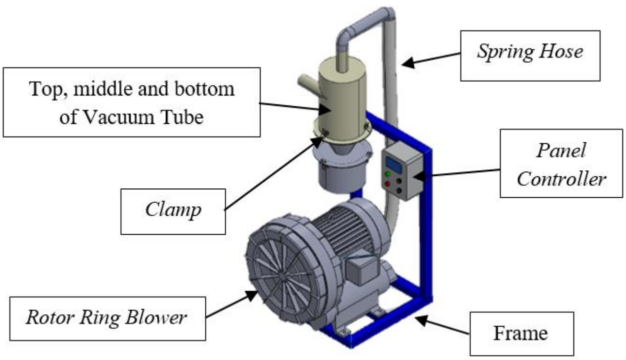


Fig. 2. Design of Plastic Seed Autoloader Machine

2.2 Research Method

This research uses a numerical calculation method where the process is to look for the effect of certain treatments under controlled conditions [6, 7, 8]. In this research, we will discuss the effect of bending pressure on the autoloader frame due to motor and vacuum pipe loads. The flow diagram of this research can be seen in Figure 3.

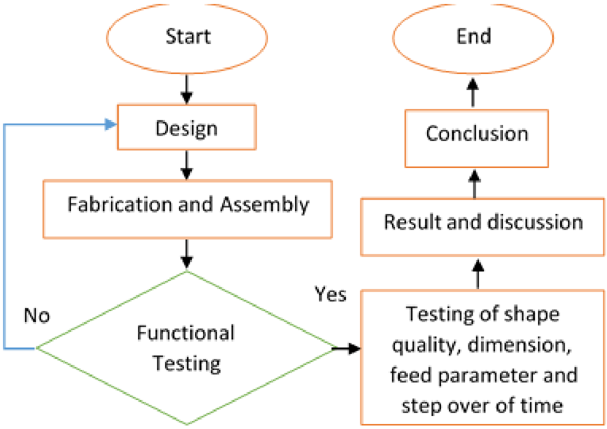
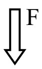


Fig. 3. Research Flow Chart

This research starts from the design process of the shape and material of the plastic pellet autoloader machine, the component manufacturing and assembly process, testing the control function and machine work, testing the plastic pellet transfer time. The test results were analyzed to find out the conclusions as presented in Figure 2.

2.3 Finite element method

Finite Element Analysis (FEA) is used to simulate the plastic pellet autoloader frame material. The material used in the frame is ASTM A36 hollow iron. The aim of this FEA is to determine the strength of the frame structure which is indicated by the similarity of the color of the frame structure being tested and the graph in the FEA simulation. In simulating the strength of frame structures, FEA simulation ensures that the frame structure used is capable and can be used to carry loads according to the calculations made. Solidworks software is used in simulations on the design of a plastic pellet autoloader as in Figure 4.



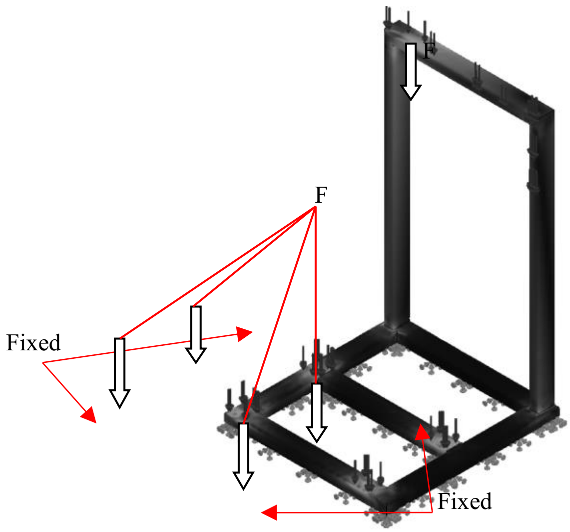


Fig. 4. Model and Boundary condition of main frame

The FEA simulation that will be carried out on the plastic seed autoloader frame as in Figure 4 contains several components that are supported on the frame, so there are 3 FEA simulation points that will be applied to the frame. Based on the research results, the calculation of the loads that occur on the frame aims to determine the forces that occur at each support. In Figure 3 you can see that there are several components that are supported on the plastic pellet autoloader frame, including the blower ring rotor, vacuum tube, and controller. The results of data collection on the weight of the components supported on the frame are explained in Table 2.

Table 2. Mass and weight of parts in the plastic pellet autoloader

No.	Parts	Amount	Material	Mass (kg)	Weight (N)
1	*Rotor Ring Blower*	1	*Steel*	22	215,82
2	Vacuum tube	3	*Stainless steel*	5	49,5
3	*Controller*	1	*Steel Plate*	1	9,81
			Total	28	275,13

2.4 Cycle time

Cycle time analysis is often called cycle time reduction. This is a strategy to reduce processing time so that productivity increases. The cycle time efficiency of the plastic pellet transfer process can be calculated using equation 1.

$$Cycle\ Time = \frac{t1-t2}{t1} \times 100\% \quad (1)$$

3. Result and discussion

The results and discussion of this research include the results of frame simulation analysis using Solidworks 2020 software, cycle time test analysis and the realization of a plastic pellet autoloader machine.

3.1 Analysis and discussion of main frame

The simulation results are stress (von-Mises) based on Figure 5, the largest von Mises stress value is 2,175 x 106 N/m^2 which occurs in the plastic pellet autoloader frame, while the yield strength value that occurs is 2,500 x 108 N/m2. Based on the simulation results, the frame can be considered safe because the stress value does not exceed the yield strength of the plastic pellet autoloader frame.

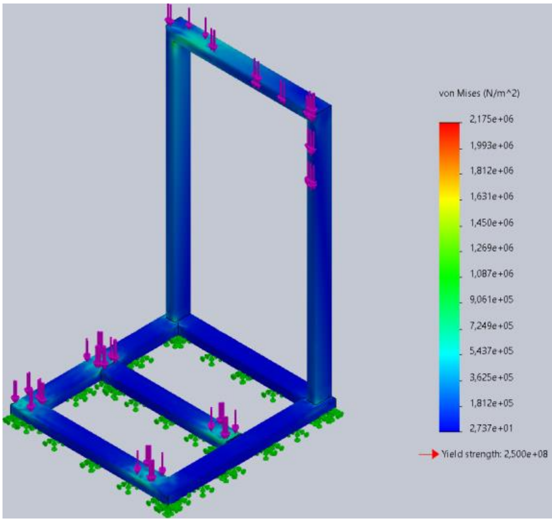


Fig. 5. von Mises Stress due to applied load

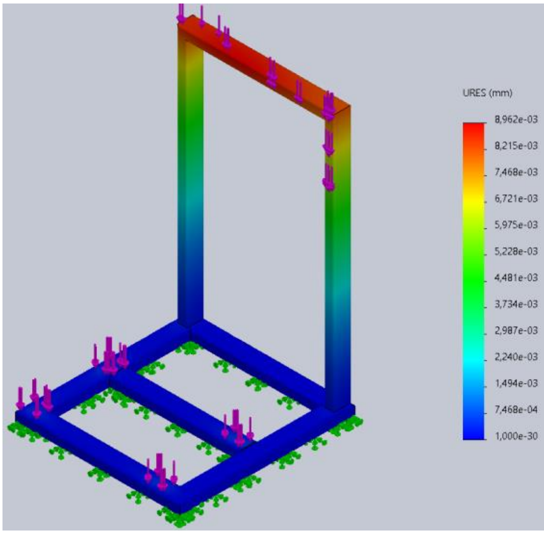


Fig. 6. Displacement

Based on Figure 6, the results of the total deformation simulation on the plastic pellet autoloader frame show that the largest displacement occurred, namely 0.008962 mm, which occurred in the plastic pellet autoloader frame, while the smallest displacement value was 0.001 mm which occurred in the plastic pellet autoloader frame.

3.2 Analysis and discussion of cycle ime

Plastic pellet autoloader engineering in the process of moving plastic pellets according to the analysis of test results that have been carried out with results before improvement takes an average of 10,832.4 seconds to reach the target of 25 kg, then after improvement the average result is 467.3 seconds to achieve target 25 kg. So we get a time difference of 10,365.1 seconds. Figure 7 is a graph of plastic pellet autoloader improvement. Based on Figure 7, it can be concluded that the improvement of the plastic pellet autoloader has an effect on reducing the cycle time of the plastic pellet transfer process.

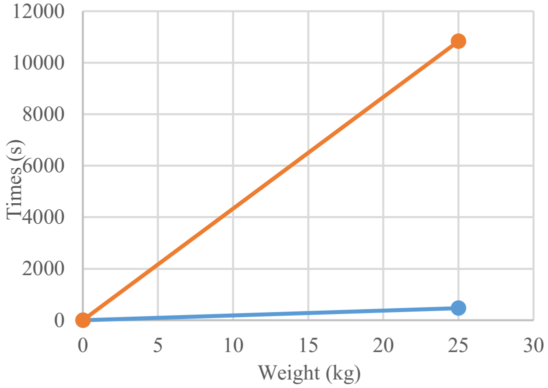


Fig. 7. Improvement of cycle times

Conclusion

Plastic pellet autoloader engineering to reduce cycle time in the process of moving plastic pellets according to analysis of test results that have been carried out with results before improvement took 10,832.39 seconds to reach the target of 25 kg, then after improvement the results obtained were 467.32 seconds to reach the target of 25 kg. So we get a time difference of 10,365.07 seconds, if the percentage is calculated it can reduce the cycle time by 95.68%. There was an error factor during tool testing in the form of a leak in the connection between the vacuum tubes and a leak in the hose connecting the plastic molding production machine with the Autoloader tool which resulted in a lack of vacuum level so that the plastic pellet transfer process was less than optimal.

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