PLASTIC REMOVAL AT THE MODULE FEEDER

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Abstract

Larger round module wrap pieces that are not removed at the module feeder often wrap around the dispersing cylinders of the feeder. As the cylinders rapidly rotate, small pieces are repeatedly detached and enter the gin, where these pieces are difficult to remove from the cotton. Contamination is a costly problem for the cotton industry. The goal of this research was to develop and test a system to remove plastic from the module feeder head of a cotton gin. A prototype was developed utilizing a variable-speed brush cylinder to physically scrub the plastic off of the cylinders. A stainless steel brush cylinder was designed, as stainless steel provided the necessary stiffness and strength to lift the plastic from the cylinder, yet not break bristles when contacting the dispersing cylinder spikes. Unfortunately, the brush failed early in testing, but did yield promising results. The commercially available strip brush backing did not have sufficient strength to resist the forces applied when the brush contacted the plastic-wrapped dispersing cylinder, as the backing deformed and no longer held the brush wire. Moving forward, an improved strip brush backing will be designed and constructed for further testing to determine the optimal brush position relative to the dispersing cylinder, brush and dispersing cylinder speeds, and brush wire diameter. Upon completion of prototype testing, a full-scale system can be developed and retrofit in a gin for real world testing.

Introduction

For cotton growers and ginners in the US, producing a high-quality end product with no contamination has been an ongoing focus. This goal is evidenced by the fact that US cotton has been found to be some of the least contaminated in the world (International Textile Manufacturers Federation, 2016). However, losses due to contamination are estimated at a staggering $200 million per year worldwide (van der Sluijs and Hunter, 2017). While improperly disposed of garbage, such as plastic bags, and other sheet plastic contamination are a concern, the primary source of plastic contamination in the US is plastic round module wrap. While the original harvester with onboard round module builder was introduced quite some time ago, and there are many commercially available systems for removing the wrap at the gin, these systems do not always work flawlessly. This could be due to an inexperienced module unwrapper operator, damaged equipment, or improper module handling practices. If the plastic is not successfully removed before the module is fed into the gin, large pieces of the plastic are wound on the dispersing cylinders of the module feeder, and if not removed immediately, can shed smaller pieces that will end up in the cotton bale. Plastic wrapped around a module feeder cylinder can be seen in figure 1.

Figure 1. Module wrap on module feeder dispersing cylinder.

Modern cotton gins have minimal defenses against plastic contamination. While it is possible some plastic is removed by stick machines and other cleaning machinery within the gin (Byler, Boykin, and Hardin, 2013; Hardin and Byler, 2016), these machines do not remove all of it. The ginning industry needs a new and better way to combat plastic contamination. There has already been research done on detecting plastic both in the field and inside of the gin (Hardin, Huang, and Poe 2018; M. Pelletier, USDA-ARS, personal communication). However, once plastic is detected, a timely and safe method of removal is needed to prevent contamination in the bale.

The goal of this research was to develop a prototype system to autonomously remove plastic wrapped on the dispersing cylinders of the module feeder. Removing plastic at the beginning of the ginning process is important to minimize the amount of plastic that enters the gin and is subject to further size reduction. The full-scale prototype will use a brush cylinder that traverses the back of the dispersing cylinders to remove plastic wrapped on any cylinder. For proof-of-concept and optimization of process parameters, a test apparatus with a single dispersing cylinder was conducted. The objectives of this project were to:

- Successfully remove wrapped plastic from a module feeder dispersing cylinder.
- Identify a suitable brush material and construction
- Optimize brush and dispersing cylinder speeds for maximum plastic removal.
- Determine the relative position of the brush and dispersing cylinders for maximizing removal efficiency

Materials and Methods

A test apparatus was constructed (figure 2). A steel frame was designed and constructed for mounting the cylinders and motors. Plywood was attached to the inside of the frame to simulate the inside of a module feeder head and proide personnel protection. Inside dimensions of the test apparatus were 115.6 cm x 115.6 cm x 189.9 cm (45.5 in. x 45.5 in. x 74.75 in.). A 157.5 cm x 115.6 cm (62 in. x 45.5 in.) base was constructed out of plywood and square tubing to allow the whole assembly to be easily moved by forklift.

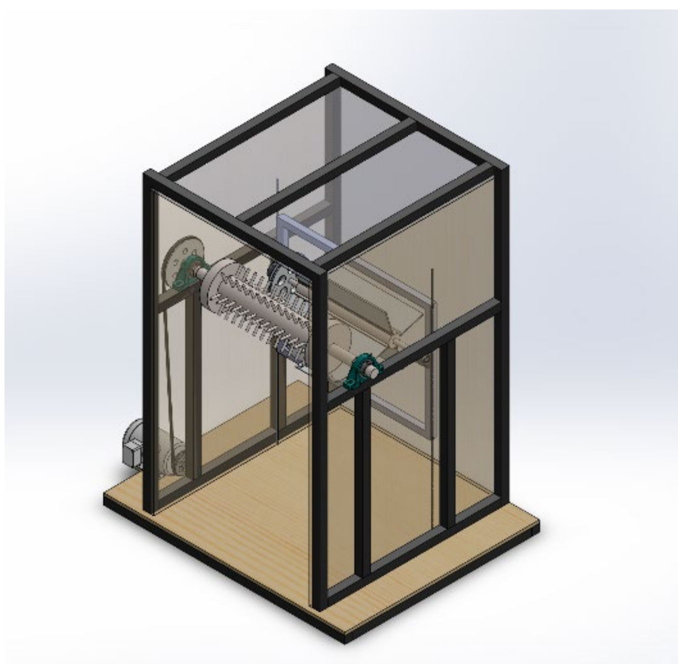

Figure 2. Test apparatus.

The dispersing cylinder used was designed and manufactured by Lummus (Savannah, Ga.). Cylinder dimensions were identical to commercial Lummus module feeder cylinders, except the cylinder was designed for a module feeder with a 76.2 cm (30 in.) inside width. A 30.5-cm (12-in.) single groove v-belt sheave was attached to one end of the cylinder axle and connected via a v-belt to a 1.5 kW (2 hp) motor with a 7.6-cm (3 in.) sheave mounted below the shaft of the dispersing cylinder on the outside of the housing assembly. The motor was then connected to a variable frequency drive (VFD) to allow for rotational direction and speed changes. This system can be seen in figure 3.

Figure 3. Dispersing cylinder drive.

The brush cylinder was mounted on a movable frame to adjust the position relative to the dispersing cylinder (figure 4). This frame was constructed from 1.5” square tubing and measured 76.2 cm x 101.6 cm (30 in. x 40 in.). The frame was welded to linear roller bearings, which traveled on guide rails inside the test apparatus. The brush cylinder assembly was moved with an electric hoist, enabling the assembly to be positioned at different distances from the dispersing cylinder.

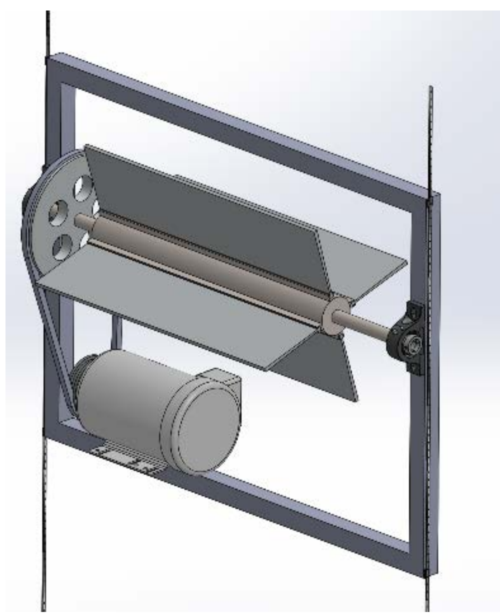

Figure 4. CAD drawing of brush assembly.

Brush cylinders were constructed from four stainless steel strip brushes, 15.2-cm (6-in.) high by 91.4-cm (36-in.) long, attached to a shaft. Two cylinders were constructed, one with a brush wire diameter of 0.20 mm (0.008 in., McMaster-Carr part no. 63595T5) and the other with 0.36-mm (0.014-in. McMaster-Carr part no. 63595T11). The brush cylinder was driven with a 12.7-cm (5-in.) diameter sheave by a 1.5 kW (2 hp) motor with a 7.6-cm (3-in.) sheave. The brush motor was also connected to a VFD so that its speed and rotational direction could be varied. A complete view of the entire test apparatus can be seen in figure 5.

Figure 5. Test apparatus.

Preliminary testing was performed by cutting pieces of round module wrap into 61 cm x 152.4 cm (24 in. x 60 in.) sections. This size was chosen to simulate the long strips of module wrap that can be generated if the cover is cut at the incorrect location. The plastic pieces were manually wrapped as tightly as possible around the dispersing cylinder. With the plastic wrapped on the cylinder, both motors were started, and the brush and dispersing cylinders were allowed to reach operating speed. During preliminary testing, and the dispersing cylinder was operated at its design speed of 420 rpm, and the brush cylinder was operated at its maximum speed of 1000 rpm. The brush was then raised to the cylinder to evaluate plastic removal. In more extensive testing, both cylinder speeds and the relative position of the two cylinders could be varied.

Results and Discussion

The stainless steel brush showed promise in removing plastic, as the piece was removed without excessive shredding (figure 6a). Unfortunately, the brush failed early in testing, so evaluation of different process parameters could not be completed (figure 6b). Failure occurred in the backing of the strip brush, not the actual brush wire. The backing deformed, and the wire was no longer held in the backing.

Figure 6. Failed brush assembly (a) and removed plastic (b).

Future Work

An improved stainless steel brush will need to be designed and constructed. Fatigue testing of improved brush designs will be performed. A study will be conducted to optimize cylinder speeds, the distance between the brush and dispersing cylinder and wire sizes using a response surface design. Upon completion of testing, a prototype will be constructed and installed in the module feeder in the Texas A&M microgin for further testing.

Summary

A stainless steel brush cylinder was designed and constructed that removed plastic from a module feeder dispersing cylinder. This concept will be evaluated in future testing to optimize system parameters; however, an improved brush design is needed. Forces applied during testing caused rapid failure of the strip brush backing. Reinforcement or redesign of the backing will be done before additional testing.

Acknowledgements

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