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PROCEEDINGS

Professional (Expert) paper

BERRY HARVESTING BY PULSED AIR FLOW

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Abstract. *This paper presents a unique technical solution of berry fruit harvesting by accurately controlled pulsations of air flow. A special harvester, which induces strong turbulent fluctuations of atmospheric air from both sides of the plants, has been designed and tested in the past fifteen years. It is towed behind a tractor, but also equipped by own diesel engine that drive all hydraulic components and, indirectly, the fan, pulsating air flow control units, machine leveling system and fruit conveyer. The study is focused to operational parameters of the harvester, technical specification and design.*

Key words: *Berry fruit, air harvester, turbulent pulsations, fan, hydraulics.*

1. INTRODUCTION

Contemporary berry fruit production suffers from the high costs of manual harvesting, because of increasingly expensive fruit pickers and their luck. Globalization of world market and economy in general has resulted in appearance of new demands related to increased competition, and introduction of new highly rigorous standards of food quality and security [5]. It is widely accepted that costs of manual berry fruit harvest reach 70-75 % of total production cost [11]. Therefore, in order to decrease the total production costs, general trends of berry harvesting worldwide move towards mechanized harvesting - mechanical berry harvesters have been designed and introduced in operation [10]. They operate on the simple mechanical principle: fruit is detached from the plant by vibrating elements, so called shakers possessing elastic "fingers", through direct mutual contact [7]. In order to achieve most of possible benefits of mechanized harvesting, application of berry pickers of this kind demands careful analysis, including careful defining shaking amplitude and frequency (see, [8], for example).

The paper presents a unique technical solution of berry harvesting by induced pulsed air flow, including the analysis of its technical and operational properties in comparison to existing mechanical shaking harvesters and manual pickers. According to [5], "there have been attempts to develop technology of air harvesting in the world, where American and Argentine companies have gone the furthest. However, nobody has managed to "pack up" technology into a commercial product available to a wider market at an affordable price".

2. TECHNICAL SPECIFICATION AND OPERATION

According to the authors knowledge, KOKAN 500s is the unique operational berry harvester that utilizes pulsating turbulent air jets to in mechanized picking the berry fruits. The air stream velocity and pulsating frequency can be accurately controlled, in order to shake canes of berry plant in appropriate way and, consequently, detach the fruits from plant bush [3]. The air jets have an additional important role: the induced turbulent air flow aerodynamically decelerates free fall of picked fruits (delaying fruits receive on catching system) and remove dry leaves/twigs by intensive air stream.

Table 1 Basic technical specification of the combine [1]

Max. length (harvest configuration - fully extended drawbar)	4700 mm
Min. length (transport configuration - drawbar retracted)	4000 mm
Max. width (harvest configuration - opened flank collection platforms)	3340 mm
Min. width (transport configuration - closed flank collection platforms)	2500 mm
Height (the lowest harvester position)	2500 mm
Weight (without workers and collected crop)	2500 kg
Operational (harvest regime) speed	2 km/h
Harvesting capacity	5 ha/day
Maximum lifting height of the harvester	500 mm
Storage capacity of collected fruit	1000 kg
Storage capacity number of crates	50 pcs
Number of persons serving the harvester (minimum)	2 persons
Minimum height of air tunnel	2000 mm
Maximum height of air tunnel	2500 mm
Maximum entrance width of harvester air tunnel	1450 mm
Maximum exit width of harvester air tunnel	850 mm
Internal diesel engine power	55 kW

Basic technical data are given in table 1. All parameters are carefully chosen in order to achieve optimal working parameters, especially machine efficiency and reliability. In addition, general configuration of combine is presented in the figure 1. The following components of the harvester are presented this figure:

(1) main fan;

(2) oil cooler with auxiliary fan;
(3) control board;
(4) sealed hydraulic oil reservoir;
(5) gear-type hydraulic motor, which drives transport system of picked fruits;
(6) main hydraulic pump;
(7) internal combustion (diesel) engine and
(8) towing beam.

Fig. 1 Air berry harvester KOKAN 500s.

In addition, figure 3 shows components of picking, receiving and transport system of the harvester KOKAN 500s:

(1) main fan;
(9) main air duct;
(10) gear-type hydraulic motor, which drives pulsed air controller;
(11) main fan hydraulic motor;
(12) air jets nozzles with deflectors and
(13) transporter of picked fruits.

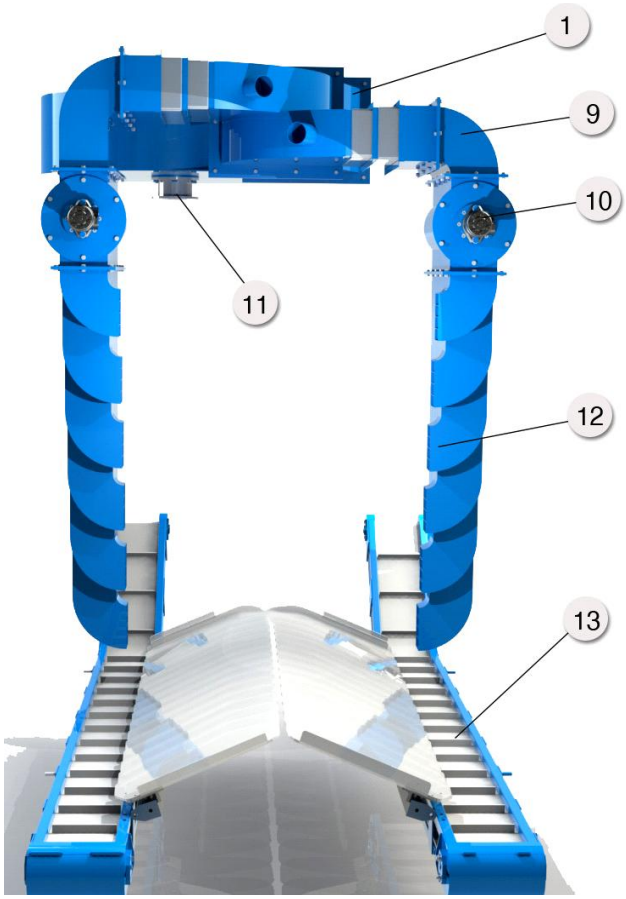

Fig. 2 Picking, receiving and transport system of the harvester KOKAN 500s.

Power transmission from the internal diesel engine toward harvester working systems and their components is performed by appropriately designed hydraulic system sketched in figure 3.

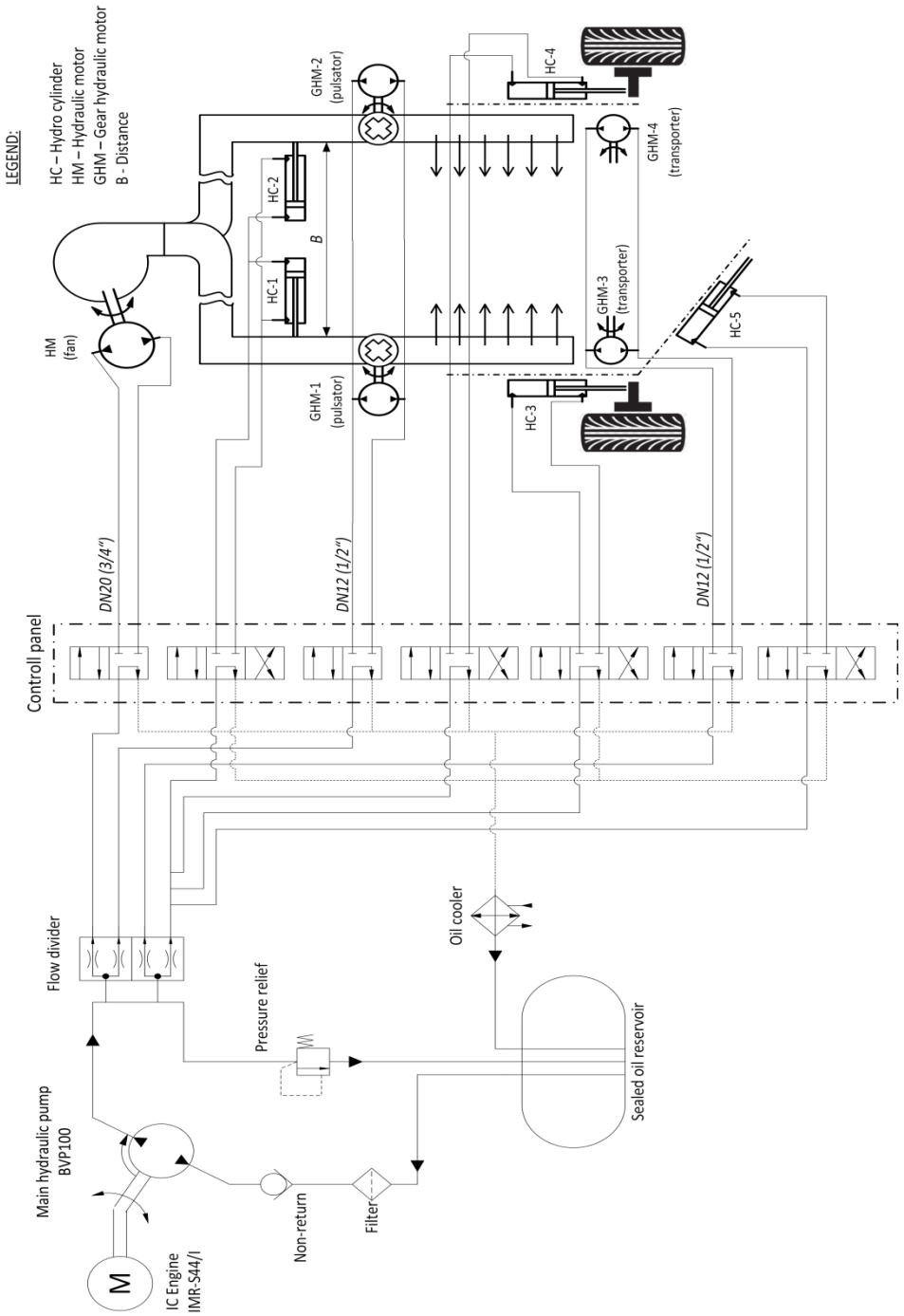

Fig. 3 Hydraulic scheme of the combine KOKAN 500s.

The air berry harvester is powered by one IMR S44/I diesel engine (pos. 7 in fig. 1), with continuous rated power of 46.5 kW at 2000 rpm, and the torque is 245 Nm at 1300 rpm. Power is transmitted from the engine and used to drive the main hydraulic pump BVP 100 (pos. 6 in fig. 1). The hydraulic power generated by main pump is further distributed via control panel (fig. 3) to other hydraulic energy consumers:

- hydraulic motor that drives harvester main fan (pos.1 in figs. 1 and 2);
- two gear-type hydraulic motors driving the flow pulsators (pos.10 in fig.2);
- two gear-type hydraulic motors, for powering two transporters of picked fruits (pos.5 in fig.1), and
- five hydro-cylinders for different harvester adjustments (HC-1 to HC-5 in fig.3).

The highest percentage of hydraulic power is consumed for driving the main fan, which transfers it further to air stream. The air supply to nozzles (pos. 12 in fig. 2) is provided via complex ducts system (pos. 9 in fig. 2) by using alternate air flow pulsation. Pulsations are generated by two pulsators (pos. 10 in fig.2), each powered with its own gear-type hydraulic motor ZMB.F19.

The berry fruits, detached from the bush plants with a pulsating air stream, fall to the left or right transporter (pos. 13 in fig.2). Each of these two transporters are powered with own gear-type hydraulic motor ZMB.F8 (pos. 5 in fig.1).

It should be noted that main fan and pulsed flow control units are designed specifically for KOKAN 500s. In order to achieve high enough pressure of air, the fan is designed following radial geometry of turbo-machines (see [2], [6], [9], etc.).

3. PROPERTIES

Performed field tests indicate that KOKAN 500s can be applied in various berry fruits harvesting: Raspberries, Blueberries, Blackberries and Black Currants. In contrast to mechanical (plant shaking) combines, KOKAN 500s agitates the fruit plants without direct contact. Consequently, fruit bruise, bush damage rate and expected rate diseases spreading are much smaller in the latter case.

Decelerated free fall of detached berry fruits is additional important design superiority of KOKAN 500s, which results in further reduction of harvested fruit bruising.

The harvester is very flexible in operation. Most of the machine working parameters, such as air jet velocity and pulsations frequency, machine leveling, etc., can be easily and independently adjusted. Consequently, it can be applied on various terrain slopes and for harvesting of different berry varieties. The application of air flow also enables purification of the collected fruit – separation of dust and plant leaves.

Besides all these advantages, the application of air berry harvester may also provide the following benefits:

- harvest is selective, i.e. highly focused to mature fruits;
- almost without birth or plant defects;
- almost without breaking the gender branches (what can reduce the yield), etc.

4. CONCLUSIONS

Presented air berry harvester is interesting and unique technical solution that indicates future potential for berry fruit harvesting. Although the machine is still in full operation, further optimizations and design advances are also anticipated by the manufacturer.

At the moment, we propose introduction of a common pulsator, placed just before main duct branching. This way, the one gear-type hydraulic motor would be enough for its powering, instead of two.

Potential markets for BSK's "Air Berry Harvester" "KOKAN 500S" is the Balkan region, the countries of Europe and North America. Potential buyers are large individual farmers (producers who have more than 5 hectares of fruit plantations), fruit associations and fruit processors (colds) with its own plantations [5].

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REFERENCES

1. BSK Obrenovac (2015) *Kokan 500 S – User Manuals*, Technical Data Sheets and Specifications.
2. Eck B. (1973, 1975) *Fans*, Pergamon Press Ltd. Oxford – new York, Torronto – Rusheutters Bay – Paris – Braunschweig (Printed by Biddles Ltd., Guilford, Surrey, GB), pp 592, ISBN 0 08 015872 2 (Translated from :Ventilatoren:, 5-th Edition, 1972, Springer Verlag, Berlin – Heidelberg - New York).
3. http://www.agriculture-xprt.com/products/kokan-model-500s-air-berry-harvester-320154: Kokan - Model 500S - Air Berry Harvester. Downloaded 25.07.2015.
4. http://www.airharvesters.com/en/: Kokan 500S is towed behind harvester that efficiently harvests raspberry, blackberry, blueberry, black currents and other berries. Downloaded 25.07.2015.
5. http://www.innovationfund.rs/bsk-ideal-solution-unique-way-berry-harvesting/: BSK Ideal Solution for Unique Way of Berry Harvesting. Downloaded 25.07.2015.
6. Protić Z., Nedeljković M. (2010) *Pumps and Fans – Problems, Solutions*, Theory, 6-th Edition, University of Belgrade, Faculty of Mechanical Engineering, Belgrade, pp 467, ISBN 978-86-7083-719-5 (IN Serbian).
7. Ramsay A. M. (1983) Mechanical Harvesting of Raspberry – a Review with Particular Reference to Engineering Development on Scotland: Journal of Agricultural Engineering Research1. 3, pp 183-206.
8. Rabcewicz J., Danek J. (2010) *Evaluation of Mechanical Harvest Quality of Primocane Raspberries*, Journal of Fruit and Ornamental Plant Research 18(2), pp 239-248.
9. Ristić B. (1987) *Pumps and Fans*, Naučna Knjiga, Belgrade, pp 368, ISBN not available.
10. Smith E. A., Ramasy A. M.(1983) *Forces During Fruit Removal by a mechanical Raspberry harvester*. Journal of Agricultural Engineering Research1. 1: pp 21-32, 1983.
11. Urošević M., Živković M. (2009) *Mechanization of Fruit and Vine Grape Production*, University of belgrade, faculty of Agriculture, Belgrade-Zemun, pp 380, ISBN 978-86-7834-076-5 9 (In Serbian).