TECHNOLOGIES AND TECHNICAL EQUIPMENT FOR HEMP FIBER CROP

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ABSTRACT

Hemp is not a crop prohibited or restricted by law, only that such a plantation must be authorized and monitored by the Ministry of Health, the Ministry of Internal Affairs and the Ministry of Agriculture and Rural Development.

The paper will present the partial results obtained in a research project in which a piece of equipment for harvesting green hemp stems was grounded and made in order to process these stems to obtain fibers. The purpose of this paper is to present a review of existing mechanical harvesting systems for hemp fiber crops with special reference to hemp.

INTRODUCTION

The technical plants sector and within it, textile plants (hemp, flax and cotton), are of particular importance, not only for the agricultural economy but also for what sustainable organic farming means. At the expense of hemp can be relaunched a series of crafts and habits that can play a decisive role in the future rural development strategy. Hemp (Cannabis sativa L.).It is a multifunctional culture that, worldwide in the last decade, has been the subject of a multitude of research projects and industrial enterprises [1] .Hemp is one of the oldest plants cultivated in our country (over 2000 years old), being used mainly to obtain fibers used in the manufacture of clothing. Hemp strains from local populations and wild hemp contain 10-12% fiber, and improved varieties, 26-32%,[5]. The fiber content in the stems is influenced by variety, technological and pedoclimatic conditions. Fibers have a number of particularly valuable properties in strength (tensile, torsional, friction, rot), extensibility (elastic and plastic), spinning capacity, longer than sisal, jute, manila or cotton fibers, which make them usable in a number of areas, Figure 1. Industrial hemp is a plant used to obtain textile fibers for food purposes which, in order to be planted, must by law have an overall THC content between 0.2% and 0.6%.

The substance content with psychoactive effects tetrahydrocannabinol (THC) in Cannabis Sativa (industrial hemp) is only 0.2%, ie one hundred times less than in narcotic hemp (Cannabis Indica) [3]. The quality of the fibers depends on the time of hemp harvest. The optimal harvest time is considered the phase of technical maturity of the stems, which coincides with the end of flowering of male plants, when the pollen no longer shakes and the plants begin to turn yellow. The delay over this phase determines the lignification of the plants obtaining less resistant and rough fibers [9] In order to achieve the flow shown in Figure 1, it must be taken into account that there are factors in the agro-industrial chain that limit the large-scale marketing of these crops and their products. From a technical point of view, there are technological gaps in harvesting technologies, which prevent the full exploitation of these hemp crops. For example, the production of high-quality textile fibers depends primarily on the quality of the raw material, which in turn is linked, inter alia, to the efficiency of the harvesting system adopted. In most cases, these systems have been developed locally, based on available solutions related to specific local agricultural practice [7]. Hemp is an annual plant with a deep root and an erect stem, more or less branched, robust, up to 3 meters high. Hemp is a plant that can be successfully grown in the world due to its good adaptive characteristics. It is an unpretentious plant because, apart from the fact that it wants a neutral PH and soils without excess moisture, no maintenance work should be done and no excessive care must be taken [6].

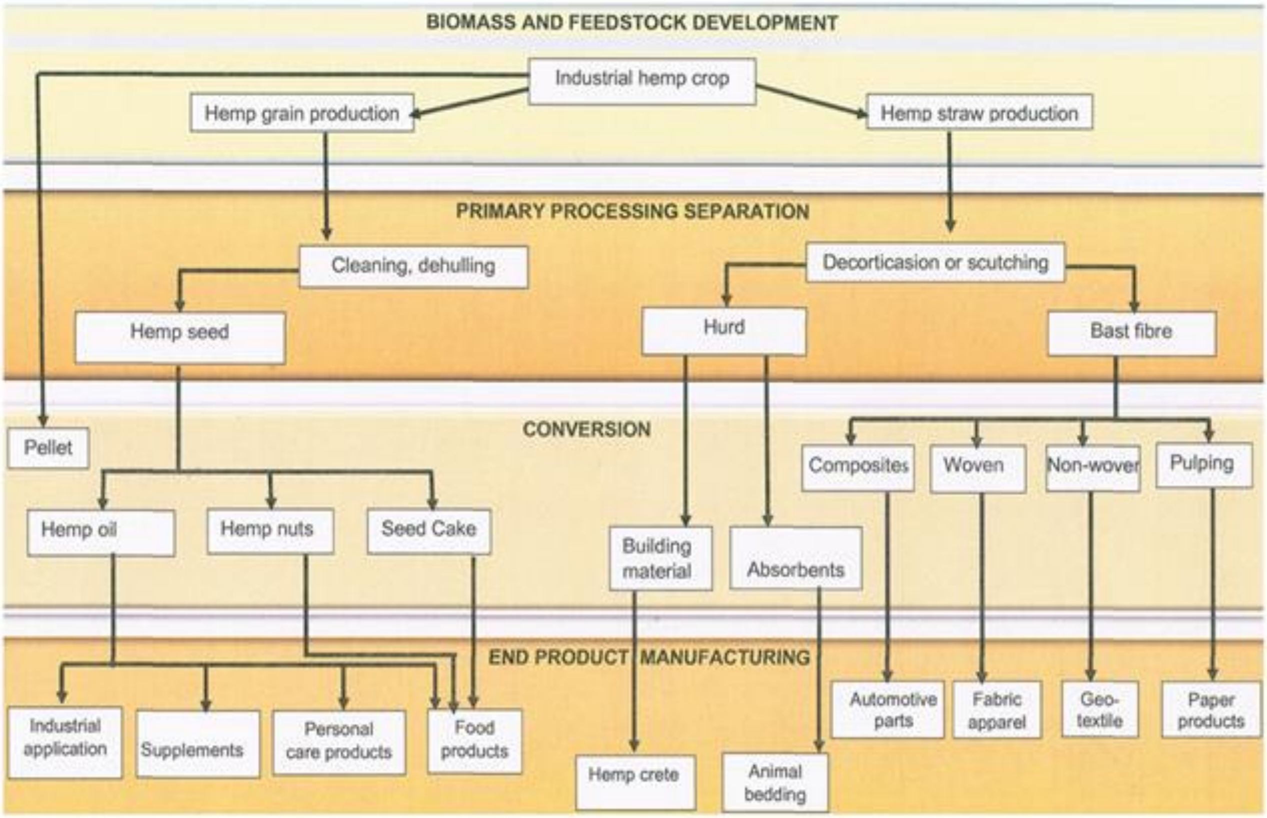

Fig. 1. Supply flow with industrial hemp

Hemp is a rustic species and adaptable to almost all soil types. It is demanding on nitrogen, but does not require excessive care or processing. Hemp wood represents about 55% of the weight of the stem and contains over 50% cellulose. If we analyze figure 1, we can see the multitude of uses of hemp, both seeds and stems. The project carried out by INMA aims to achieve green harvesting technologies and equipment and the processing of hemp stems.

Plastics reinforced with hemp fiber show considerable energy and greenhouse gas (GHG) savings compared to their counterpart fossils. When considering biogenic carbon storage savings between 30% and can even reach 75% [4]. More and more researchers are looking for innovative solutions for making hemp harvesting equipment, in general that meet the specific requirements of local varieties and farms [11].

MATERIAL AND METHOD

In order to meet the requirements of the beneficiaries, who grow or process hemp INMA has developed a technology, figure 2 and a technical equipment for harvesting green hemp stems, figure 3. Agriculture has and will continue to play an important role in ensuring the income of a significant part from the active population from the exploitation of agricultural lands but also through the diversification of activities in rural areas. The experimental model of Green Hemp Stem Harvesting Equipment ERCV is intended for the sequential harvesting of hemp stalks, in order to process them to obtain the string.

In the case of using this equipment, the cut plants remain mixed in the furrow, the inflorescence with the stems. When making the technical harvesting equipment, the technological requirements were taken into account, in the case of harvesting hemp for fiber: strain losses to be less than 5%; broken stems of up to 6% .It should be noted that this equipment is intended for small and medium-sized hemp farms.

The green harvesting equipment of hemp stems, figure 3 a and b consists of the following subassemblies (Phase report; 2020 INMA):

1- Assembled mobile platform ERCV - 1.0;
2-Knife 1 ERCV - 2.0;
3- Knife 2 ERCV - 3.0;
4- hydraulic installation ERCV - 4.0

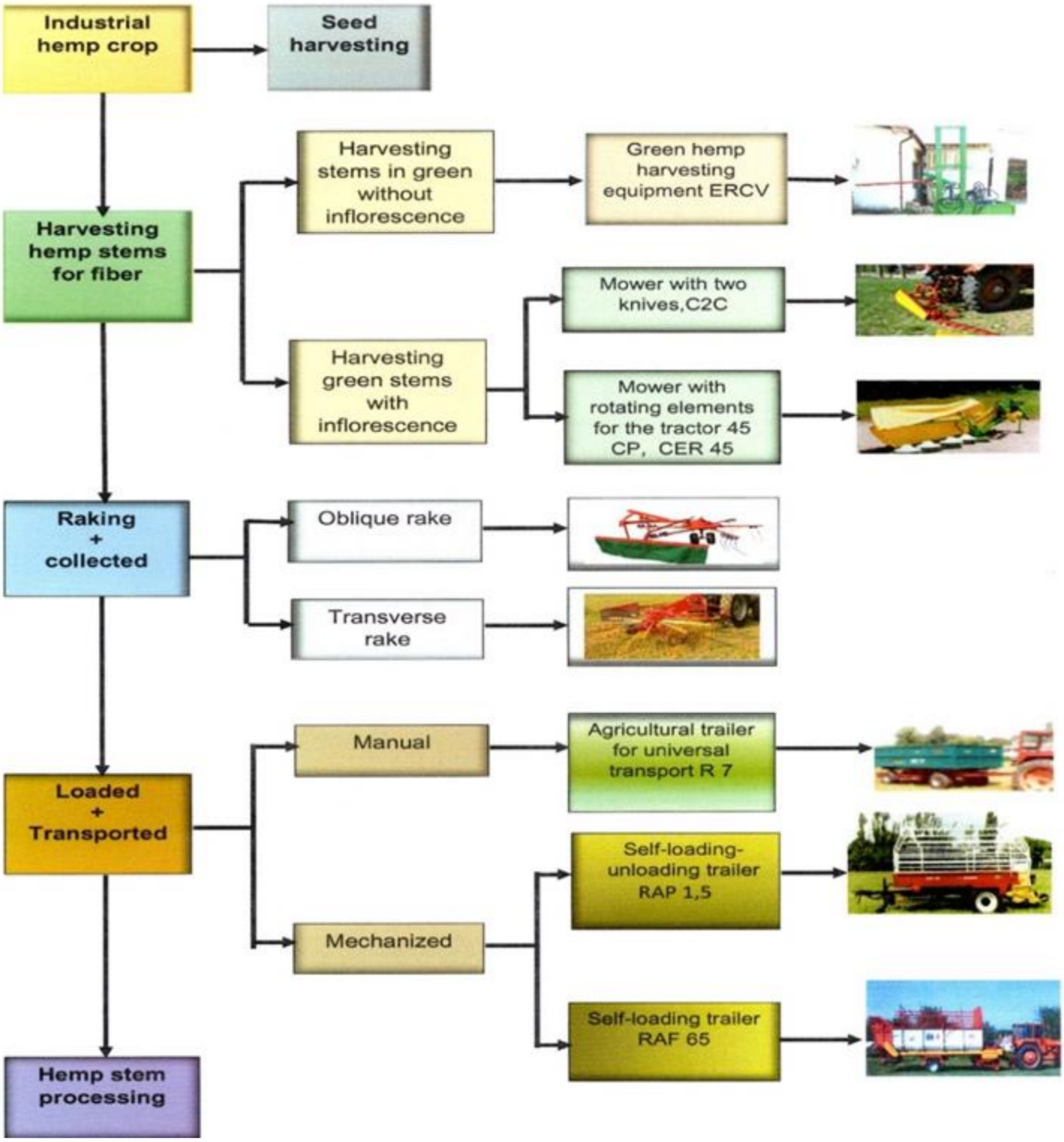

Fig. 2. Green hemp harvesting technology

Fig.3. Green harvesting equipment for ERCV hemp stalks [10]
a-side view; b-front view; c-overview

Assembled mobile platform ERCV -1.0, figure 3 a, position 1 is a construction composed of several subassemblies:

-Assembled platform ERCV -1.1.0:

-Assembled chassis ERCV - 1.1.1.0;;

-Dump ERCV -1.1.2.0;

- Assembled prop ERCV -1.2.0:

-Welded rag ERCV -1.2.1.0;;

-Assembled bolt ERCV-1.2.2.0

The assembled mobile platform is a metal construction type towed semi-trailer, on which the components are mounted: Mobile knife arm 1 ERCV –2.1.0, figure 4 position 1 and Mobile knife arm 2 ERCV -3. 1.0, figure 1 Knife 2 ERCV – 3.0 , figure 5, position 1 (components that support the two sequential cutting knives) and the hydraulic drive system.

On the move, the platform is supported on two wheels, and a support leg on the platform is also used on the stationary.

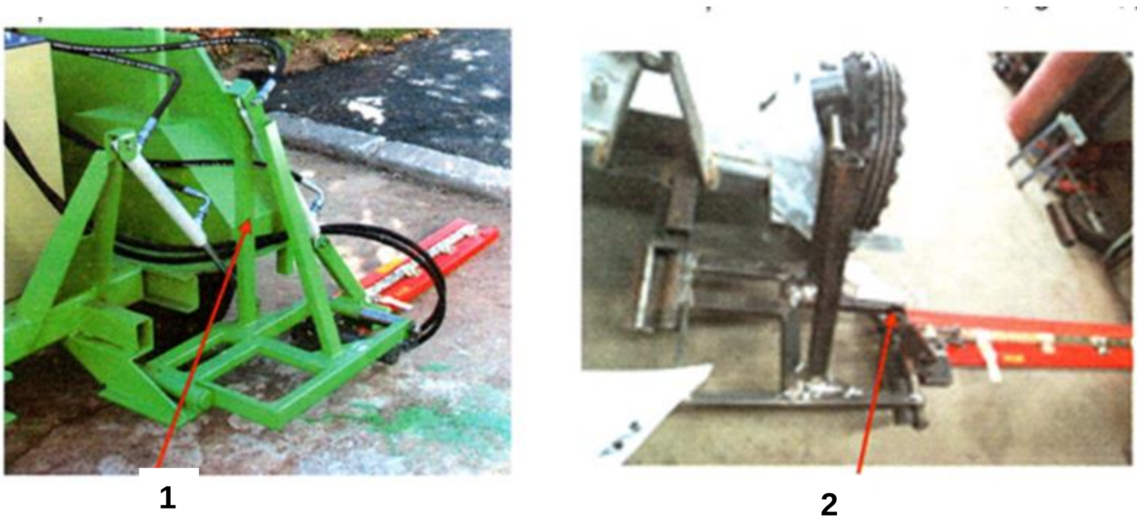

Fig. 4. Knife 1 ERCV – 2.0

On the move, the platform is supported on two wheels, and a support leg on the platform is also used on the stationary. The platform is coupled to the tractor by means of a towbar. Knife 1 ERCV -2.0, figure 3 position 2, is mounted on the back of the platform and cuts the stems to a height of 100 mm from the ground in the working position. In the transport position, the knife is folded and raised vertically by operating with two hydraulic cylinders working at the stroke ends. Knife 1 is a subassembly which constitutes the cutting apparatus and is of the double knife type, in which the role of the fingers and the contracting plates is fulfilled by the second knife which moves with an equal speed and in the opposite direction to the first.

Knife 1 ERCV – 2.0 is made of:

-Mobile knife arm 1 ERCV –2.1.0 figure 4, position 1;

-Knife 1 with hydraulic motor, Figure 4, position 2.

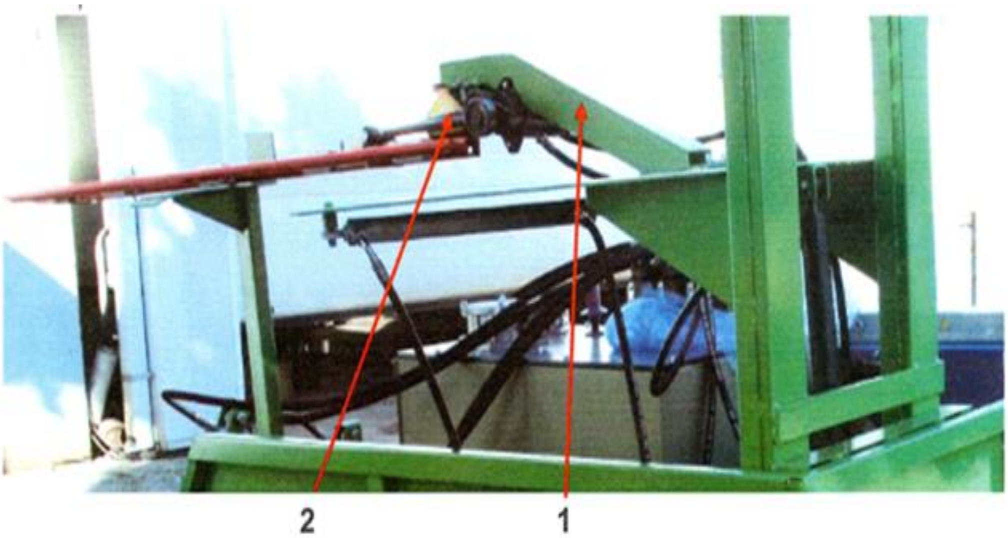

Fig. 5. Cuţit 2 – ERCV – 3.0

Knife 2 ERCV - 3.0, figure 3 position 3 is mounted offset horizontally from the first cutting device, in the front of the platform and performs the cutting of the inflorescences of hemp plants.

Knife 2 ERCV - 3.0 consists of:

-Mobile knife arm 2 ERCV –3.1.0 figure 3, a;

-Knife 2 with hydraulic motor.

Because the height of the inflorescence of the hemp varieties varies, this knife has the possibility of adjusting the cutting height in a wide range of values with the help of a vertical cylinder. The second hydraulic cylinder works at the stroke ends in the working or transport position of the equipment.

In transport, this knife can be folded 90 degrees backwards on a support (figure 3), with the help of the hydraulic installation. This knife is a double-edged knife like the first knife.

Each knife is driven by a hydraulic motor through a distributor, driven by the hydraulic installation of the equipment.

A device is mounted at the rear of the platform and performs the cutting of the stems at a height of 100 mm from the ground in the working position, and is a double knife-type cutting device, in which the role of fingers and contractors is performed by the of the second knife moving at an equal speed and in the opposite direction to the first, figure 6.

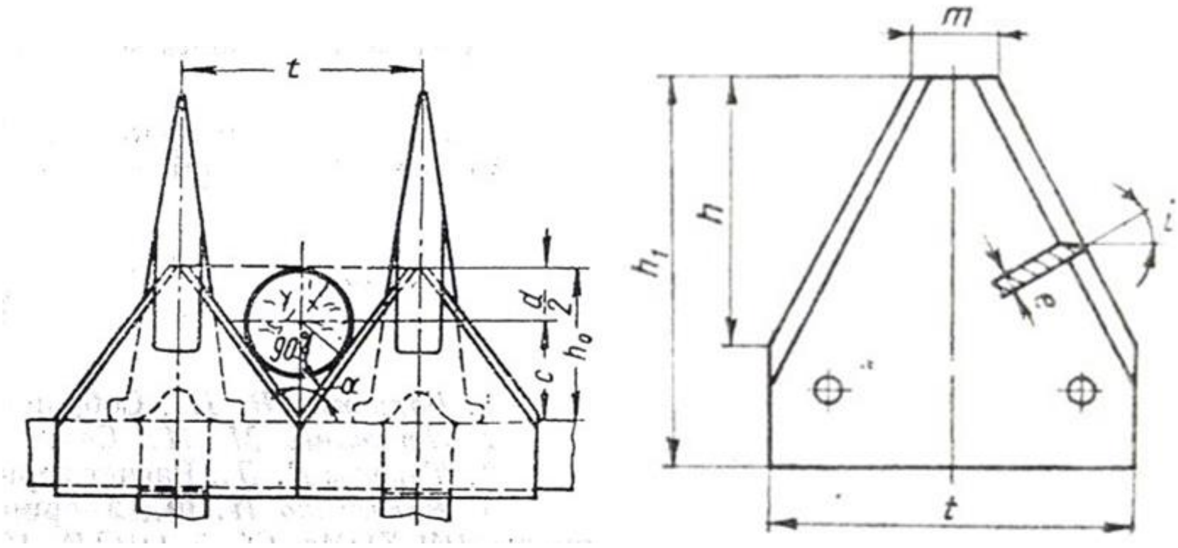

Fig. 6. Characteristics construction of the cutting machine [8]

The simple stroke of the cutting device shown in figure 2 is determined by the relation [9]:

$$S = t = t_0 = 76{,}2 \text{ mm} \quad (1)$$

where:

S - is the knife stroke at the half turn of the crank;

t – the distance between the axes of two blades (step of the blades);

t_0 - the distance between the axes of two fingers (step of the fingers).

The pitch of the fingers t_0 determines the transverse inclination of the plants in the cutting process.

The supply, namely the distance traveled by the machine while the cutting device performs a simple stroke (S = t) determines the longitudinal inclination of the plants in the cutting process, and its size is given by the relation:

$$l = \frac{30\, v_m}{n} \quad (2)$$

where:

v_m - is the working speed of the machine;

n - number of rotations of the crank.

A satisfactory cutting height is obtained for the following values of the feed, obtained experimentally: $l \leq 1.2\ h_0$ for mowers with animal traction $l \leq 1.3\ h_0$ for mowers with mechanical tension, $l \leq 1.5\ h_0$ for combines of grain and polishing reapers, h_0 being the height of the working part of the cutting blade cut.

At a given supply, the number of complete strokes of the segment is determined by the relations:

$$n = \frac{30\, v_m}{l} \quad (3)$$

Relation (3) is for cutting machines that have a simple knife stroke

$$n = \frac{30\, v_m}{2l} \quad (4)$$

Relation (4) is for cutting machines that have a double knife stroke.

Cutting grasses and straw cereals in good condition, finally ensuring a uniform stubble, depends on the cutting speed *v*, the feeding *l*, the step of the fingers t_0, the type of cutting edges (smooth or serrated), the sharpness of the cut and the play between the cutting blade the contracting plate.

The minimum cutting speed that ensures a good cutting of grass must be *2.15 m / s*. Due to the higher thickness and stiffness of the stems, straw cereals can be cut at a speed of $v_{min} \geq 1.5$ *m / s*. The speed of a certain point of the cutting blade, which is at a distance x from the initial position is determined by the relation:

$$v_x = S_\omega \sqrt{\frac{x\left(1-\frac{x}{S}\right)}{S}} \quad [\text{m/s}] \quad (5)$$

The complete stroke of the knife, taking into account the offset *i*, is determined by the relation:

$$S = \sqrt{(u+r)^2 - i^2} - \sqrt{(u-r)^2 - i^2} \quad (6)$$

in which :

$\omega = \frac{\pi n}{30}$ is the angular velocity of the crank;

u - stem length

r - radius of the crank.

The average speed relative to the relation $v_c = \frac{S_n}{30}$, and the maximum one with the relation $v_{max} = \frac{S_\omega}{2}$.

Absolute average knife speed

$$v_a = \sqrt{v_m^2 v_c^2} \quad (7)$$

RESULTS AND DISCUSSIONS

Before entering the hemp crop, the tractor is started and the two cutting devices are operated by means of the hydraulic installation - ERCV - 4.0, figure 7 [4].

The experimental model provides the following general characteristics:

-Stem processing capacity, m^3 / h	0,3-0,5
-Drive the processing mode:	
-coaxial gear motor	MR202-112M2
-power, kW	4
-input speed, rpm	n_1 = 3000
- output speed, rpm	n_2 = 833
-Fiber cleaning mode drive:	
-electric motor	with sole
-power, kW	1,5
-speed, rpm	1500

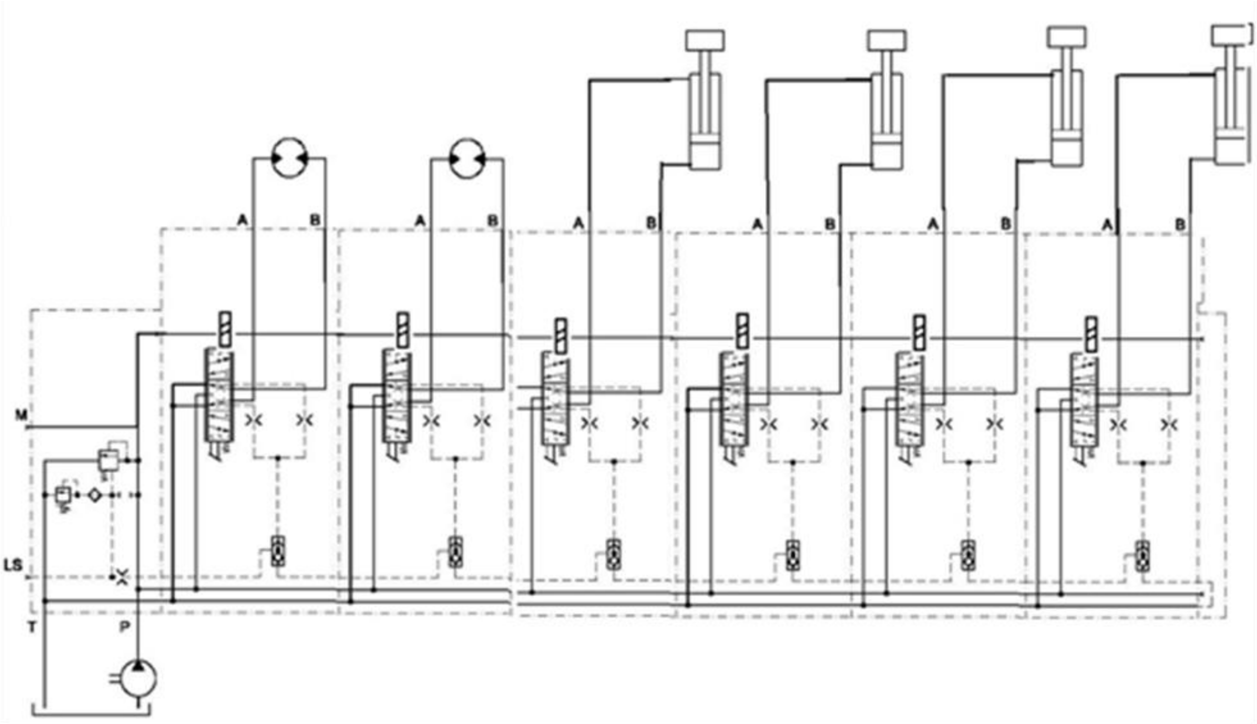

Fig.7. The hydraulic installation [2]

CONCLUSIONS

The constructive solutions adopted aimed at creating an equipment that would ensure the following technological requirements in case of harvesting hemp for fiber:

- the average cutting height from the ground must not exceed 100 mm;
- strain losses should be less than 5%;
- the percentage of broken stems must not be higher than 6%;
- realization at a lower cost price than externally.

It is a technical equipment for small and medium-sized hemp farms.

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