DESIGN FOR DRIVE OF INTERAXLE MECHANICAL CUTTER USED IN LOW TRELLIS SYSTEMS

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Abstract. A mechanical pruner (similar to a special sprinkler for chemical pruning) serves to prune new hopvine shoots in spring. Later yield depends on the right timing and quality of pruning, which is why pruning is one of the most important agrotechnical operations. The double-disc mechanical pruner used with high trellises cannot be used with the technology of low trellises. Due to the effort to minimize the chemical environmental burden, the special sprinklers for chemical pruning used abroad are considered inappropriate. This was the reason which led to a design of a mechanical pruner operating in low trellises. The results are several main designs of the mechanical pruner. Design for the rear transmission with the motor and design for the whole set. The design for the whole set shows and describes how the laboratory measurement was conducted. For laboratory testing, a special carrier for the mechanical pruner was created. In this part the design of a hydraulic circuit supplemented by one-way valve is also described. Conclusions contain a summary of the results and the next steps for research in the mechanical pruner for low trellis systems.

Keywords: hops, mechanical pruner, low trellis.

Introduction

For low trellis systems the usage of a single-disc hop pruner with a flat cutting disc of 600 mm in the diameter proves to be the most effective [1]. The disc is made of abrasion-resistant steel with the cutting edge covered with a wolfram-carbide coating 1 mm thick and 20 mm wide. In case the disc is coated on one side only, the self-sharpening effect occurs when the disc in the soil is self-sharpened due to different abrasion resistance of the upper and lower part [2]. A flat disc may be further sharpened during the pruning by means of a grinder which is mechanically pushed to the cutting disc edge by rectilinear hydraulic motor. The recommended disc rotational frequency is from 600 up to 750 min^{-1} [1].

Materials and methods

1. Basic requirements for mechanical pruner

The basic requirement is trimming the hopvine shoots (so called new wood) down to a depth of 50 mm below the terrain level. Thus, the old hopvines are cut off their root part (rootstock). The cutting mechanism operates in the space under the low trellis anchoring rope, which is stretched at the maximum height of 250 mm above the terrain. Such height, however, is not the same for all low trellises due to which this limiting value cannot be relied upon. Generally, we may say that the lesser the construction height of the rear transmission with the cutting disc, the more universal the mechanical pruner will be. On the anchoring rope of 6 mm in diameter there is usually hung a drop irrigation system which must not be damaged by the passing mechanical pruner. Some low trellises have the drop irrigation placed right on the ground in the axis under a plastic net. This type of low trellis excludes the usage of a mechanical pruner, where it is necessary to apply chemical pruning through a specially adapted sprinkler. Sharpening of the cutting disc when the machine is in operation improves the cutting and above all minimizes the idle time caused by disassembling, sharpening, and reassembling of the cutting disc. Without quality sharpening the cut would fray rendering the rootstock more prone to mildew and pest. Automated motion of the mechanical pruner arm makes the operator's labour easier and above all minimizes the mistake which might result in damage of the hop field equipment or the used machinery. The energetic means must move in low trellis always in the same track rows, i.e., in the axis of hopvine interrows.

2. Mechanical pruner carrier

Mechanical pruner motion is one of the key parts of the mechanical pruner design. Hop rootstocks are planted in the hop row axis under the drop irrigation. In the particular axis there are also low trellis supporting poles. The mechanical pruner rotor motion (deflection of the cutting disc from the operating position and its return) is necessary so that the cutting disc edge would not meet the low trellis supporting pole, thus causing its damage.

Owing to a close cooperation of the Department of Agricultural Machines, FE of CULS in Prague, with the Hop Research Institute Co., Ltd. in Žatec, an installation and following measurement of kinematic parameters for Wallner interaxle carrier (Fig. 1) were completed. The measurement was carried out on Zetor 5245 tractor.

There are three possible ways of placing the cutting mechanism to be considered. They are:

- front three-point linkage;
- interaxle tool carrier;
- rear three-point linkage.

The presented design uses a placement of the mechanical pruner on an interaxle tool carrier produced in series. Such a placement seems to be advantageous compared to the other ones in that the tractor operator can see the pruning device from the cab and manipulate the carrier arm motion directly. Another advantage of using the interaxle carrier is that it is produced in series with lower financial costs at acquiring a mechanical pruner. An interaxle carrier is a universal device enabling hanging of various working tools.

Fig. 1. **Wallner interaxle carrier**

Results and discussion

1. Design for rear transmission with hydromotor

The whole device set is depicted in Fig. 2. All the parts of the mechanical pruner design are connected in a way to keep their coaxiality. The piston axial hydromotor is connected through the thread bars to the rear angular gear. Between those there is inserted a coupler with a connecting shaft. The conical wheel of the angular gear is further connected to the carrier with the cutting disc.

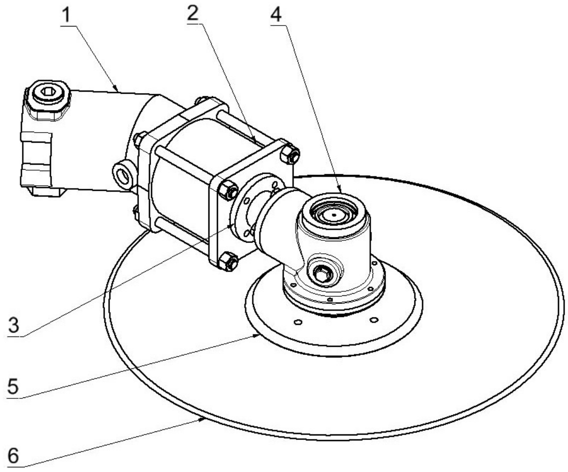

Fig. 2. **Rear transmission with hydromotor:** 1 – axial piston hydromotor; 2 – coupler; 3 – extension; 4 – angular gear; 5 – carrier; 6 – cutting disc

2. Design for the whole set

The rear transmission with the hydromotor is fixed by means of four eye screws with a loop onto a clamping plate (Fig. 3, position 4). By these screws we can set any cutting angle of the cutting disc we need. The clamping plate secures the connection between the rear transmission with the hydromotor and the interaxle carrier (Fig. 1). A little plough blade (Fig. 3, position 3) serves to wipe the soil carried by the cutting disc off the body of the axial hydromotor. This prevents stuffing the soil in the space between the cutting disc and the hydromotor block during hopvine cutting.

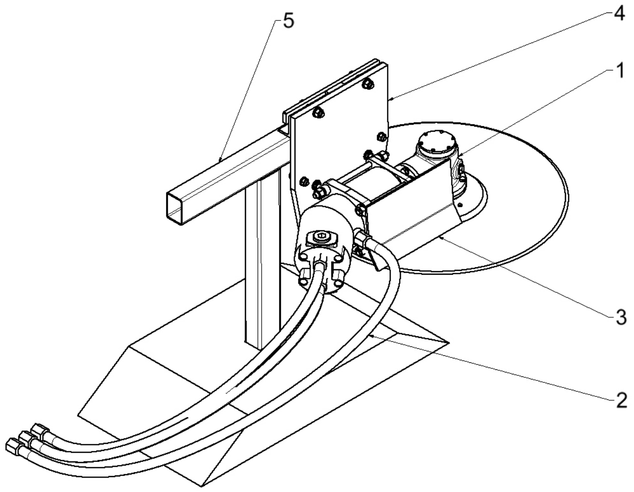

Fig. 3. **Laboratory set of mechanical pruner design:** 1 – rear transmission with axial piston hydromotor; 2 – hydraulic lines; 3 – little plough blade; 4 – clamping plate; 5 – frame for laboratory measurement

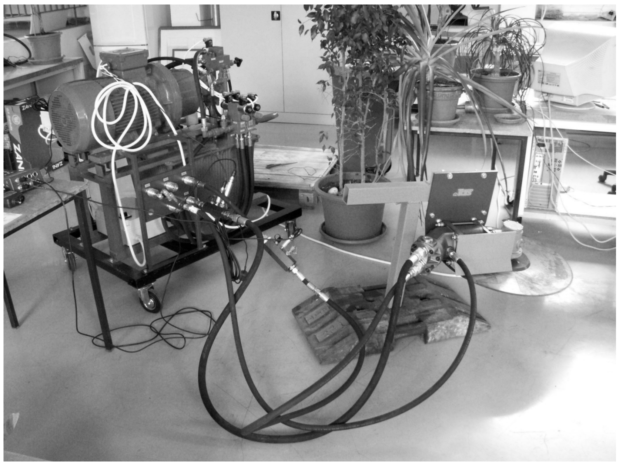

Fig. 4. **Laboratory set of mechanical pruner**

3. Measuring of axial piston hydromotor

The design uses the axial piston hydromotor with inclined block A2FM, size 62 by Bosch Rexroth. When measuring the flow depending on rotational frequency of the cutting disc of the mechanical hop pruner hydraulic circuit (HC), the hydraulic oil temperature was kept at 35 ºC. The measurement was carried out by Multi System 5060 measuring equipment provided by a hydrotechnic company. The mechanical pruner was measured without load.

The rotational frequency changed every 60 s, when after each change the actual values measured on the flowmeters were recorded. The difference between both flows can show the flow of the leakage fluid.

The measured values are shown in the following graph (Fig. 5).

The thermometer serves only to check the operating HC oil temperature.

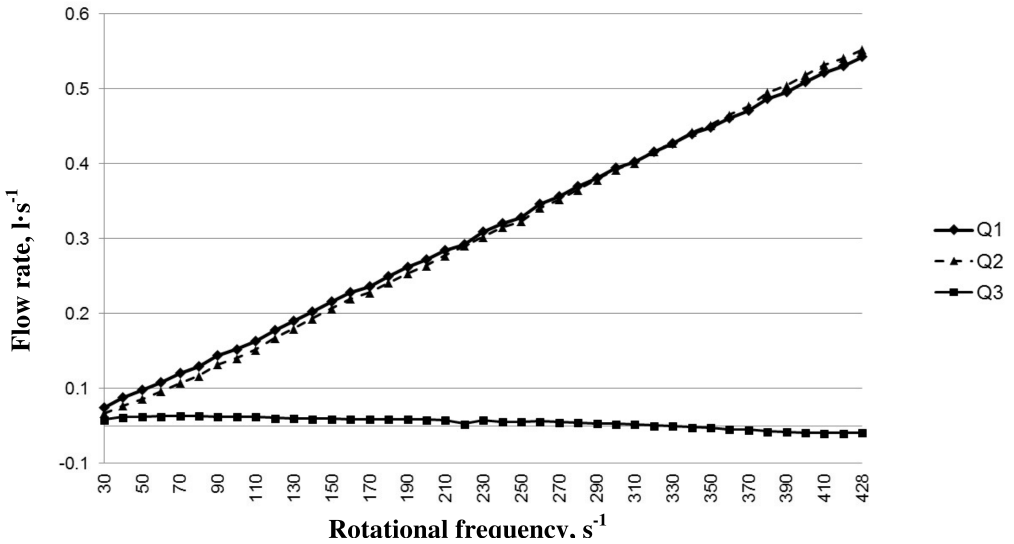

Fig. 5. **Graph of dependancy of hydraulic oil flow on cutting disc rotational frequency:** Q1 – hydraulic oil flow in pressure line; Q2 – hydraulic oil flow in drain line; Q3 – calculated flow of leakage fluid

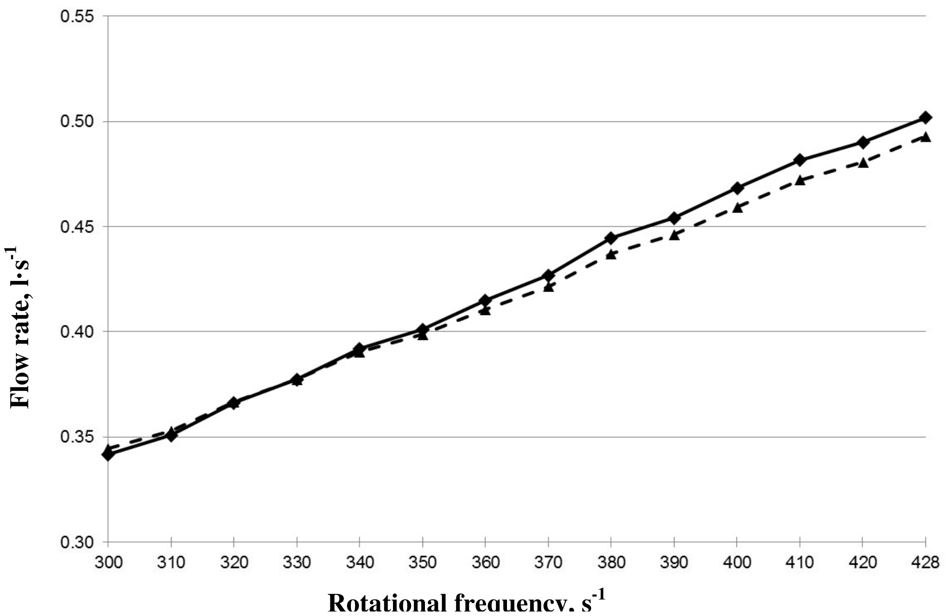

Fig. 6. **Details of graph depicting dependency of hydraulic oil flow on cutting disc rotational frequency:** Q1 – flow of hydraulic oil in pressure line; Q2 – flow of hydraulic oil in drain line

By measuring the axial piston hydromotor we found out that with increasing the rotational frequency the amount of leakage fluid decreases. This effect occurs up to 330 s^{-1}. Above this value the opposite effect starts occurring, when due to the influence of the risen underpressure the leakage fluid (return line) is sucked in. The graph (Fig. 6) depicts details of the flows dependency on the rotational frequency at which the mentioned effect starts occurring.

Conclusion

The article presents a design for a mechanical pruner and its experimental verification in laboratory conditions. It is still necessary to deal with a range of issues and problems. As seen in Fig. 3 and Fig. 4, the block of the hydromotor is, owing to the lack of handling space under the tractor to move, turned by 90º, i.e., into a horizontal position. Regarding the relatively high weight of the mechanical pruner (app. 90 kg), it will be necessary to supplement the design with a coppying wheel, which would keep even sinking of the cutting disc.

Another step we take will be a test of the mechanical pruner in field conditions.

After all the hidden troubles have been settled, automated motion of the movable hanging will be added, so that the operator might focus fully only on the machine driving in the hopfield interrows and on the optical control of the pruning mechanism operation.

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