REVIEW OF CORE TECHNOLOGIES INSUGARCANE HARVESTER

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ABSTRACT

Sugarcane is major crop in India and Harvesting is a crucial component of sugarcane production . In this article, we critically reviewed sugarcane harvesting technologies currently being used. Review of two harvesting practices was represented and two harvesting modes were introduced including a comparative discussion on their technical challenges ,advantages and limitations.It is followed by a comprehensive review of core technologiesof current sugarcane harvesters like cane base cutting mechanisms. The influence of base cutter kinematic and geometric parameters, such as blade cutting velocity, disc tilt angle, blade number, blade oblique angle, and blade shape on harvesting efficiency and cutting quality, were reviewed.

Keywords:Base cutting mechanisms, green cane Harvesting, Burn cane harvesting, Cutting quality

I.INTRODUCTION

According to World Crop andLivestock Statistics published by the Food and Agriculture Organization (FAO), world sugarcane growing area increased from 6.3 million hectares in 1950 to 25.4 million hectares in 2011 (FAOSTAT, 2013).India has largest area under sugarcane and is the second largest country in the world in sugarcane production, India produced 341.2 million tonnes in 2013 where world-wide production of sugarcane was 1877.1 million tonnes. India has 4.999 million hectare of land under sugarcane cultivation with average sugarcane yield 68.25 tonnes per hectare in 2013(DEPD,India 2015).Before mechanical harvesting systems were introduced, sugarcane had been harvested manually using various types of hand knives. Manual sugarcane harvesting is a very labour-intensive and laborious activity. Harvest laborers can easily fatigue due to excessive stress on the joints and muscles (Clementson and Hansen, 2008) and are exposed to harmful pests from plantations, creating safety concerns (Carvalho, 2012). The advent of mechanical harvesting systems frees harvest labourers from the drudgery of field operations. To harvest one hectare of sugarcane, it requires 3.3-4.2 machine-hour by mechanical harvesting whereas 850- 1000 man-hour by manual harvesting (Yadav et al., 2002).The goal of this study is to comprehensively review the existing literature on harvesting technologies currently being used in commercial sugarcane production. This article particularly focuses on critically reviewing technical features of base cutting mechanism .

II.CURRENT SUGARCANE HARVESTING METHODS

This section will represent a brief review of various types of harvest practices.Based on the form of harvested stalks, these machines can be categorized into two groups: whole stalk harvesters and chopper harvesters. Basedon how the sugarcane is presented to the harvester, harvesting practices are classified into two groups; burnt cane harvesting and green cane harvesting.

2.1 HARVESTING MODES

The following sections provide a brief review on the two harvesting modes: whole stalk harvesting and chopper harvesting.

2.1.1 WHOLE STALK HARVESTING

In this method cane is only cut at bottom of plant rather than cutting at several points on stalk .King(1969) developed machine without a cleaning mechanism so it does not cut extraneous matter. In this harvesting mode, farmers usually set fire to the windrows and burned off the leafy materials.The machine developed by Beckwith (1995) is come along with detaching mechanism where normally sugarcane plants can grow up to 5 m (Baztarrica et al., 2011), it is challenging for whole stalk harvesters to handle cane stalks. Harvesting bent canes also results in canes twisted into various directions. Therefore, it is difficult to arrange the stalks into compact bundles

2.1.2 CHOPPER HARVESTING

In chopper harvesting method whole stalk is cut into small uniform-sized pieces by different mechanism,such a system was proposed in 1955 by Ken Gaunt, an Australian engineer (DIISRTE, 2011) which simplify cane handling operation. Later, other similar chopper harvesters were developed based on this technology.Generally, wagons are running along machine and chopped billets are directly loaded. Which eliminating stalk collection operation so chopper harvesting mode does not require additional equipment or manpower to pick up sugarcane stalks. The major limitations of the chopper harvesting system is that due to chopping process sugar deterioration is accelerates which makes easy access of bacteria through cut surfaces in chopped billets. The harvested billets need to be milled as fast as possible. (Burrows and Shlomowitz, 1992). In addition, there also exists substantial juice loss during cutting and chopping operations because cane juice is squeezed out from the torn cells (Maleki and Jamshidi, 2011).

2.2 HARVESTING PRACTICES

The following sections provide a brief review on the two harvesting practices: whole stalk harvesting and chopper harvesting.

2.2.1 BURNT CANE HARVESTING

In the Burnt Cane Harvesting process, fire is set in a confined predetermined field. This fire burns off leafy extraneous materials like stalk tops and dry leaves. Previous studies of sugarcane composition showed that the amount of leafy materials constitute about 37% of whole cane plant dry matter and about 42% of cane plant dry matter above the ground (Deepchand, 1986). Burnt Cane Harvesting burns off about 80% of cane leafy materials leading to 30% to 40% improvement in harvester productivity (Braunbeck et al., 1999). Burnt Cane Harvesting ensures a cleaner cane entering in sugar mill, making the process more efficient (Lionnet, 1986; Bernhardt et al., 2000).Due to reduction in leafy materials waste in sugar production is reduced.

However, Burnt Cane Harvesting has various negative impacts. Burnt Cane Harvesting poses a risk of saccharose deterioration, which reduce rate of sugar extraction. Cane burning causes juice leakage, cane splits, leaves and other leafy materials were detached when severed stalks passed through a defoliation device. In this harvesting mode, farmers need not set fire , and wax removal, which facilitates the infection of sugar canes (Lionnet, 1986).As well as burning produces lot of harmful gases so it is one of the most sensitive environmental issue.

2.2.2 GREEN CANE HARVESTING

In the green cane harvesting process, A particular Harvesting device is then used to separate leafy materials and canes are harvested without any preconditioning such as burning or removing leafy materials before harvest. .For soil nutrient balance and environmental effects Green Cane Harvesting may provide a more sustainable option for sugarcane harvesting compared with burnt cane harvesting. The residues left in field could help to decrease soil erosion, control weeds and reduce soil moisture loss (Braunbeck et al., 1999). The residue also helps to improve nutrient cycling because organic matter contributes to the production of nutrients and nutrients contributes to grow healthy crops that add residues to soil. Thus, the residue improves soil fertility, and productivity (Núñez and Spaans, 2008). Núñez and Spaans (2008) reported that weed control and irrigation costs after green cane harvesting were reduced by 35% and 10%, respectively. Pest bug called 'Lesser Cornstalk Borer' is attracted by smoke and may increase pest stress when cane burning is practiced. Sandhu et al. (2011) showed that green cane harvesting method could reduce Lesser Cornstalk Borer damage to sugarcaneA major challenge for green cane harvesting practice is that the increased amount of extraneous materials (such as tops and leafy materials) extensively increases machine load.According to Eiland and Clayton (1983) the fuel consumption with green cane harvesting was increased by 12% and the harvesting efficiency was decreased by 17% compared to burnt cane harvesting. The trash layer generated in green harvesting method can lower the soil temperature, which can slow down early plant growth and increase the risk of frost damage in young plants during winter (Viator and Wang, 2011; Sandhu et al., 2013b)

III.CORE TECHNOLOGIES FOR SUGARCANE

Sugar cane harvesting machine is consist of four main parts respectively base cutter, feeding mechanism, defoliating device and discharging device. Base cutter mechanism cuts the base of sugarcane stalks close to the ground. Feeding mechanism hold the ends of stalks and convey entire stalks into the machine for post-processing. A defoliating device remove all leafy materials from stalks. discharging device is used to discharge defoliated cane stalks into cane stalk wagons behind the harvesting machine which running along with it. In this section only base cutting mechanism along with its functionality and cutter parameter had studied

3.1 BASE-CUTTING MECHANISM

Base cutting mechanism is very important part of any Sugar cane harvesting machine. A high-performance Base cutting mechanism need should have less cutting energy consumption, good cutting quality, and less cutting force. various kinematic and geometric parameters of base cutter such as blade cutting velocity, blade oblique angle, cutting disc tilt angle and the shape of blades should be consider while designing high-performance Base cutting mechanism. The base-cutter of sugarcane harvesters usually consists of two contra-rotating discs with multiple blades installed on their periphery (Quick, 1977). In this subsection, we reviewed relevant studies on blade cutting force and cutting quality

3.1.1 CUTTING FORCE

A lot of studies have been conducted to investigate and identify critical dynamic and geometric parameters affecting cutting forces. Cutting force is most important indicators that can be used to measure the performance of an base cutter..

Gupta and Oduori (1992) investigated the relationship between system parameters and cutting force. system parameters are like blade oblique angle, cutting disc tilt angle, and blade cutting velocity. It was found that: s (i) The desirable blade oblique angle was between 20°and 50°; and (ii) The recommended operating tilt angle was from 25° to 50° (iii) The desired blade cutting velocity ranged from 13.8 to 18.4 m/ (Gupta and Oduori, 1992).

To study the effect of blade shape on cutting force, Mello and Harris (2001) carried out a investigation and trials for serrated edge blades and smooth edge blades. They found that serrated blades have good cutting ability and are required less cutting force then smooth edge blades. Penetration of serrated blades in sugar cane stalk is also more than smooth edge blades (Mello and Harris, 2000).

Song et al. (2006) investigated on cutting test which are lab base. He studies relationship between major machine parameters and cutting force of base cutter of a sugarcane harvester .He shows that forwarding speed of sugar cane harvester has great influence on cutting force. Cutting force and cutting velocity are in proportional relationship when the blade cutting velocity was less than 618 rpm but they were in inverse relationship when the blade cutting velocity is more than 618 rpm.

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Liu et al. (2007) carried out cutting tests to study the effect of machine parameters on cutting force. Liu et al. (2007) focused on very important three parameters of base cutter(i) blade cutting velocity (ii) blade oblique angle and (iii)disc tilt angle. This study proved that when the cutting velocity is higher, the required cutting force will be higher and the blade cutting velocity and cutting force has linear relationship (Liu et al., 2007a).

3.1.2 CUTTING QUALITY

A smooth cutting quality of sugar cane stalk is insure less juice loss. Researchers like Gupta and Oduori (1992) and Liu et al. (2007) conducted studies to find out how parameters of the system affect cutting quality.Gupta and Oduori (1992) investigate how the cutting velocity of bladeeffect on cutting quality. When cutting velocity is less than 13.8 m/s cutting blade tear the sugar cane stalk from its root rather than sharp cut on stalks base. For this study cutter parameter like oblique angle and tilt angle were set to 35° and 27° (Gupta and Oduori, 1992). Later, Liu et al. (2007) also concluded that the blade velocity should be minimum for average cutting quality. According to Later, Liu et al. (2007) cutting velocity should not be less than 20.0 m/s . For this study cutter parameter like oblique angle and tilt angle were set to0° and 8° (Liu et al., 2007).These two studies concluded different blade velocities probably because of different oblique angle and tilt angle

Harris (2000) conducted study performance of cutting blades with serrated edges and smooth edges in terms of sugar loss and stalk damage. The serrated blades had better cutting than smooth blades but the sugar loss by serrated blades is greater because the roughness of serrated blade surface removed more sugar cells (Mello and Harris, 2000).

IV.CONCLUSION

Harvesting is very important part in sugar cane production. The main aim of this paper is study of existing scenario of sugar cane harvesting technology. We investigate critical review of harvesting technology focusing on base cutter mechanism .this work will help design and modify current sugar cane harvester as well as provide data to design new harvesting technology

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