Automatic Silverware Napkin Wrapping Machine: Phase II

*Design Team*
Jess Hohenstein, Michael Shih, Hao Chih Wei

*Design Advisor*
Prof. Yiannis Levendis

*Abstract*
The main goal of this project is to design and build a functional, fully automated machine that wraps sets of silverware in napkins. The design should be inexpensive, reliable, and easy to use. The machine will use a mechanism consisting of a spring lift system, two needle hooks, and a linear track to fold the napkins. The napkins will be loaded onto a tray attached to a spring that will continually raise the tray as napkins are removed from the top of the stack. Two needle hooks will puncture the front edges of a single napkin and slide it to a loading area, where utensils will be loaded onto the napkin via a rotating wheel silverware dispenser. The bundle will then be slid past stationary folding prisms, which will fold the two ends of the napkin over. The bundle will then be slid to the rolling area, where two parallel rotating rods will pinch the napkin and roll it into a wrap. A tab will be used to keep tension on the napkin to ensure a neat, tight roll. The completed roll will then be dropped into a storage bin. The final design must comply with FDA standards regulating the handling of food utensils.

For more information, please contact y.levendis@neu.edu.
The Need for Project

A more cost effective and efficient method of folding sets of silverware in napkins is needed to replace the current process. Large restaurants and cruise ships are currently spending a lot of time and money to complete the process of folding silverware into napkin bundles. This activity also involves a risk of silverware contamination because humans are folding the napkins. A machine that wraps silverware napkin bundles quickly and automatically will be beneficial in these situations.

Although patents exist for such a machine, the designs are overly complicated and have not gone to production. The “It’s A Wrap” by Autowraptec was once commercially available, but the company seems to no longer be in business (Rep. 3.1.3).

The Design Project Objectives and Requirements

The Design Project Objectives

The overall objective of this project is to create a functioning, completely automated machine that will increase the efficiency of wrapping sets of silverware in napkins for businesses in the food industry while being inexpensive, reliable, and easy to use. All components should be easy to repair and replace. The final product should be compliant with FDA regulations regarding sanitation and food utensil handling. In the current phase, the design of three subcomponents of the machine was addressed.

Design Requirements

The machine should be produced for less than $2000 to keep the target market price reasonable for potential customers. The overall weight of the machine should be less than 150 pounds to ensure that it can be moved through the use of a dolly or wheels. Based on a survey of local restaurants, the ideal output of the machine should be 11-15 bundles per minute, with a minimum design requirement of 3 bundles per minute (Rep 3.2). The product should be powered by plugging into a standard, 120V outlet.
Design Concepts Considered

Various initial concepts were identified and considered for each of the machine sub-processes: napkin storage, napkin dispensing, silverware dispensing, napkin folding, and napkin rolling. The total process was broken down into five sub-processes: napkin storage, napkin dispensing, silverware dispensing, napkin folding, and napkin rolling. Many design concepts were identified and evaluated, including the ideas from Phase 1.

Napkin Storage

The weight napkin lift was identified as a method for storing a stack of napkins. Napkins would be stored inside a box with a lift on the bottom base. This lift would be moved upwards through a pulley system, wherein tension created by a weight on one end would cause the oppositely situated napkin stack to rise. A stopper would ensure that the stack lifted to the same level each time.

Napkin Dispensing

A fan method was considered to move the napkins. This would have involved using the suction created by fans to lift and move the napkins, and disengaging the fans would have dropped the napkins.

Silverware Dispensing

The rotating wheel silverware dispensing system was developed during Phase 1. This concept involved stacking silverware in a vertical cartridge above the napkin folding area. A rotating wheel mounted at the base of the cartridge with two distinct feature cuts on opposite sides would rotate and engage a single piece of silverware.

Napkin Folding

A moving rod system, developed during Phase 1, involved two bars moving in arc shapes to perform the napkin folds.

Recommended Design Concepts

The final design includes a spring napkin storage system, needle hook dispensing system, rotating wheel silverware dispense system, prism folding system, and dual rod rolling system. Aspects of the initial design concepts including their complexity, size, cost, and reliability were evaluated to make the best decisions about the final design components. Due to time constants, the silverware dispense and rolling systems were omitted.

Design Descriptions

In the spring napkin storage system, napkins are stored inside a box and sit on a base that can move vertically. This base is stabilized by surrounding walls. Three support springs (between the napkin-holding base and the base of the storage box) with a specific spring constant will always push the napkin stack to the correct height.
The needle hook system then grabs and moves the napkin on the top of the stack. Two precisely bent needles create small hooks and attach to arms. The arms are attached to a slider that runs along a track at the top of the machine. Springs attaching the arms to the slider keep the arms in a constant position. When the slider moves towards the napkin stack, the arms come into contact with a bar and are pushed downwards and into the napkin, hooking it. The slider then reverses directions and pulls the napkin away from the stack.

The rotating wheel silverware dispense system involves a simple conveyer with borders attached to the outside to create storage slots for the silverware. This mechanism will be stored in a box with a slot-sized opening, and silverware will be dispensed with the turning of the conveyer.

The dual prism folding system consists of two 30° triangular prisms. As the napkin comes into contact with and slides past the prisms, the sides slide up the ramps and fall over, resulting in folds on the napkin ends.

The dual rod rolling system consists of two rods mounted on a circular plate. This plate will be capable of rotation and horizontal movement along a track. The two rods will move and pinch the napkin bundle. Rotation of the rods will then cause the bundle to roll. The finished bundle will then be disengaged and dropped into a storage compartment.

**Analytical Investigations**

Calculations were performed to investigate the financial feasibility of the design, as seen in the Financial Issues section. It was also necessary to precisely calculate the necessary spring constant for the spring in the napkin storage system so that the base would consistently rise to the correct level.

**Experimental Investigations**

To ensure that the folding system would work every time, experimental testing was completed to find the angle, height, and width necessary for the prisms. Similar testing was completed to determine the necessary dimensions and springs in the needle hook system.
Key Advantages of Recommended Concepts

The main advantage of the chosen design concepts is their simplicity, especially in comparison to the designs of Phase 1 and those found in similar patented processes. Less complexity means that this machine will be more reliable. Specifically, the storage and folding systems are much simpler, as they involve no moving parts. The designs are also relatively inexpensive to produce and fit within the original budget.

Financial Issues

The design was produced under the stated budget of $2000. Even though more materials will be necessary to complete some additional work to make a fully functioning machine, this is promising when compared with the current cost of folding silverware napkin bundles. On a typical large cruise ship, approximately 250 hours and upwards of $2500 is spent each voyage on this task (Rep. 3.1.2). With a suggested retail price of $6000, there is certainly benefit to buying such a machine and potential for profit.

Recommended Improvements

Due to time constraints and the complexity of the processes, prototypes were not created for the rolling system and silverware dispense systems. The robotics that will control the functioning of the entire system must also be implemented once all systems are complete. Making the machine fully automated is extremely important, and this should be the main goal of any future work.