Automated Potting Machine: Design, Development, and Implementation

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Abstract

Curtis Instruments, a renowned pioneer in the electronics industry, operates a manufacturing site in Carolina, Puerto Rico that is a vital component of its global supply chain. Despite being at the forefront of technological innovation, Curtis Instruments faced an ongoing challenge - the traditional potting process. This crucial process, which ensures the protection and longevity of sensitive electronic components, was labor-intensive and time-consuming. Recognizing the inefficiencies, the company aimed to redefine and streamline the potting process. The result was the development and implementation of the Automated Potting Machine. This revolutionary project harnessed advanced robotics, artificial intelligence, and machine learning technologies to automate the potting process. Rigorously tested and fine-tuned for optimal performance, the machine notably increased the efficiency and consistency of the potting process, while significantly reducing human error. This innovative breakthrough has not only transformed operations at the Carolina site but also sets a new industry standard for automation in the potting process, reinforcing Curtis Instruments' reputation as a trailblazer in the electronics industry.

Problem

Curtis Instruments, a well-established entity in the electronics industry, is known for its comprehensive product range that includes motor speed controllers, battery monitors, and a variety of other instruments for electric vehicles and industrial equipment. Their reputation as an industry leader is underpinned by a firm commitment to technological innovation and high-quality product offerings, which echo the principles outlined in the "Handbook of Industrial Robotics" [1]. A significant part of Curtis Instruments' production process in Carolina, Puerto Rico, is the potting process, a technique pivotal to protecting electronic components. Potting is a procedure that involves immersing electronic components or assemblies in a compound for resistance to shock and vibration, and for exclusion of moisture, dust, or corrosive agents [2,3]. However, the potting process has traditionally been labor-intensive and time-consuming, leading to potential inefficiencies and human errors.

Recognizing the need for improvement, the team initiated the design, development, and implementation of an Automated Potting Machine. This project, consistent with the principles of safe human-robot interaction, aimed to significantly enhance the efficiency of the potting process, while minimizing the potential for human error [4].

The objectives for the Automated Potting Machine project were clearly defined, aligning with the modeling approaches for automated systems [2,3]. Leveraging modern technology, the team sought to optimize the potting process, enhance the durability of electronic components, and reduce labor and time commitments.
The team adopted a systematic approach. This involved dissecting the existing process, identifying its challenges, and exploring innovative solutions. The project was segmented into key milestones: the design, development, and implementation stages, each requiring meticulous planning and execution.

Methodology

In the arena of automated potting systems, several existing solutions can be explored from both commercial and academic spheres. From commercial enterprises, various implementations have been noted, each with their unique adaptations to address different challenges inherent in the potting process. Concurrently, ongoing academic research and development have led to innovative solutions, offering a wellspring of information on potential methodologies and technologies that can be leveraged [2].

The backbone of any automated potting system, including the Automated Potting Machine developed by Curtis Instruments, lies in its technological components. At the heart of this are the disciplines of robotics and automation, central elements in designing systems that can precisely execute complex tasks with minimal human intervention. This trend is evident in many manufacturing industries as they strive to enhance efficiency and accuracy and aligns with the observations of Latombe in the field of robot motion planning [5].

Moreover, with the advent of computer vision and machine learning, the capabilities of automated systems have been greatly expanded. They offer enhanced perception and decision-making abilities, transforming the way traditional processes, such as potting, are performed [1].

Automated potting systems present a myriad of benefits to manufacturing industries, including but not limited to improved efficiency, consistency, and reduction in labor intensity. The development of the Automated Potting Machine embodies these advantages. It integrates both hardware and software components, including a compound dispenser, a positioning system, and a control interface, working in unison to improve the potting process.

However, it's equally important to acknowledge the challenges and limitations presented by these systems. These range from initial implementation costs to the need for specialized training for operators, to potential technical issues. For the Automated Potting Machine, these challenges were addressed through extensive testing focused on dispensing speed and compound consistency. Based on the results, the team made necessary adjustments to both hardware and software configurations, demonstrating an iterative approach to development and optimization [4]. As shown in Figure 1, the machine concept is a combination of all iteration performed to fulfill all problems requirements while maintaining the best safety standards and within budget.

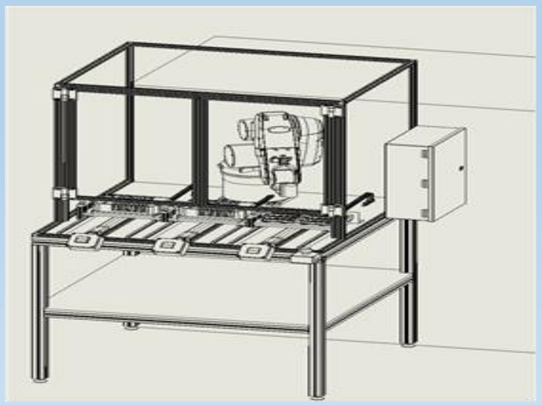

Figure 1. Automated potting machine concept

The team conducted extensive tests on the machine to ensure its optimal performance as shown in Figure 2. These tests focused on the dispensing speed and consistency of the compound. Based on the test results, the necessary adjustments were made to the hardware and software configurations to improve efficiency and accuracy.

Figure 2. Accuracy and consistency of the adhesive mix ratio over multiple tests

Results and Discussion

The implementation of the Automated Potting Machine has led to significant improvements in the potting process. The preliminary data shows a substantial increase in efficiency, with a reduction in the time required for potting by approximately 45%. The machine's precision has also reduced human error, leading to a consistent improvement in the quality of potting. Furthermore, the machine's capabilities allow it to adapt to different component configurations, making the process more flexible and versatile.

The results clearly indicate the potential of automation in enhancing the efficiency and quality of the potting process in the electronics industry. However, it is also essential to consider the initial investment required for implementing such technologies. While the upfront costs may be significant, our analysis suggests that the increased efficiency and quality could offset these costs in the long run.

As shown in Table 1, the initial investment is $70,000. The current process uses three operators, and the gool is to reduce this to only one. This will achieve a payback time of approximately seven months if only the machine is used on one shift.

Table 1

Cost comparison

	Current	Proposed
Operators	3	1
$Cost/hr	$ 9.35	
$Overhead/Hr	$ 32.73	
Yearly Cost	$ 184,078.13	$ 61,359.38
Cost Reduction	$ 122,719	
Investment ($) =	$ 70,000.00	
Pay Back Time =	0years & 6.8months	

Training Program

To ensure the successful operation and maintenance of the Automated Potting Machine, a comprehensive training program for operators and maintenance personnel was developed. The program covers essential topics such as machine operation, troubleshooting, and preventative maintenance.

Future Work

To meticulously document each stage of the project and to ensure continual improvement and innovation, the team decided to initiate a Progress Journal. This journal will serve as a critical tool in tracking advancements, recording experiences, and guiding the project to its successful completion. With this new approach in place, the team anticipates refining the Automated Potting Machine by exploring new configurations and identifying potential improvements, thus enhancing its performance and efficiency. They also plan to apply the machine in various applications and meticulously evaluate its impact on the industry through this recorded journal of progress.

Conclusion

The Automated Potting Machine project demonstrates the potential benefits of automation in the electronics industry. By optimizing the potting process, the machine promises to increase efficiency, reduce human error, and improve product quality. The development and implementation of this innovative solution has the potential to revolutionize the industry and set new standards for electronic component potting.

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