Sticky Solution-An Assistive Device to Apply Sealing Tape onto an Insulation Foam (Duke University)

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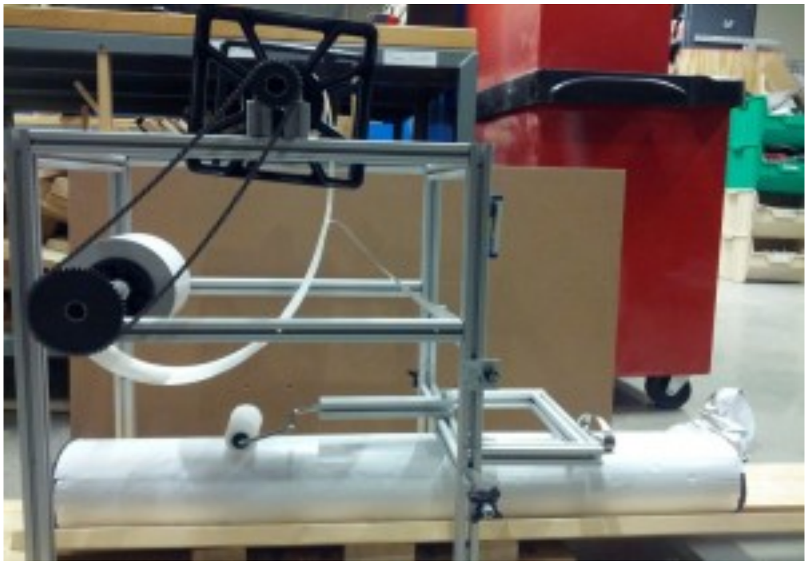

Figure 1: Sticky Solution Device

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Abstract

A number of employees at OE Enterprises have special needs that require assistive technology for them to complete certain job functions. The goal of our project, Sticky Solution, was to create a device that enables employees with disabilities at OE Enterprises, Inc. to separate and linearly apply an accurate, wrinkle-free piece of sealing tape to an insulation foam. The device consists of multiple components: frame, pressure applicator, a wooden trough, backing and tape spools with automatic spooling, and a cutting mechanism; all of which help to apply wrinkle-free tape onto various foam dimensions ranging from 3 3/8" to 5 5/8"(total width). Quantitative analysis was performed to assess the feasibility and practicality of device's "slip" mechanism. Finally, a client result survey portrays a positive reaction to device functionality.

Client Background

OE Enterprises is a community rehabilitation non-profit organization that provides occupational opportunities to individuals with disabilities. Their goal is to empower individuals with physical and mental disabilities primarily through vocational training. Serving as a labor subcontractor, OE Enterprises currently assembles a large proportion of new Armacell foam pipe insulation, which is used in construction work all across the country.

Figure 2: Approach one of Tape application

Figure 3: Approach two of Tape application

OE’s production needs a mechanism to separate and linearly apply an accurate, wrinkle-free piece of backed sealing tape to an insulation foam. Initially, OE had the tape from the fifty yard roll pre-cut to the appropriate length (36 inches) independently of the tape application. The pre-cut tape was then brought to a tape application area, where employees approach the task in different ways, depending on their dexterity. In the first approach, an employee removes the entire backing from the tape at an endpoint, then aligns and applies the sticky end at one end of the insulation foam (Figure 2). This process requires strong motor skills, so employees with lesser dexterity conduct the process differently and more slowly due to the difficulties in handling the long sticky strand of tape. They choose to first remove only a small part of the backing, and then inch their way towards the other side, smoothing the tape along the tube as they go along. Unfortunately, this process is prone to error, as the alignment of the tape with the second (final) edge of the tubing is not integrated into a general feedback source for the employee. We felt that the second application process (Figure 3) represents the characteristics that limit many employees at OE as the few staff members possessing proficient manual dexterity exclusively undertake such roles, which hinders output expansion and limits their time supervising other tasks.

Many commercial devices separate the backing from tape, cut the tape at a certain length, and apply tape when manually pushed or pulled. Tape dispensers[1] are available in electric and manual models. Our device had to be simple, functional, inexpensive, and suitable for use in a small industrial setting like OE Enterprises. The main aim was not to completely automate but to allow employees with disabilities to complete the task accurately and reliably.

Consequently, our device will enable the tape application step faultless for those employees; in particular, it addresses the following processes: removes the tape backing, cuts the tape to 36 inches, and applies pressure that enables tape application onto the insulation foam.

Problem Statement

The goal of the project was to create a device that helps to separate and linearly apply an accurate, wrinkle-free piece of sealing tape onto an insulation foam.

Functional Specifications

The functional specifications were weighted out of 100 to highlight the goals to be met in the device implementation.

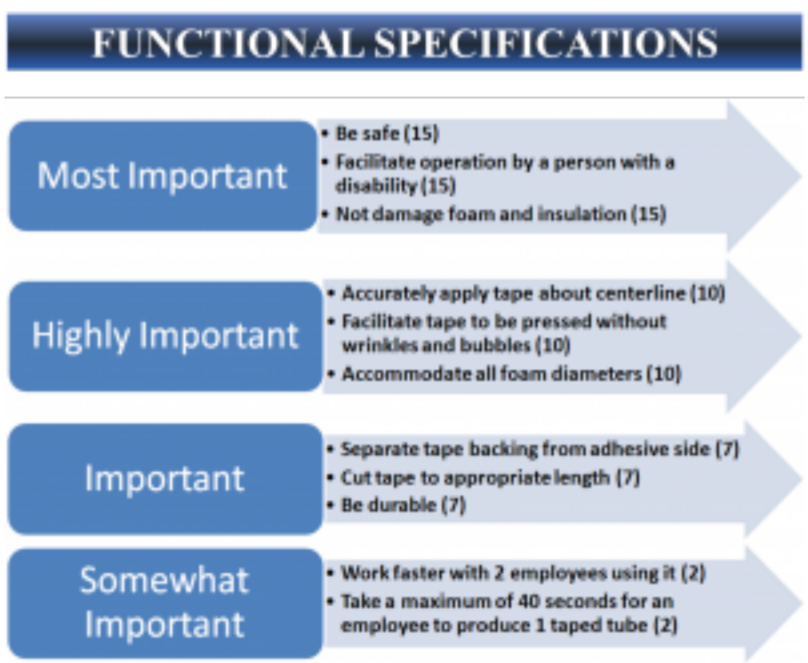

Figure 4: Functional Specifications

Device Design

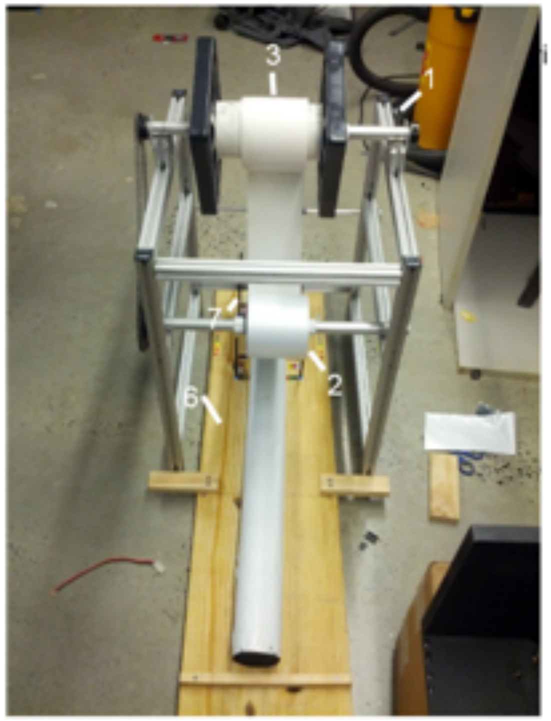

Figure 5: Device (Front view)

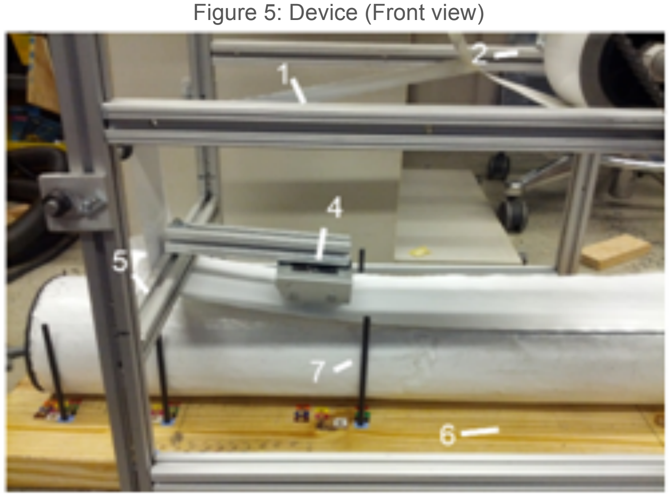

Figure 6: Device (Side view)

The device (Figures 5 and 6) comprises a base, a frame, two axles with sprockets, a cutting mechanism, and a pressure applicator. The 11” x 1 3/8” x 49 5/8” base is entirely constructed of wood.

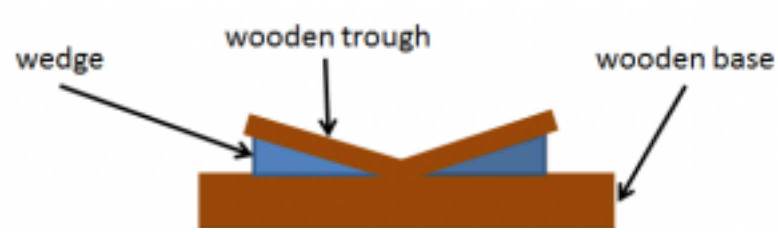

Figure 7: Schematic of angled wooden trough

Figure 8: Foam hitting the stopper

A wooden trough that keeps the foam tube in place is attached to the base at a 30° angle, via 3 triangular wedges on either side that are fastened to the base with screws (Figure 7). The trough extends past the front of the base, allowing the user to rest the tube comfortably while applying the tape initially. Each side of the trough is 48” x 1” x 3 1/2”. There is a 11” x 1/4″ x 5/8” wooden stopper (Figure 8) attached to the base to prevent pushing the tube too far, calibrated so that the perfect length of tape is applied every time. There are wooden supports to hold the frame in place relative to the base. The top side supports are 4 7/8” x 2 1/4” x 3/4″.

Figure 9: Aluminum T-frame

The frame is made of aluminum extrusion(Figure 9). The vertical members are each 2'. The topmost middle members are 14 1/4" each. The side members are 17 3/4" each. All members are four slot, single, 1" solid square aluminum extrusion, with a .255" T-slot width, and a 0.205" hole diameter at both ends of each member. At the junction points of two members, there is an access hole for a 5/32 hex screw, in which the aluminum inch T-slotted framing system 90 degree connector can be loosened or tightened.

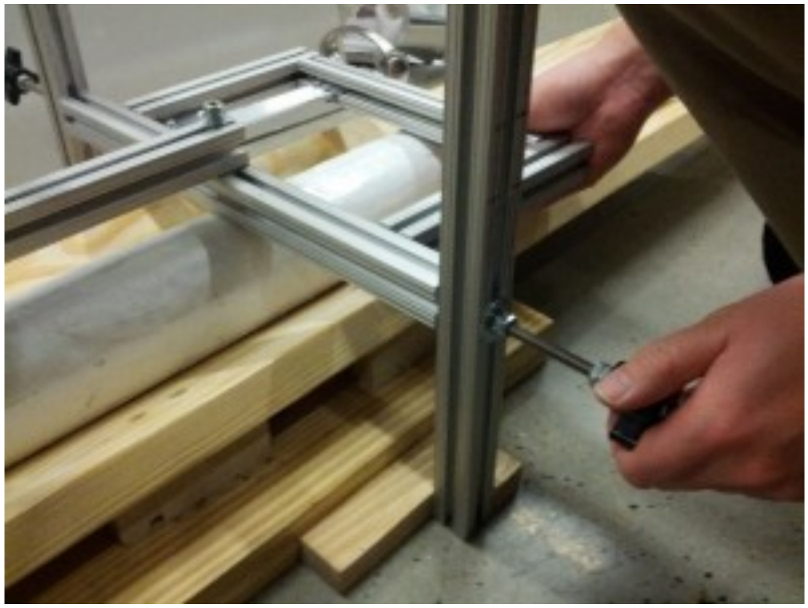

Figure 10:Adjusting side knobs

To remove parts of the frame, the connectors must be loosened, and then the members can loosely slide along the t-slot with the help of butterfly-shaped access knobs that allows easy vertical adjustment (Figure 10).

Figure 11: Level indicator to check alignment

A level indicator, which is fastened with the help of a velcro on the vertical frame is then used to check if the extrusion is perfectly aligned (Figure 11).

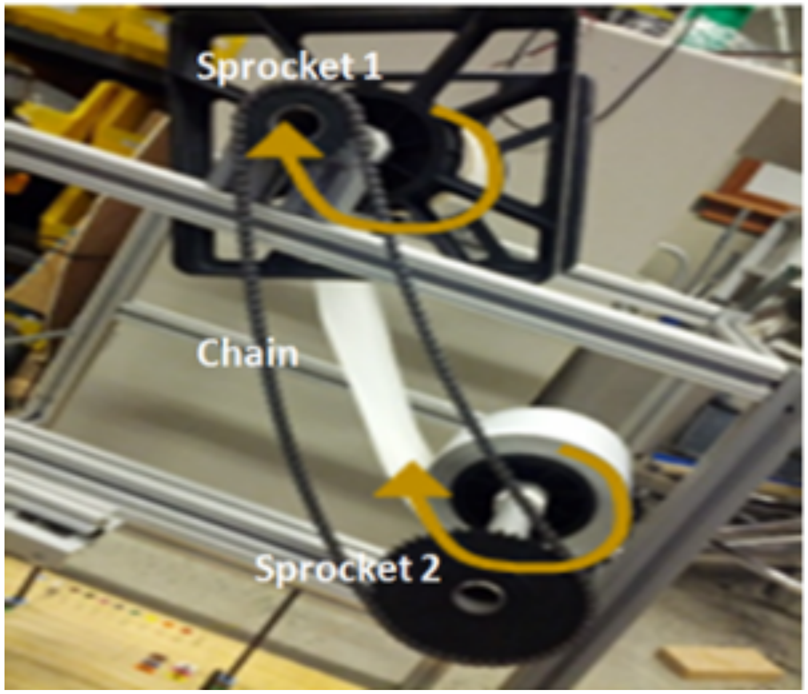

Figure 12: Tape and Backing collector spools with Automatic spooling

The axles are made from aluminum tubing, that were cut to 19” lengths, and a 7/8” outer diameter, .805” inner diameter, and .035” wall thickness. The lower axle holds the tape roll which is provided by the client. The upper axle collects the backing of the tape about a cylindrical piece of PVC tubing. The tape roll and backing collector tubing are held in place on both sides by plastic holders that rest on PVC tubing. Each axle has a sprocket at one end. Both sprockets are steep finished-bore, 7/8” bore, 1/4” pitch. The axle with the tape has a sprocket with 48 teeth, and the axle with backing has a sprocket with 24 teeth, for a 2:1 ratio. The sprockets are connected with a length of machined chain to allow for synchronized automatic spooling and collection of tape backing (Figure 12). There is a 5/16” x 12” chrome coated low carbon steel support rod running across the front face of the device. The support rod has black oxide steel 7/8” diameter set screw shaft collars on both ends of the rod to prevent from falling out of the frame, as well as two in the center to guide the tape through.

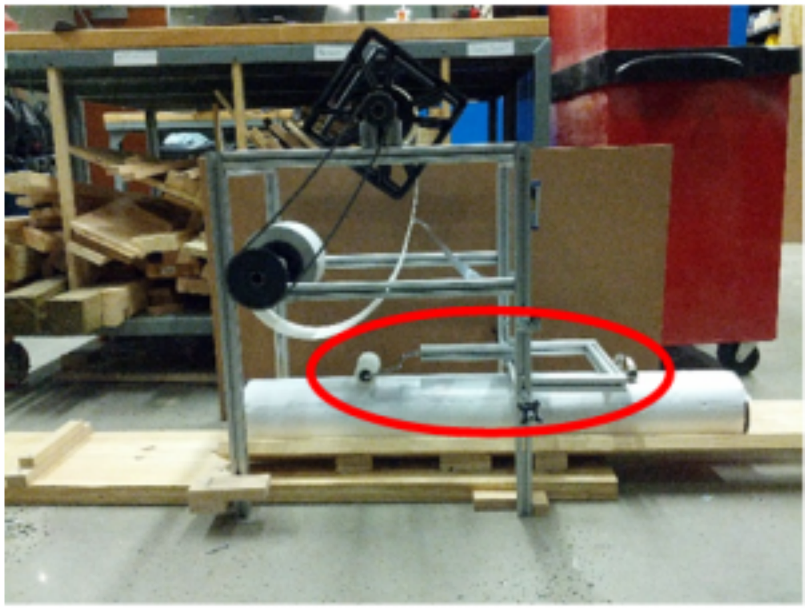

Figure 13: Pressure applicator

Figure 14: Pressure applicator and foam in place

The pressure applicator comprises a machined piece of aluminum extrusion with the same specifications as previously mentioned with the frame (Figure 13). At the end of the extrusion, there is a woolen paint roller (Figure 14) that applies pressure to the tape as the tube is pushed through. The height of the pressure applicator is adjustable to accommodate different sized tubes. There are adjustable side knobs, which rest on 1/4” 20 steel screws, cut to 4” lengths each, that are held in place by 1/4″ 20 nuts and washers. These side knobs can be loosened to adjust the pressure applicator, and then tightened to lock in place.

Figure 15: Using cutter to cut the tape

As soon as the foam touches the stopper, the user then slides the cutter from left to right to dispense an exact length of tape (36 inches) onto the foam. (Figure 15).

Validation and Quantitative Analysis

Prototypes made from wood and PVC pipes were presented to a panel made of professors, biomedical engineering students, and physical therapists. Feedback and suggestions were provided during these presentations. Modifications were made based on information gathered from client testing of our prototypes and final device.

The final device was validated to assess client ease of use, device effectiveness and safety. Ease of use was assessed by observation and actual testing by the client. Detailed hazard analysis and risk assessment were conducted and risks identified were addressed through redesign.

Due to expensive parts (customized slip clutches) that cost more than $100 and general infeasibility of having motor driven tape in place, there was a need to evaluate cheap, easily accessible in-house custom solutions.

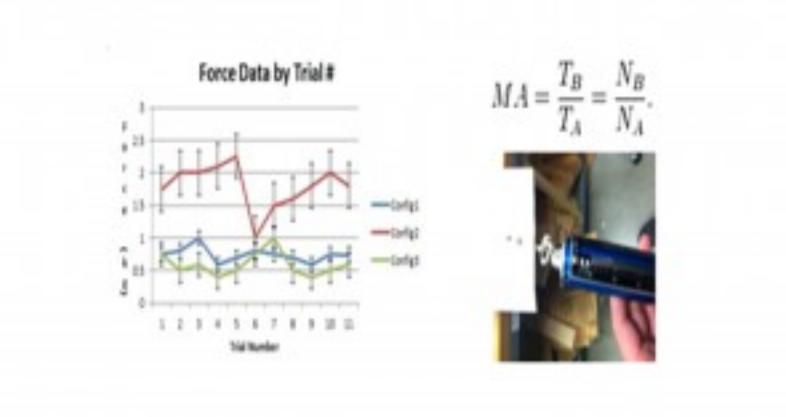

Figure 16: Quantitative Analysis to assess 'slip' mechanism

The device has a large need for ‘slip’ due to a constant gear ratio (2:1) which was chosen to allow for steady uptake of backing. The analysis was aimed at categorizing the nature of slipping mechanism within a variety of important configurations as a design consideration for end use and product efficacy. Since the gear ratio translates to torque ratio, force analysis was performed for multiple trials. Statistical inference was then used to compare and assess the best configuration.

Based on the result (Figure 16), the team chose to move forward with the configuration that surrounds the backing collector spool with two slots for friction fit and plastic boundary pieces that achieves the best ‘slip’ with comparatively lesser force.

Discussion, Costs and Conclusions

The device is simple, functional, inexpensive, and suitable for use in a small industrial setting like OE Enterprises. The main aim was not to completely automate but to allow employees with disabilities to complete the task accurately and reliably.The device accomplishes the requirements set forth by our goals very satisfactorily.

To summarize, the device contains the following mechanisms:

i) Automatic spooling that does not require user intervention.
ii) Pressure applicator that ensures the tape is applied along the center line.
iii) Easily interchangeable parts such as the spool rods.
iv) Centering trough that accommodates all foam dimensions.
Simplicity in setup enables a wide range of users to complete the task, while simultaneously increasing throughput efficiency. This enables employees at OE Enterprises to perform the tape application task safely and effectively, thus increasing

their workplace opportunities. Also, staff workers previously occupied by this responsibility can now allocate their time and efforts elsewhere, if needed.

The development cost includes the cost involved in building prototypes and the final device ($331.58). Replacement cost is the cost of the device if it were to be built from scratch ($216.28). Materials include: Aluminum T-frame, T-frame fasteners, drop-in fasteners, aluminum tubing, roller chain sprockets, #25 ANSI chain, shaft collars, spool holders, razor blades, wood.

In conclusion, the device has empowered OE Enterprises employees with disabilities to perform a task they previously were unable to do. Employees and supervisors at OE Enterprises have warmly received the device and given positive feedback, commenting that the device allows more people to do their job and has increased productivity. However, the flip side of the device involves re-working on the cutting mechanism to ensure the sticky tape end does not contact the blade.

Acknowledgements and References

[1] Frohbach Harold O., Gill Earle F., Marran John S., Romano Anthony J. Chart-Pak, Incorporated, Tape dispenser. U.S. patent 2918189 Jul 8, 1957.

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