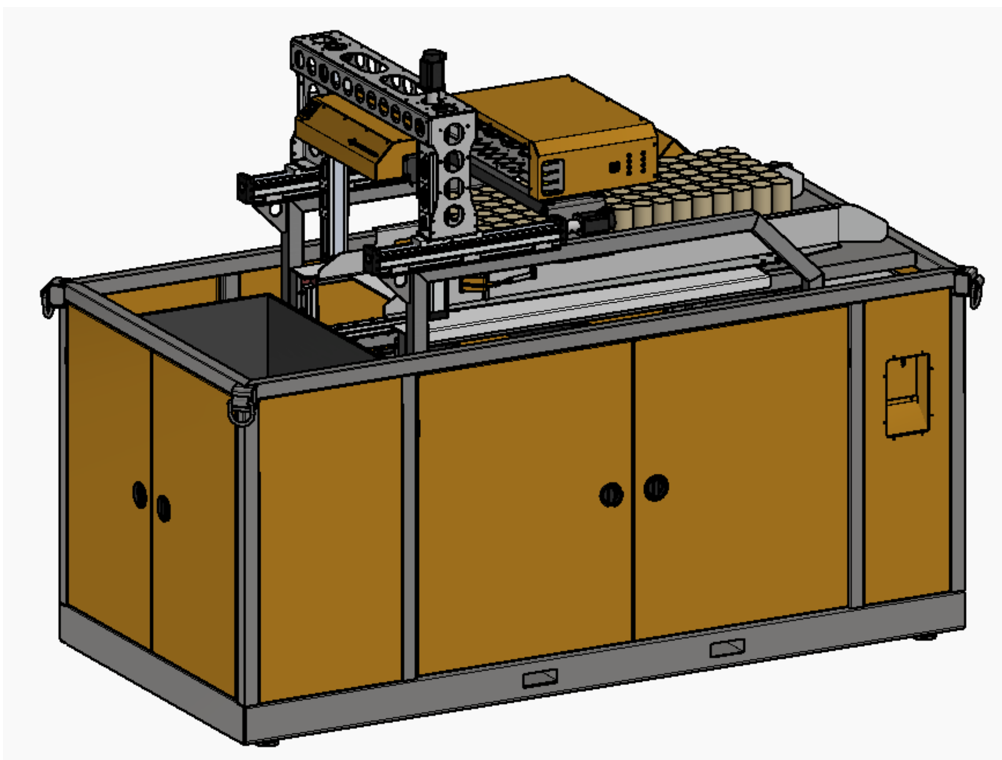
Mattress Pocketed Coil Component Separation and Recycling

Executive Summary of Final Report



KNOBLE DESIGN LLC

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I: Introduction

The Mattress Recycling Council (MRC) was created to develop, implement and administer mattress recycling programs in states that have enacted product stewardship laws which require mattress manufacturers to provide consumers with options to responsibly recycle old mattresses. To achieve these statutory objectives, MRC contracts with third party mattress recycling companies and sponsors research to improve recycling rates and process efficiencies. In May 2019, MRC sponsored a research contract with Knoble Design LLC to develop a novel method for recycling pocketed coils.

Pocketed coils are springs wrapped individually in a fabric sleeve and are popular with consumers because the springs react to pressure independently. This construction minimizes movement and allows for a more buoyant feel. At the end of their product life, however, pocketed coil layers have proven difficult to recycle. MRC estimates that pocket coil mattresses represent at least 25% of the current recycling stream. Given the popularity of this construction in recent years, the percentage of pocketed coil mattresses is steadily increasing.

When a mattress is deconstructed, the pocketed coil layer is easily separated from other components, but it is impractical to manually cut the fabric sleeves to remove the metal coils inside. Despite pocketed coils containing over 90% metal, most metal recyclers will not accept them due to the fabric contamination. As a result, pocketed coil units are landfilled unless the recycler can separate the components. Additionally, mattresses with pocketed coil layers are burdensome to landfills because they are problematic for machinery. This project's objective was to search for an innovative process to separate the fabric effectively and economically from the metal, ideally without sacrificing the revenue potential of each component.

II: Executive Summary

Over the past thirteen months, Knoble Design LLC followed its product development process to examine pocket coil separation solutions. This modular project approach examined current methods and focused on exploring alternate methods for processing.

The development approach evolved as experimentation and testing proved or disproved early concepts including shredding and burning. The original concept iterated high velocity metal shot blasting to separate the fabric from the steel coil springs. This process of stripping fabric showed merit, but cost projections were a hindrance. Alternate separation methods were discovered that focused on performance, process and cost efficiencies.

Knoble Design manufactured a prototype 1/8 scale demonstrator with the goal of integrating all mechanisms in a single process and developing a business case for further development. The demonstrator efficiently separates the coil springs from the fabric pocket, yielding maximum value from both materials. It also meets the primary objective as stated in the original RFQ which is to:

- automate the process and require minimal labor inputs.
- separate the steel coils from the fabric without cross contamination of either material.
- produce clean and separated commodities without secondary separating processes.
- require significantly less power to operate (relative to shredding processes).
- have a small footprint with potential to integrate into existing recycling operations.
- cost less than $100,000 to manufacture a fully scaled commercial unit.

The machine was successful in performing the duties required by the initial development phase and provides a solid foundation to expand into a larger configuration. There are opportunities to improve performance and decrease cycle time. Upgrades and improvements can be applied to make the demonstrator adaptable to a wider variety of pocketed coil construction types and decrease cycle times. Once these upgrades are applied and tested, the demonstrator would be a solid foundation to expand into a larger configuration utilizing proven components and processes.

It is recommended that parallel development paths be taken toward the development of a commercial scale machine. The first development path would use the demonstrator to test performance enhancements, process additional samples and collect more data based on real world inputs. Evaluating demonstrator performance in a recycling facility would allow for further testing of component durability. This experience would be extremely valuable for a final production design.

The second development path would evaluate upgrades for a full-scale machine with a critical look at design, layout, functionality and cost. Initial cycle rates examined on the demonstrator do not reflect a production status machine, as the steps performed were focused on proving out principles, design, and allowing for single function modifications during testing. Once the demonstrator was deemed successful, alterations and combinations of these functions can be reorganized to focus on cycle time. Further details are explained in following section.

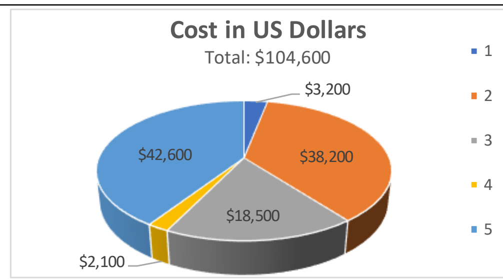
III: Business Case

A breakdown of the actual costs incurred during the development of the demonstrator was used as a basis to estimate the cost of a commercial scale machine (**See Figure 1**), assuming the existing machine is upgraded, rearranged, or scaled up to a king size bed. Adjustments to each category are based on Knoble Design standard rates.

FIGURE 1

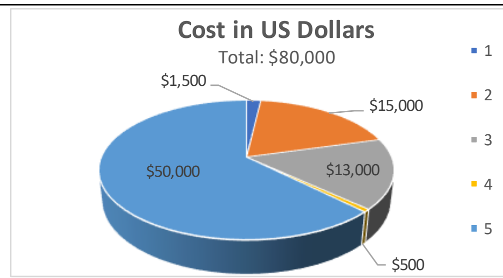
DEMONSTRATOR COST

	Activities	Cost
1	Meetings and Planning	$3,200
2	Engineering and Design	$38,200
3	Assembly and Fabrication	$18,500
4	Travel	$2,100
5	Expensed items	$42,600
	Total Cost=	**$104,600**



ESTIMATED FIRST PRODUCTION UNIT COST

	Activities	Cost
1	Meetings and Planning	$1,500
2	Engineering and Design	$15,000
3	Assembly and Fabrication	$13,000
4	Travel	$500
5	Expensed items	$50,000
	Total Cost=	**$80,000**



The Pocketed coil throughput rate is a key metric for a viable, commercial machine. The current production rate for the demonstrator is not representative of a production machine but represents all the necessary steps to successfully separate the steel coils from the fabric for most mattress configurations. The current rate per queen bed using 2.5" coils is approximately 11.25 minutes per bed (**See Figure 2**). Modifications can be made to improve process times by changing several factors:

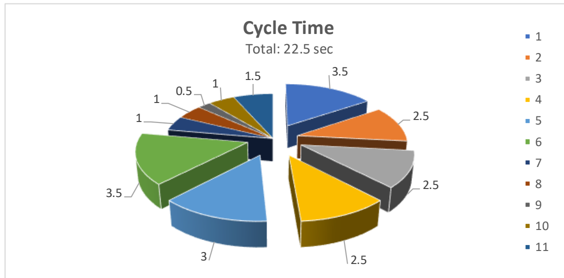
- Rearrange process steps to allow simultaneous movements
- Update air system
- Update actuators with faster units: replace cylinders with air slides

- Redesign long stroke processes into shorter engineered movements

FIGURE 2

CURRENT DEMO UNIT CYCLE TIME

Operation	Time/sec
release grips	3.5
grab next row	2.5
advance/compress	2.5
lower coil adjust	2.5
cutter extend	3
cutter retract	3.5
extractor up	1
extractor down	1
blade open	0.5
blade close	1
cut	1.5
Total cycle time=	**22.5**

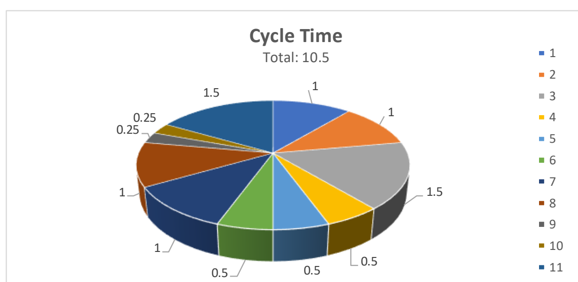


These modifications described with improved cycle times would reduce deconstruction to approximately 4.5 minutes per bed **(See Figure 3)**. These improved cycle times would be necessary to incorporate into the production machine to build a strong business case and continue with confidence into Phase 2. Improving the modified cycle times to even lower numbers could be possible but evaluating costs beyond the proven demonstrator's processes would be required.

FIGURE 3

MODIFIED PRODUCTION UNIT CYCLE TIME

Operation	Time/sec
release grips	1
grab next row	1
advance/compress	1.5
lower coil adjust	0.5
cutter extend	0.5
cutter retract	0.5
extractor up	1
extractor down	1
blade open	0.25
blade close	0.25
cut	1.5
Total cycle time=	**9**



The estimated cost of a production machine based on the existing data collected from the demonstrator with suggested upgrades is $80,000.