A stationary large round bale shredder

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Misener, G.C., McLeod, C.D., Barclay, J.A. and Esau, C.A. A stationary large round bale shredder. Can. Agric. Eng. 33:127-129. A large round bale shredder with a capacity of four large round bales was developed for use in a tie-stall barn. The stationary unit consists of a bale accumulator with a capacity of four bales, a bale shredder, and a shredded product conveyor. A comparative study using 16 large round bales established that the system worked best when bales were fed through the shedding rollers with the axes of the bales parallel to the axes of the shredding rollers. The study determined that bales could be shredded at a rate of 48.5 kg/min with a power requirement of 11.8 kW.

Un déchiqueteur, capable de déchiqueter quatre grosses balles rondes à la fois, a été mis au point pour servir dans une étable à stabulation enterrée. L’unité fixe comprenait un accumulateur d’une capacité de quatre balles, un déchiqueteur et un convoyeur de produits déchiquetés. Une étude comparative, fondée sur 16 grandes balles, a démontré que le système fonctionnait mieux lorsque les balles étaient introduites dans les rouleaux déchiqueteurs avec leurs axes parallèles à ceux des rouleaux. L’étude a déterminé que les balles pouvaient être déchiquetées au rythme de 48,5 kg/min avec une consommation énergétique de 11,8 kW.

INTRODUCTION

Large round baling systems for harvesting hay have increased in numbers in recent years. Although large round bales require specialized handling equipment, they have the advantage of reduced labour requirements. Often, large round bales are fed by simply placing them outdoors on a feedlot or pasture. Hay losses can be high with this approach, ranging from 40 to 50% (Von Bargen 1978). In more sophisticated systems, bales are fed in feed racks outdoors or under the cover of sheltered feeders or pole barns. Losses with these systems are reduced to roughly 5% (Lechtenberg 1978).

Most of the currently available systems have been designed for the cattle to have unrestricted access to the bales. Tie-stall barns do not provide unrestricted access and only a few tie-stall barns have enough space to accommodate tractors and other bale handling equipment (Kemp 1979). With current technology, large round bales must be broken apart or shredded to create smaller packages for handling in tie-stall barns. Bilanski and Graham (1989) developed a tractor mounted round bale cutter for slicing bales into sections to facilitate feeding in confined areas.

There are several mobile large round bale shredding systems available commercially that have been designed primarily for outdoor use. Power requirements are high and losses of the fine material occur (PAMI 1978; Rider and Moustafa 1978).

The objective of this research was to develop a stationary shredder for large round bales to use in conjunction with tie-stall barns. The system will enable farmers to continue to use the large round bale forage harvesting systems with their associated cost savings.

DESCRIPTION OF SHREDDER

The prototype shredding system was designed to be operated by one person. It consists of a bale accumulator, bale shredder, and shredded product conveyor (Fig. 1). The bale accumulator is a temporary holding platform where the farmer can load up to four large round bales for automatic feeding into the shredding cylinders. This approach was chosen over the utilization of a tub grinder in order to reduce the large power requirements of chopping hay. Although the shredding rate was chosen to be slower than that obtained with a tub grinder, the use of a bale accumulator would allow the farmer to carry out other tasks while the bales are being shredded.

Fig. 1. Schematic diagram of the prototype shredder.
The cylinders were constructed from 2.6 mm plate steel which was rolled to form a cylinder 470 mm in diameter. End plates were welded to each cylinder and a 32 mm diameter shaft was fixed to the axis. Twenty-four knives were attached radially and aligned perpendicular to the axis of each cylinder. This resulted in a lateral spacing between knives of 80 mm. The knives were bolted to flat bars which had been welded to the surface of the cylinders. The knives are replacement cutter bar knives for sickle bar mowers. Angle iron bars 350 mm in length with 25 mm deep notched teeth were also attached to the shredding cylinders' surfaces and are located between the knives parallel to the center lines of the cylinders. The bars are designed to pull the hay from the bales after the knives have shredded the material. The shredding cylinders are driven hydraulically and are reversible. The cylinders' rotational direction is controlled by a hydraulic control valve, and the speed is controlled by a metering valve. The valves are mounted in the barn at a suitable operator station.

The cross conveyor is a solid bottom conveyor that has a bed chain capable of handling loose hay and is driven with a reversible hydraulic motor direct coupled to the chain drive pulley. Loose hay is thrown from the shredding cylinders onto the cross conveyor and then transported to the end of the conveyor at which point it falls off into the barn.

Hydraulic power was used in the prototype unit to provide maximum operating flexibility during testing. In a commercial system, electrical drive components could be used to reduce the capital cost. The hydraulic power pack and controls were located in the barn adjacent to the end of the cross conveyor.

**EVALUATION OF SHREDDER**

A performance evaluation study was conducted to determine the feed rates for the bales, the cutting speeds of the cylinders, and the cross conveyor delivery capability for loose hay. The parameters that were measured were: bale feed rate, chop length of the hay, and total machine power requirements. Sixteen bales with diameters ranging from 1.47 m to 1.58 m and a length of 1.52 m were fed through the system. The bales consisted of a mixture of alfalfa and grass of approximately an equal ratio. The average moisture content of the bales was 18 percent, wet basis. The first four bales were positioned on their circumferential surface with the flat cylindrical end of the bale surface entering the shredder rollers first (method 1). The next four bales were placed on their flat cylindrical ends with the circumferential surface entering the rollers first (method 2).

The remaining eight bales were fed through the system lying on their circumferential surface with their center lines parallel to the shredding cylinders and with their circumferential surface entering the rollers first. The first twelve bales were low density bales while the remaining bales were uniform density bales. Power utilized during the shredding operation was determined by measuring the flow and pressure of the hydraulic oil in the system. A combination flow/pressure meter (UCC model UC-4154) was connected to the hydraulic lines to facilitate flow and pressure measurements.

The results were measured in terms of the ease with which the bales passed through the shredder rollers and the resulting chop length. The best results were obtained when the bales were fed through the system when their cylindrical axes were parallel to the axes of the shredding cylinders (method 3). The maximum feed rate was 48.5 kg/min with the shredder cylinder rotating speed at 210 rpm (Table I). The floor conveyor travelled at 134.1 mm/min, and the cross conveyor operated at 13.4 m/min. The torque required to operate the three shredding cylinders was determined to be 415.2 N·m. Total power requirements for the system was 11.8 kW at a feed rate of 48.5 kg/min. By operating the shredding cylinders in the opposite direction relative to the feed conveyor, jamming of the bales between the bottom cylinder and the floor was avoided. The low density bales had a higher mass feed rate than the high density bales. When the bales were fed with the cylindrical end surface entering the shredder rollers first, the power requirements for shredding the bales exceeded the hydraulic power supply and consequently, no data was obtained for this portion of the study. The notched teeth on the shredding cylinders were not effective in pulling the hay from the bales as compared when the bales were fed into the shredding mechanism with their cylindrical axes parallel to the axes of the shredding cylinders. An excessive amount of dust in the barn was a major difficulty encountered with the prototype shredder. This problem could be solved by housing the shredder in a small shelter separate from the main barn.

Sibley et al. (1988) conducted an extensive evaluation of various mobile large round bale shredders and a brief summary of the results are included in Table II. Since there is a lack of technical information available on stationary shredders, the results from the mobile units were used for comparison purposes instead. The power requirement and capacity of the prototype shredder is comparable with the first two shredders listed in Table II.

**Table I. Performance of prototype shredder**

<table>
<thead>
<tr>
<th>Method of feed</th>
<th>Bale type</th>
<th>Power required (kW)</th>
<th>Output (kg/min)</th>
<th>Hay length</th>
</tr>
</thead>
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<tr>
<td></td>
<td></td>
<td></td>
<td>&lt;10 mm</td>
<td>10-50 mm</td>
</tr>
<tr>
<td>Bales standing on end</td>
<td>soft core</td>
<td>10.4</td>
<td>39.9</td>
<td>15.2</td>
</tr>
<tr>
<td>Axes of bales parallel to axis of shredder roller</td>
<td>soft core</td>
<td>11.8</td>
<td>48.5</td>
<td>16.5</td>
</tr>
<tr>
<td></td>
<td>uniform density</td>
<td>11.1</td>
<td>43.8</td>
<td>19.9</td>
</tr>
</tbody>
</table>

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Table II. Large round bale shredder performance parameters

<table>
<thead>
<tr>
<th>Shredder</th>
<th>Capacity $^2$</th>
<th>Output (kg/min)</th>
<th>Chop length (mm)</th>
<th>Maximum power (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kidd model 6-10</td>
<td>1 x 1.83</td>
<td>48</td>
<td>102-152</td>
<td>22</td>
</tr>
<tr>
<td>Kesston BP-20</td>
<td>1 x 2.13</td>
<td>38</td>
<td>76-305</td>
<td>34</td>
</tr>
<tr>
<td>Haybuster</td>
<td>1 x 2.13</td>
<td>165</td>
<td>76-203</td>
<td>32</td>
</tr>
</tbody>
</table>

$^1$ Information obtained from Sibley et al. (1988) while shredding straw.

$^2$ Number of bales x diameter (m).

CONCLUSIONS

The prototype stationary shredder designed for handling large round bales satisfactorily shredded the bales in order that the hay could be transported by a conveyor to a temporary storage. The feed platform holds four large round bales and the shredder can process 48.5 kg/min of hay. The power required to shred bales at this capacity was 11.8 kW. The shredding operation caused excessive dust which would probably not be acceptable in tie-stall barns; conducting the shredding operation in a shelter separate from the main barn should be considered.

REFERENCES


