Enhancing Safety-Critical Assembly Processes through Electrical Testing: Advanced Manufacturing Solutions for Wire-Harness Assembly in Treadmill Components

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Abstract

The misalignment of safety-critical components can have serious consequences, particularly in consumer products such as treadmills. In this study, I investigated an assembly issue in treadmill plastic components that allowed wire-harness bases to be seated in either correct or incorrect orientations. The problem posed a significant safety hazard, as an incorrectly seated wire harness would prevent the stop-button safety feature from functioning correctly, potentially endangering users. Immediate corrective actions were taken to fix the problem both at my company and at the customer's site. Two long-term solutions were proposed: a design change and an ampere test. The customer chose to implement the ampere test for future production, and this solution was verified to ensure proper assembly in all future lots.

Keywords: Wire-harness assembly, safety switch, treadmill component, ampere test, assembly misalignment, corrective action, preventive action

Introduction

In the manufacturing world, especially when dealing with safety-critical components, even the smallest assembly oversight can lead to serious consequences. This is particularly true in consumer products that are used frequently and by people of various skill levels, such as treadmills. Treadmills come equipped with several safety features, one of the most important being the stop-button, which ensures immediate halting of the machine in case of an emergency. In October 2020, while assembling treadmill components that included wire-harnesses, brass inserts, screws, and metal washers, we encountered a potentially dangerous issue with the wire-harness base assembly. The plastic part into which the wire-harness base was inserted was designed in such a way that it allowed the base to be seated in either orientation—both correct and incorrect. This posed a serious risk, as an incorrectly seated wire-harness could result in the treadmill's stop-button not functioning properly, leaving users exposed to potential accidents.

In industries like ours, where human assembly plays a role, there’s always the possibility of error. While automation can reduce the likelihood of such mistakes, certain tasks, like installing wire-harnesses, are often performed manually. When I was informed about this issue by one of the assemblers, I realized the potential gravity of the situation. A critical component responsible for user safety, if misaligned, could lead to catastrophic results. Not only would the stop-button malfunction, but it would also go unnoticed until the treadmill was in use, possibly causing injury to the user. Therefore, the issue needed to be addressed immediately to prevent defective products from reaching the end users.

This paper documents the steps I took to investigate the root cause of the problem, the immediate corrective actions that were implemented, and the preventive solutions developed to ensure this situation did not recur. The resolution of this issue required both quick thinking and long-term strategic planning, as any misstep could have resulted in far-reaching consequences for both the manufacturer and the customer.

Problem Statement

The treadmill component assembly involved multiple parts, including a wire-harness base, brass inserts, and metal washers. A significant issue was discovered when it became clear that the wire-harness base could be inserted in two orientations within the socket on the plastic part. The issue specifically revolved around the seating of the wire-harness base, which was responsible for the alignment of the treadmill's stop-button mechanism. If the wire-harness base was installed upside down, the safety stop-button, a magnetic sensor responsible for halting the treadmill in case of emergency, would not be triggered properly. This malfunction would go unnoticed until the treadmill was in operation, posing a significant risk to the user.

The design flaw in the plastic socket allowed the wire-harness base to fit either correctly or incorrectly, providing no clear indication to the assembler whether it was properly oriented. The assembler might insert the base, complete the assembly, and not realize that the wire-harness was in the wrong orientation. This situation was particularly concerning because the stop-button was a crucial safety feature, and its failure could result in serious injuries to anyone using the treadmill.

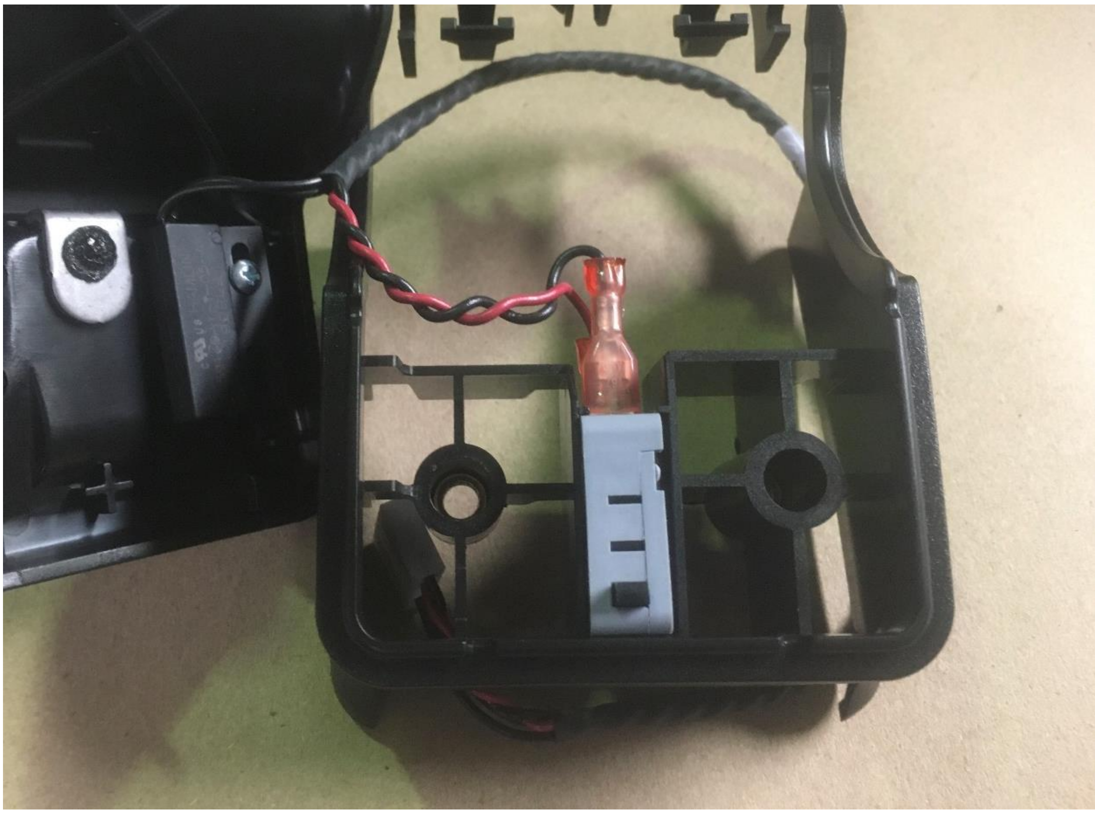

Figure 1: "Wire-Harness Base Seated in Socket"

Upon discovering the issue, I immediately began to investigate the extent of the problem. I quickly identified that this issue had already affected several assemblies, with a portion of them already sent to the customer. If left unaddressed, these defective assemblies could have reached end users, putting their safety at risk and damaging our reputation as a reliable supplier. The need for both a corrective action plan to deal with the immediate issue and a preventive solution to ensure this problem didn't happen again became clear.

By thoroughly analyzing the root cause and implementing corrective solutions both at my company and at the customer's facility, I was able to resolve the immediate issue. However, this problem also required a forward-thinking approach to prevent future occurrences, which led to proposing both design changes and testing methods to enhance assembly reliability. This proactive approach ensured that not only was the current risk mitigated, but future production runs would also be safeguarded from similar safety hazards.

Root Cause Analysis

When this safety issue was first brought to my attention, my immediate priority was to determine the extent of the problem and why it occurred in the first place. The treadmill component assembly process included a wire-harness base that connected to a stop-button mechanism—a critical safety feature. Upon deeper investigation, I discovered that the root of the problem was directly tied to the design of the plastic socket that housed the wire-harness base. The socket was designed without any keying or guiding features that would force the wire-harness base to be installed in only one orientation. This oversight created a situation where the base could be seated both correctly and incorrectly, with no visual or tactile indication to the assembler as to which way was correct.

Figure 2: "Close-Up of Misaligned Wire-Harness Base"

The root of this issue lay in two critical aspects: the design of the part itself and the manual assembly process. The plastic socket design had too much room for error, allowing the harness to be seated upside down without immediate detection. In a fast-paced manufacturing environment where human assembly plays a role, it is crucial that parts are designed to be as foolproof as possible to minimize the risk of assembly errors. However, in this case, the design of the socket lacked the necessary restrictions to ensure correct orientation.

Additionally, the assembly process did not have a built-in quality control check for this particular issue. Because the wire-harness base could be seated in either orientation without affecting the visual appearance of the assembly, the assembler could easily complete the assembly without noticing the error. The misaligned base would then result in the treadmill's stop-button malfunctioning, as it relied on the correct positioning of the wire-harness to activate properly.

Upon identifying this as the root cause, I immediately traced back the affected production batches. I found that several assemblies had already been completed, and a portion had even been shipped to the customer. Further inspection revealed that four boxes of suspect parts were still at the customer's location, and another partial box had already been installed on treadmills that were in the process of being delivered. This quick assessment allowed me to intervene before the defective products reached end users, but it became clear that immediate corrective actions were required to fix the problem both at our site and at the customer's.

Corrective Actions

Given the severity of the issue, my first action was to contain the problem and prevent the defective assemblies from causing harm. I immediately initiated a full review of the suspected lots, both in our facility and at the customer's site. This was critical to ensure that none of the misaligned wire-harness bases made it to the end users, as any failure of the stop-button could have led to serious accidents. After identifying all the suspect lots, I took the following corrective actions:

1. **Identification and Recall of Suspect Parts:** My first priority was to locate all the assemblies that could potentially have the wire-harness base installed incorrectly. At our facility, I identified several suspect lots and halted production immediately. Additionally, I reached out to the customer and informed them of the situation. We identified four full boxes of suspect parts at their location. These parts were isolated for inspection. One partial box had already been installed on treadmills that were being prepped for delivery, but fortunately, these units had not yet reached the end users. Customer was able to recall the shipment while it was still in transit, ensuring that the treadmills were returned for re-inspection before delivery.
2. **Disassembly and Reinstallation:** After identifying the suspected lots, I personally took charge of disassembling the affected units, both at our facility and collaborating with customers at the customer's facility. In total, I reviewed and corrected several assemblies, ensuring that the wire-harness base was reinstalled in the correct orientation. At the customer's site, I worked alongside their team to inspect and fix the assemblies in three full boxes and the partial box, preventing any defective treadmills from being delivered to their final destinations.

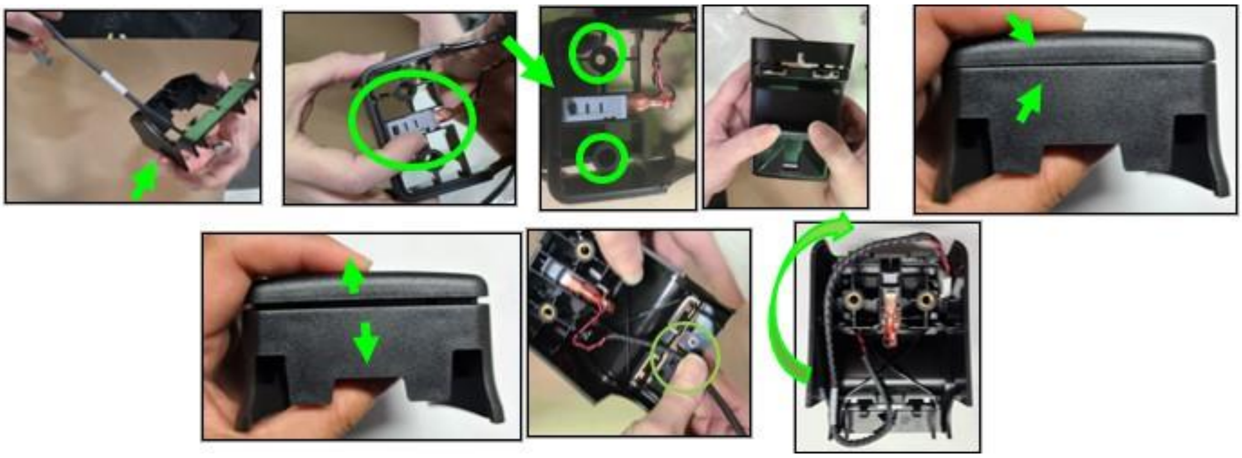

Figure 3:"Correctly Reassembled Wire-Harness Base"

3. **Temporary Production Halt:** While the immediate issue was being addressed, I implemented a temporary halt in the production of the wire-harness assemblies. This pause allowed us to review our assembly procedures and ensure that no further errors occurred. The halt was crucial to preventing more defective parts from being produced while we worked on the long-term preventive measures.
4. **Communication with the Customer:** Throughout this process, I maintained close communication with the customer to keep them informed about the situation and the steps we were taking to resolve it. This transparency helped maintain their trust and confidence in our ability to manage the issue effectively. The customer appreciated the swift action, and the effort put into ensuring that no defective products reached the end users.

The corrective actions taken ensured that the immediate problem was addressed, but I knew that a long-term solution was necessary to prevent future occurrences. This led to the development of the preventive solutions, which included a design change and the implementation of an ampere test, as detailed in the subsequent sections.

Preventive Solutions

While the corrective actions were effective in resolving the immediate issue, it became clear that a permanent solution was necessary to prevent future occurrences of this safety-critical problem. After reviewing the assembly process and the design of the components involved, I proposed two preventive solutions to address the root cause of the wire-harness base misalignment. These solutions aimed to make the assembly process more reliable and error-proof, minimizing the chances of human error and ensuring consistent safety across all future treadmill components.

1. Design Modification of the Socket

The first solution I proposed was an engineering change to the design of the plastic socket. The goal was to modify the socket in a way that would physically prevent the wire-harness base from being seated incorrectly. I worked with the design team to suggest the addition of keying features—small ridges or tabs within the socket that would only allow the base to fit in one orientation. With this design modification, if the operator attempted to install the wire-harness base upside down, it simply wouldn’t fit, and the cover wouldn’t sit flush. This would immediately alert the assembler to the error and prevent the part from being assembled incorrectly. Additionally, the design was adjusted so that if the base was incorrectly oriented, the stop-button wouldn’t engage, and the assembler would hear no “clicking” sound, which was a key part of the assembly verification process. By introducing these design constraints, we aimed to eliminate any possibility of human error during manual assembly.

This design change was an ideal long-term solution because it directly addressed the root cause of the issue—the socket’s ability to accommodate the wire-harness base in both orientations. By physically restricting incorrect assembly, this solution ensured that future assemblies would always be correct, regardless of the skill or attentiveness of the operator.

2. Implementation of Ampere Testing

The second preventive solution focused on improving the quality control process by introducing a new method of testing the assembly electrically. I suggested the implementation of an ampere test using an electrical tester to verify whether the wire-harness base was seated correctly. This test involved connecting the two ends of the wire-harness and engaging the stop-button. If the wire-harness base was installed in the correct orientation, the stop-button would trigger a green light on the tester, indicating a successful assembly. However, if the base was seated incorrectly, the electrical connection would not function properly, and the tester would display a red light, signaling a problem.

This ampere test added a layer of quality assurance to the assembly process, ensuring that even if an error occurred during assembly, it could be caught before the product was shipped to the customer. This solution was especially appealing to the customer because it provided a clear, measurable way to verify the safety of each assembly. As a result, the customer chose this option for their ongoing production, integrating it into their quality control process.

By combining these two solutions—an engineering change to the design and the introduction of electrical testing—I was able to create a robust, fail-safe system that would ensure the correct installation of the wire-harness base in all future assemblies. The combination of physical design restrictions and electronic verification greatly reduced the likelihood of assembly errors and provided peace of mind that the safety-critical stop-button would function as intended.

Conclusion

The safety-critical assembly issue involving the wire-harness base in treadmill components highlighted the importance of robust design and quality control processes in preventing potentially dangerous product failures. In October 2020, after discovering that the wire-harness base could be installed incorrectly, I immediately took action to address the issue both in my facility and at the customer's site. By tracking down and correcting the defective assemblies, I ensured that no unsafe products reached end users. This quick response helped prevent potential injuries and safeguarded the reputation of both my company and the customer.

However, addressing the immediate issue was only part of the solution. To prevent future occurrences, I proposed two preventive measures: a design modification to physically prevent incorrect assembly and the implementation of an ampere test to verify proper installation. The combination of these two solutions provided a long-term fix that greatly reduced the risk of human error in the assembly process. The customer ultimately chose to implement the ampere test, which gave them an added layer of assurance in their quality control process.

This experience underscored the critical role that both design and quality control play in ensuring product safety, especially when dealing with consumer products that include safety features like stop-buttons. By taking a proactive approach and addressing both the root cause of the problem and its potential consequences, I was able to implement solutions that improved the reliability of the assembly process and enhanced the overall safety of the product.

Acknowledgments

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