Design of an efficient and compact non hydraulic cotton module builder

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Abstract - *The need to produce a better quality product for sale to the cotton textile mills and to reduce labour costs during processing has led to considerable interest in machinery optimization concepts for cotton module builders and gins. Commercial module builders are hydraulic, bulky and require regular maintenance. In addition, a human operator is required to closely monitor the moduling process. This paper presents a newly built electromechanical module builder that requires very little maintenance and can be remotely operated. The newly developed module builder will help in saving the environment by reducing pollution and power consumption.*

Résumé - *La nécessité de produire un coton de bonne qualité pour le vendre aux marchands de textile et pour réduire les coûts de main-d'oeuvre au cours de son traitement provoque un intérêt considérable dans la conception optimisée des machines aux constructeurs de modules de coton. Les modules réalisés sont hydrauliques, encombrants et exigent un entretien régulier. En effet, un technicien surveille en permanence le processus moduling. L'article présente un nouveau type d'équipement électromécanique de module exigeant un faible entretien et peut être actionné à distance. Cet équipement de module nouvellement développé aidera l'environnement en réduisant la pollution et la consommation d'énergie.*

Keywords: Module builder - Cotton module building - Induction motor - Cotton processing.

1. INTRODUCTION

Cotton remains the most miraculous fiber under the sun, even after thousands of years. No other fiber comes close to duplicating all of the desirable characteristics combined in cotton. The fiber of a thousand faces and almost as many uses, cotton is noted for its versatility, appearance, performance and above all, its natural comfort. From all types of apparel, including astronauts' in-flight space suits, to sheets and towels, and tarpaulins and tents, cotton in today's fast-moving world is still nature's wonder fiber. It provides thousands of useful products and supports millions of jobs as it moves from field to fabric.

In major cotton producing countries, shown in Fig. 1, today's modern cotton production system provides significant benefits to rural economies and environment. Healthy rural economies are based on stable farm income, and cotton yields and prices are often among the healthiest of all field crops, vegetable or fruit.

Cotton continues to be the basic resource for thousands of useful products manufactured in many countries. For example, the U.S. textile manufacturers use an annual average of 7.6 million bales of cotton [1]. A bale is about 227 kilograms of cotton. More than half of this quantity (57 %) goes into clothing, 36 % into home furnishings and 7 % into industrial products. The average U.S. crop moving from the field through cotton gins, warehouses, oilseed mills and textile mills to the consumer, accounts for more than $35 billion in products and services [1].

This injection of spending is a vital element in the health of rural economies. The gross dollar value of cotton and its extensive system of production, harvesting and ginning provides countless jobs for mechanics, distributors of farm machinery, consultants, crop processors and people in

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other support services. Other allied industries such as banking, transportation, warehousing and merchandising also benefit from a viable cotton production system.

A vital piece of machinery, in the farm-to-warehouse process, is the cotton module builder that prepares seed cotton stacks for the gin machine. The module builder distributes and compresses the cotton to build a large freestanding module that contains about 13 tonnes. A standard module may be 11-12 m long, 2.5 m wide and 2.5 m high [2].

2. COTTON PROCESSING

For centuries cotton has been picked by hand. Hand picking is done in the less progressive cotton growing regions of the world. It is very inefficient and no longer practiced in modernized countries.

Today's modern cotton harvesters can cover up to 6 to 8 rows at a time and can harvest more than 80000 kilograms of seed cotton a day. These new cotton harvesters are a major improvement over the hand methods of the past.

Prior to the development of the module builder, most cotton picked by machines was dumped into cotton trailers and hauled to a cotton gin (a place where seed and fiber are mechanically separated). This system became inefficient when the trailers were filled faster than the gin could process the cotton and the cotton pickers had to cease harvesting while waiting for trailers to empty [3, 4]. This challenge was met with the invention of the module builder in 1972. This implement allows cotton to be dumped from the picker onto the ground and be compressed hydraulically to form a module (tightly pressed stack) of cotton. Each module holds 12-14 bales [5, 6]. This module can be left in the field for storage and later be hauled directly to the gin or transported by a module mover to the gin's storage yard. The use of these builders allows the pickers to continue harvesting, unimpeded by ginning problems or delays.

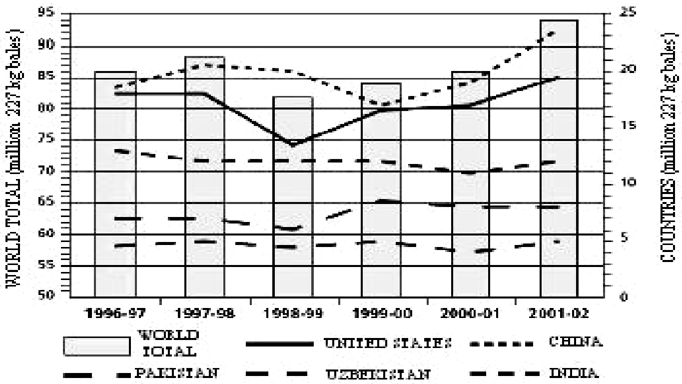


Fig. 1: Major cotton producing countries

The cotton gin is where cotton fiber is separated from the cotton seed. The first step in the ginning process is when the cotton is vacuumed into tubes that carry it to a dryer to reduce moisture and improve the fiber quality. Then it runs through cleaning equipment to remove leaf trash, sticks and other foreign matter.

The raw fiber makes its way through another series of pipes to a press where it is compressed into bales, banded with steel straps, sampled for classing, wrapped for protection then loaded onto trucks for shipment to storage yards, textile mills and foreign countries.

The cotton seed is delivered to a seed storage area. Where it will remain until it is loaded into trucks and transported to a cottonseed oil mill or directly for livestock feed. A summary of the whole process is depicted in the block diagram shown in Fig. 2.

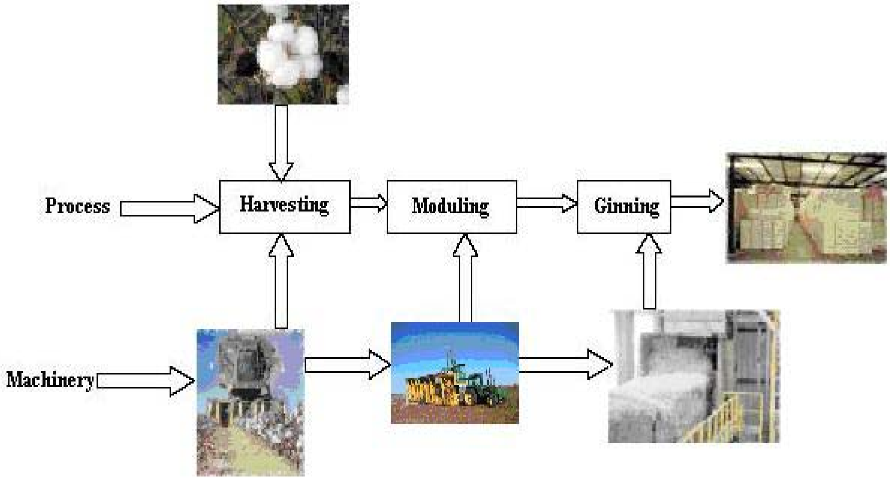


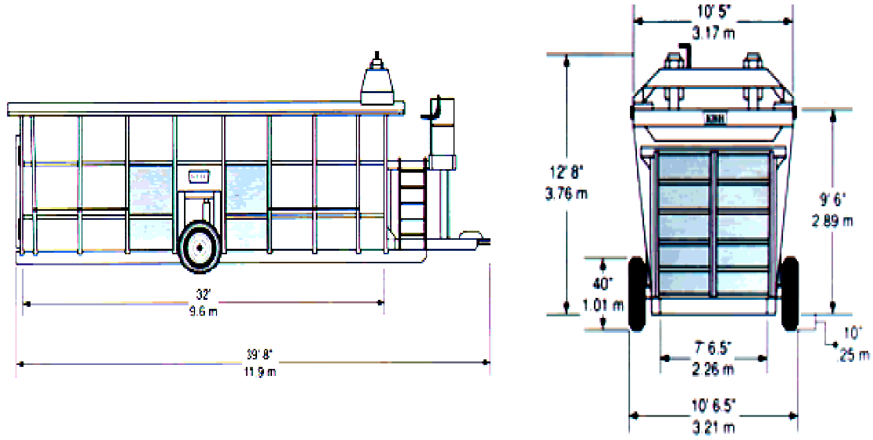
Fig. 2: Cotton farm-to-warehouse process

2.1 Hydraulic Module Builder

The steel module builder consists of a box large enough to hold about 7000 kilograms (10 to 12 bales) of seed cotton, a cab, and a hydraulic tramper. Cotton from strippers or spindle pickers is emptied directly into the box, and an operator in the cab compresses the cotton with the tramper. When the box is full, a tractor pulls it forward, leaving on the turn row a "loaf" of cotton that is 2.4 m high by 2.4 m wide by 9.6 m long. The module is covered with a polyethylene tarpaulin and marked for field identification with a harmless spray. A specially designed module mover, a modified flatbed trailer, picks up the module and carries it to the gin, where it is unloaded into the cotton storage yard or directly under the suction telescope for ginning [7]. A typical hydraulic module builder is shown in Fig. 3. Its geometrical dimensions are shows in Fig. 4.

(a) External view (b) Internal view

Fig. 3: Hydraulic module builder



(a) (b)

Fig. 4: Hydraulic module builder external geometrical dimensions

This typical module builder uses 4 hydraulic motors mounted directly to 4 drive wheels. An oil reservoir of 280 liters is used to supply the hydraulic system.

2.2 Electromechanical Module Builder

In the present work, a novel type of module builder was built. The main objective of the proposed electromechanical module builder, shown in Fig. 5, is distribution of the seed cotton material on an open area or container for forming cotton modules. This will circumvent the need for expensive standardized steel boxes.

The module builder shown in Fig. 5, employs an electromechanical system (3) which consists of a squirrel-cage induction motor coupled to a gearbox [8], in order to reduce the rotational speed from 1450 rev/min to an optimal speed of about 450 rev/min, which is required for the rotating cylinder of such module builder. The module builder is fixed on a rotating stand (stage). This arrangement enables throwing the output of the builder in the required directions and module zones (places).

Initially, the cotton material is discarded in the receiving container (4) of the builder. The builder operating part- drum with cleaning rod sis rotated by a 5 kW induction motor (3), which is linked with a gearbox to reduce the speed. As a result this drum rotates with a speed of 6.6 m/s, capturing the coming cotton with 29.9 N.m and throwing it by the tangent direction in respect to the guider (5). Depending on the direction of the moving guider (5), the throwing angle and consequently throwing trajectory are variable. Movement of the guider is accomplished by another system of induction motor with a gearbox (5) of corresponding power of 0.6 kW.

Maximum throwing distance of the present prototype module builder is about 18 m, which enables forming modules of different sizes. Fig. 6 shows the relationship between the throwing distance, the motor speed and the drum diameter.

The prototype module builder, shown in Figure 7, weighs only 400 kg, which is very light compared to standard commercial ones. Using this light-weight module builder enables forming modules with different heights. The maximum height of the module depends on the density of the raw cotton. Different curves in this figure correspond to ways of the cotton distribution in the module. More homogeneous distribution enables getting more maximum height.

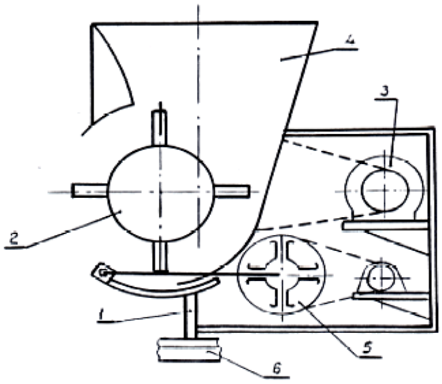


Fig. 5: A detailed drawing of the new electromechanical module builder

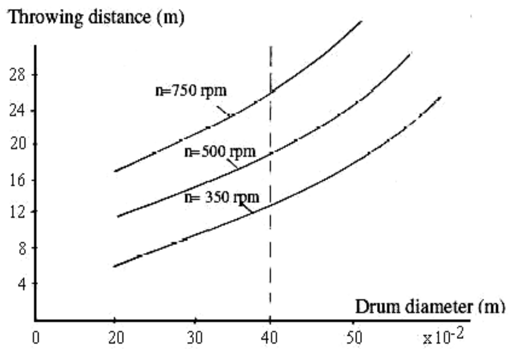


Fig. 6: Throwing distance as a function of drum diameter

Using the newly constructed module builder, stacks of up of different sizes can be easily and efficiently formed.

3. TECHNICAL SPECIFICATIONS

The technical specifications of the prototype of this module builder are shown in Table 1.

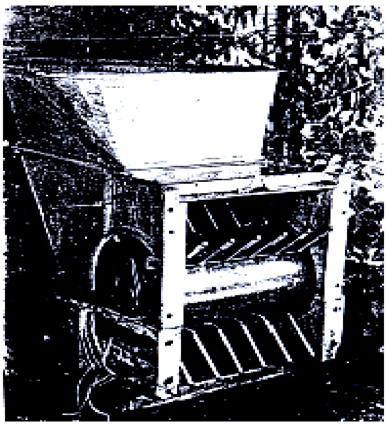


Fig. 7: A prototype module builder

Table 1: Electromechanical module builder technical specification

General specification	
Productivity (by the cotton material), t/h	35-40
Maximum throwing distance, m	16-18
Diameter of the rotating cylinder, mm	400
Diameter of the rotating cylinder with the vertical cleaningrods, mm	800
Length of the rotating cylinder, mm	600
Height of vertical cleaning rods, mm	194
Pitch between vertical cleaning rods, mm	70
Number of groups (rows) of vertical cleaning rods, mm	4
Diameter of the receiving end, mm	900
IM power, kW	5
Motor speed, rev/min	145
General sizes	
Length, mm	1200
Width, mm	800
Height, mm	1200
Mass, kg	400

4. ADVANTAGES OF THE NEW MODULE BUILDER

The main advantages of the new module builder are summarized as follows:

1. Compactness and light weight
2. Size of seed cotton stack is independent of module builder size.
3. Flexibility: easy to transport and to operate.
4. Low maintenance.
5. Low construction and operating cost.
6. Versatility: it allows building of stacks of various sizes and it can be used for other purposes.
7. Energy saving of about 20 %.
8. Pollution free.

5. CONCLUSION

The cotton industry is constantly striving to develop new and improved methods for producing quality products at a reasonable price. The cotton industry continues to look toward the future at further improving their product while providing employment opportunities for millions of people in a variety of related areas.

The invention of cotton module builder has literally changed the face of the cotton landscape, resulting in a chain of improvements and cost savings throughout the entire farm-to-warehouse process. In this paper, a new electromechanical module builder was presented and tested. Low cost, compactness, lightweight, flexibility and easiness of operation were demonstrated as just a few of the many features of the novel module builder. The flexibility of being able to form modules of any standard may lead to removing many of the constraints imposed by the gin machine.

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