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Modification and Enhancement of Pick Place Cam Part in SDKZ Semi Auto Machine

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ABSTRACT
This research investigates the optimization of semi-automated machines, specifically the SDKZ and RD 708 models. The study focuses on identifying and addressing bottlenecks in the current production process, aiming to reduce cycle time and increase productivity. The primary bottleneck in the SDKZ machine is the manual pick-and-place operation of cams. We propose implementing an automated pick-and-place system inspired by the RD 708 model to mitigate this. This involves a comprehensive design process, encompassing 2D and 3D modeling, mechanical and electrical integration, and programming. Additionally, manufacturing considerations such as material selection, assembly procedures, and process optimization are incorporated to ensure the overall effectiveness and efficiency of the modified machine. The study's outcome shows that productivity efficiency has increased from 69% to 76.5%. This work will contribute to the enhancement of the SDKZ machine's overall performance and competitiveness.

Keywords: Pick and place process, Automation, Production efficiency, Manufacturing Process Enhancement

1. INTRODUCTION

In the era of modern manufacturing, automation has emerged as a critical enabler for efficiency, accuracy, and cost reduction. Among the numerous components of automated systems, the pick-and-place mechanism plays an indispensable role, particularly in the assembly and packaging industries. These systems enable precise movement and placement of components, ensuring seamless workflow and high throughput. However, as industries adopt more complex designs and higher production targets, the need for innovative modifications and enhancements in these systems becomes increasingly apparent. Factory automation will focus on the product lines through electronic controls, fluid power and sensor products. The automation machine use PLC as a cpu which is connecting the input and output of the machine. Since most recent commercial PLC is use general purpose processors, they should execute an relay ladder logic (RLL) program (Cai et. Al., 2016, Koo et. Al., 1998)).

The SDKZ semi-automatic machine represents a vital intermediary between fully manual and fully automated systems. Its semi-automatic nature combines human oversight with machine precision, offering flexibility and reliability. Within this machine, the cam part of the pick-and-place system is a critical component that dictates the motion profile and operational efficiency. As such, any modification enhancement to the cam part can significantly influence the overall productivity, precision, and operational lifespan of the machine.

Historically, cam mechanisms have been extensively used due to their ability to convert rotary motion into specific, repeatable linear or angular motions. These mechanisms, when applied to pick-and-place systems, offer a precise way to control acceleration, deceleration, and positioning of the end-effector. However, challenges such as wear and tear, misalignment, and limitations in speed often necessitate improvements. Through advancements in materials, manufacturing techniques, and computational modeling, opportunities exist to redesign and enhance the performance of these critical components.

This paper explores the modification and enhancement of the pick-and-place cam part in the SDKZ semi-automatic machine, focusing on improving its functionality and addressing limitations observed in existing configurations. The study was conducted in a manufacturing company in Malaysia which produces sensors, tact switch, potentiometer and some mechatronic products. The primary issue with the assembly product is the potential for a significant decrease in productivity. The employer has set a monthly productivity target for their product. The semi-auto assembly process for the SDKZ switch product takes too long, consuming 13s per cycle, compared to the manual line's 8s. The cam pick and place (PNP) process primarily causes this problem. The process happens after the inspection of the contact blade and before the cam grease. Japan manufactures the process entirely by hand. This situation occurred when the cam is finished in the tunnel and needs to be filled up by the operator. Therefore, the process must be halted, which could potentially impact the switch's productivity levels. However, after the research has been done, the process can be solved by upgrading the jig from manual to semi-automatic. Moreover, reducing the cycle time is feasible. This enables the achievement of the productivity target.

Leveraging advanced CAD modeling, finite element analysis (FEA), and kinematic simulations, the study aims to identify optimal designs that minimize operational inefficiencies and extend the component's durability (Flores, 2012). Additionally, real-world testing and validation are proposed to ensure that the modifications meet industrial standards and practical requirements (Lampinen, 2002). The significance of this work lies in its contribution to the broader field of semi-automatic machine optimization. With industries increasingly demanding precision and scalability, the study underscores the importance of integrating engineering innovation into traditional systems. By addressing the limitations of the cam part in the SDKZ machine, this work not only enhances the machine's performance but also sets a precedent for similar advancements in other semi-automatic systems.

2. Methodology

2.1. Automation Machine

The manufacturing industry uses automation machines worldwide. This is due to the numerous advantages this type of machine offers over other types. Such tasks require the companies to be able to counter unpredictable, rapid, and fluctuating market changes in a responsive and cost-effective way (Pengjia Wang et. Al., 2014). When industrial machines use automation, they produce higher turnout and productivity (Ahmed & Samuel, 2023). Compared to manual machines, they require a larger workforce, which in turn impacts the workers' salaries. Automation machines have the ability to operate 24/7. In this evolving scenario, industries that are able to minimize expansion costs can obtain an advantage over challengers (Marulcu et. Al., 2012)

There are numerous compelling financial benefits to running continuous, minute-by-minute operations, such as increased use of capital investment, modifications to client management, and shorter payback imes for investments in computerization. Adding another task to the sequential construction system necessitates preparation with a human administrator; however, we can customize robots to perform any task. This makes the assembling process more adaptable. Most people assume they are familiar with the term "simple machines" due to the prevalence of such machines in our surroundings (Haik, 2003).

2.2. SDKZ Machine

The SDKZ machine was developed to assemble a switch known as the SDKZ switch. Home appliances worldwide use this kind of switch. An example of a home appliance that uses this switch is a washing machine. ALPS Malaysia is one of the industrial companies that operates this machine. They have about 7 lines, which is manual in operation. This machine has 22 processes to assemble one product. There are several methods to assemble the product into a single unit. These methods include camera inspection, pick and place, grease placement, and blow molding. This project will concentrate on enhancing the SDKZ machine. Figure 1 displays the SDKZ Machine layout.

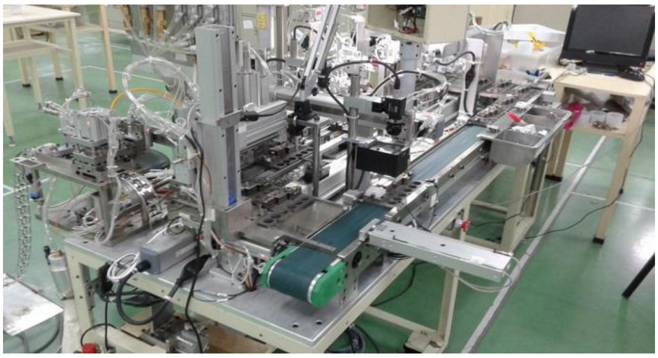

Figure 1. SDKZ Machine

2.3. RD 708

The RD 708 machine assembles a sensor known as a potentiometer. Japan manufactures and imports this type of machine. RD 708 is a semi-auto type of machine. According to the research, there are a few processes that are nearly identical to those found in the SDKZ machine. The process occurs when the cam passes through the channel. Figure 2 displays the layout of the RD 708 machine.

Figure 2. RD 708 Machine

2.4. Pick and Place Process

The manufacturer, a process engineer, is seeking a solution to automate their recently designed sample transporting system in a quiet and fast-paced manner. After conducting research, they discovered that the pick-and-place process is the most effective method in the industry. Pick-and-place automation systems often form part of a larger mechanized gathering framework. One of the most important tasks that a robot must perform is picking and placing (Luo & Zhang, 2023). However, it is often challenging for a robot to automatically plan its pick-and-place motion. This difficulty stems from the geometrical complexity of both the situation and the item under grasp (Patel & Singh, 2022). The consumer goods industry employs these machines for a diverse range of product transmission applications. Part feeding and material transfer are crucial components in any production chain, significantly influencing the workload and time constraints of an assembly process (wang et. Al., 2014). Figures 3 and 4 show us the pick and place sections in the SKZ and RD 708 machine.

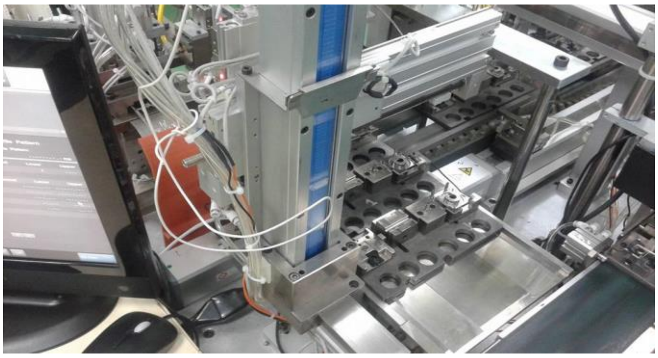

Figure 3. Pick & Place SDKZ Machine

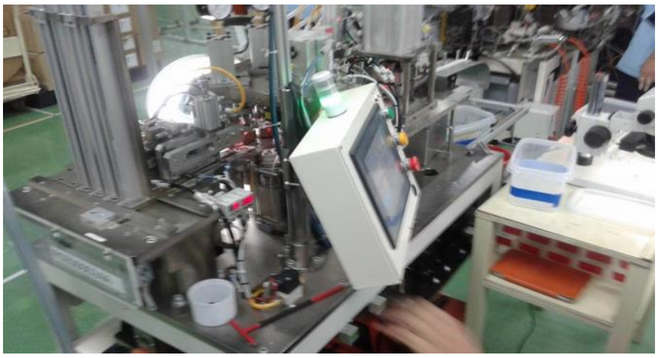

Figure 4. Pick & Place RD 708 Machine

2.5. Analysis Procedure

This project work has been divided into two major processes: simulation work on the top side and experimental work on the bottom side. The simulation work begins by identifying the machine's problem. The process engineer conducts a literature review and consults with the supervisor on implementation of the machine's input parameters. A study of both of the machines was conducted. This involved the pick and place process for both machines, specifically the SDKZ and RD708 models.

In the experiment work, the project was divided into three major phases, which include design 3D CAD, modification of the design, and concept applied to the machine. The experiment began with the creation of a 3D CAD model of the machine (Lee & Wang, 2021). The design of a semi-auto SDKZ machine bears a striking resemblance to the pick-and-place industry. The component, then, will be assembled to build an exact machine. The experimental work proceeded with the modification of the cam pick and place mechanism in the SDKZ machine. The engineers will then upgrade the PNP part to ensure its compatibility with the machine and boost the switch's productivity. The SDKZ machine will then use the modified PNP part. If the design fails to meet the project specifications, it will undergo a redesign until it meets the target.

3.0 RESULTS & DISCUSSION

3.1 . Before Modification of Pick and Place Cam Part

3.1.1. Operational Time of SDKZ Switch

The operational time for manual jig is 6.4s for one complete cycle to assembly SDKZ switch while the time taken for the semi auto machine to assembly one SDKZ switch is 13.04s which is longer than the manual line. From the observation, a pick and place of cam part is major cause of problem due to this time taken. Firstly, the cam need to be inserted into the tunnel. The machine will stop when the cam reaches its end. The operator will then proceed to refill the cam into the tunnel once more. Using a stopwatch, the operator completed the task of filling the cam into the tunnel in approximately 4 minutes. Calculations at that time indicated a potential impact on the switch's productivity.

Time Taken for 1 Switch = **15.64 s ~ 16 s**

Time Loss = 3 minutes

= 3 x 60 s

= **180s**

Productivity of Switch in $= \dfrac{Time\ Loss}{Time\ for\ 1\ Switch}$

$= \dfrac{180s}{16\ s}$

= 12 **units**

1 shift = 8 hours

=8hours x 60 minutes

=480minutes

480/24

=20 cycle per shift

20 x 12 = 240 units per shift

480 units per day

- The total loss of productivity in 1 day is **480 units**

3.1.2. Usage of Labor

In terms of labor usage, ALPS Electric Industrial uses many operators to assemble the SDKZ switch. In the manual line, ALPS Electric Industrial employs seven operators, one of whom is responsible for the switch's quality check. The manual line then transitions to a semi-auto machine, allowing for a reduction in labor usage. When comparing the manual and semi-autoline, there is a significant difference in the amount of labour required. In a semi-autoline, there are only four operators, who also perform a quality check on the switch. A higher production loss can lead to an increase in the switch's productivity. Figure 5 shows the layout of operators in the SDKZ machine line.

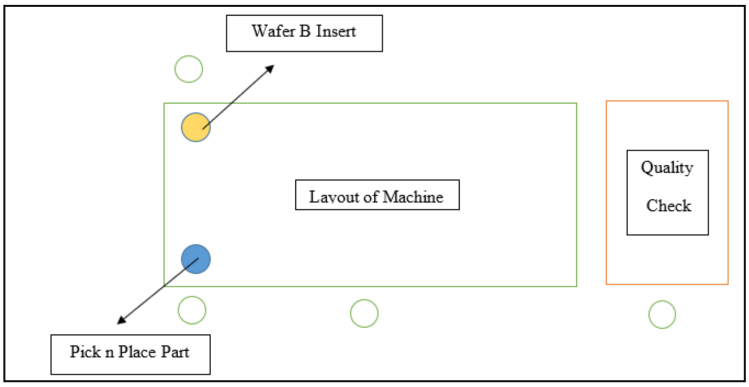

Figure 5. Layout SDKZ Semi Auto Machine

3.1.3. Productivity

The calculation of cycle time, number of workstations, and machine efficiency reveals differences between manual and semi-automatic SDKZ machines. The cycle time of the semi-auto is bigger than the manual machine. The semi-auto's lower desired output rate compared to the manual machine's output rate is the root cause. The task time calculation shows that the manual machine has a longer task time than the semi-auto. This is due to the semi-auto machine's assembly process, which involves 22 steps. In terms of machine efficiency, it appears that the manual machine outperforms the semi-auto machine. This can be attributed to the fact that the manual machine experiences fewer errors.

$$\textbf{Efficiency} = \sum \frac{\textit{Actual Output}}{\textit{Effective Capacity}}$$

$$= \frac{4416}{6400}$$

$$= 69\%$$

3.2 After Modification of Pick and Place Cam Part

A 3D model of the SDKZ machine was modelled in Solidworks. The RD 708 model design was used as the base design and modifications were made to it to build the SDKZ machine design. The tunnel of the cam was increased from 1 tunnel to the 4 tunnel in the new design to enhance production.

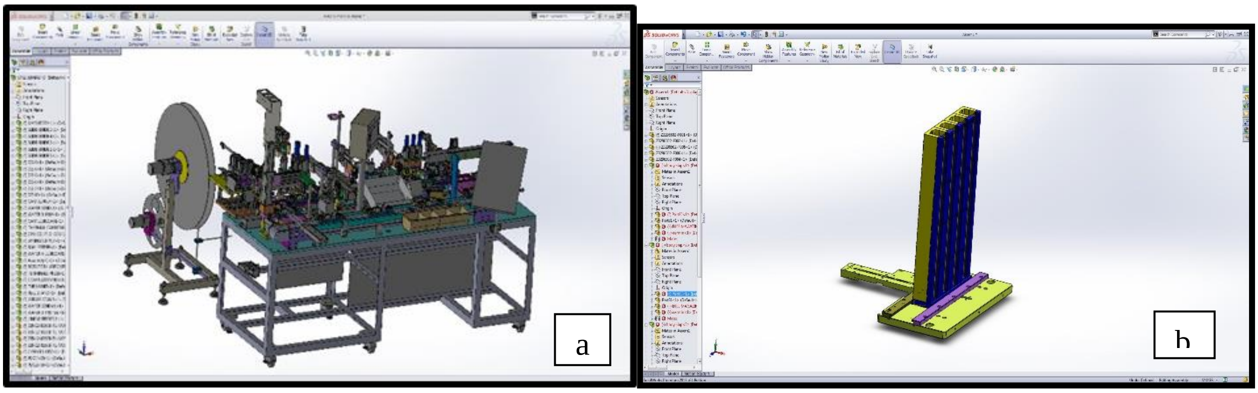

Figure 6a. Complete Design of the SDKZ machine after modification, 6b. 3D view of the new pick and place part after modification

3.2.1. Operational Time

After pick and place part has been modified, it seems that the machine can continuously operate. So, by this improvement, there are no more time loss and productivity loss occur during the assembly of the product. Based on before modification, the total unit that loss is 480 units. By doing modification, the total unit loss become zero thus make efficiency of the machine increase from before.

3.2.2. Usage of Labour

From the expected result, it shows that the part of the pick and place machine now is fully operated by a motor. There are no more operators need in this operation. By doing this kind of modification, it can reduce the usage of labour. Semi auto SDKZ machine line now need only 3 operators to operate.

3.2.3. Productivity

From the calculated operation time loss, it shows that the total loss is 18 units per hour. This problem is caused by the time loss of the machine that affect the productivity of the machine. The example is shown below:

Efficiency $= \sum \frac{Actual\ Output}{Effective\ Capacity}$

$= \frac{4896}{6400}$

= 76.5%

The modified pick and place part appears to enable continuous operation of the machine. As a result of this improvement, time and productivity losses during product assembly have been eliminated. Based on the previous modification, the total number of units lost was 480. After the modification, the total unit loss drops to zero, resulting in an increase in the machine's efficiency compared to before.

4.0. CONCLUSION

In conclusion, this project successfully met its objective. The modification of the SDKZ machine's cam pick and place process part produced the anticipated outcome. This project has also developed a new design aimed at reducing the productivity of the SDKZ switch for semi-auto SDKZ machines. The use of Solidworks for simulation and drawing facilitates the creation of drawings, analyses, and other related tasks. This project has also imparted a wealth of knowledge, particularly in the area of industrial manufacturing simulation.

The RD708 machine was used as a benchmark and applied its concept to the SDKZ machine. The RD708 was chosen as the benchmark machine because its parts are similar to those of the SDKZ machine. This project initially studied both the SDKZ and RD708 machines. This is because both machines have different flow processes. The SDKZ machine adopted and modified the pick and place part from the RD708. The project highlights the crucial role of creativity in modifying a machine. This is because modifying a machine is the most challenging aspect of the industrial process.

Furthermore, the productivity of the switch appears to be improving compared to its previous state. The hope was to reduce the total time loss by modifying a pick and place part in the SDKZ machine. This project also required the inclusion of calculations and comparisons between manual and semi-auto machines. The comparison of a semi-auto machine with the most recent upgrade of the SDKZ machine was done. The time taken, the process of the machine, and productivity have been recorded, so comparisons can be made. Calculations reveal that the efficiency of manual and semi-auto SDKZ machines is significantly different. The calculation of productivity shows the machine's efficiency is increasing from 69% to 76.5%. This is because of the reduction of the time loss in the assembling process. Thus, there is less error occurring on the machine anymore.

Both manual and semi-auto machines differ in terms of manpower. It is understood that reducing or eliminating operations leads to an increase in productivity. Using the semi-automatic machine offers the advantage of reducing manpower, thereby increasing productivity. Despite all the challenges, this project successfully completed all the tasks within its scope.

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