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A TIMBER SORTING FOR DOUBLE-WHEEL SAW D9

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Abstract: The paper describes a design of a timber assorting line which has been intended for a sorting at the back of double-wheel angle saw D9. The basic information about the possible applications and design of timber sorters are described in introduction of this paper. In next part, the attention is paid to the working principle of a designed device together with a definition of material parameters, with which the device can work. Constructional design of individual devices which are the members of the assorting line, are described in more details. The main part of this paper deals with the design of the assorting manipulator and roll train. Designed sorter shows an alternative solution to sorting at the back of the saw D9 and it expands the possibilities of nowadays assorting systems.

Key words: *manipulation, assorting manipulator, roll train*

INTRODUCTION

In nowadays saw technologies, the timber assorting systems are still used more often. The assorting system applications represent the basic condition for achievement of a full automated manufacturing process, which is the main reason for their using in practice. Using of these devices allow to remove a hard monotonic human work and ensure the smooth running of a manufacturing process.

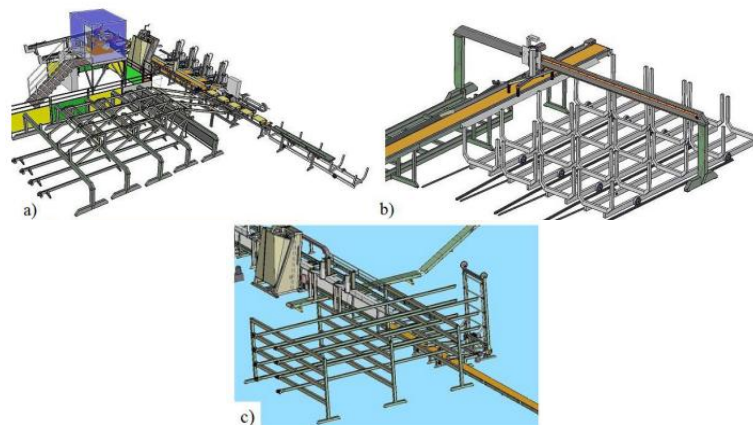
The timber sorter represents an additional device for a timber assortment on the individual products. These devices are designed and modified to the concrete requirements. Among the most important initial requirements belong:

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- minimum and maximum length of a graded timber,
- minimum and maximum dimension of a timber cross-section,
- number of graded groups,
- required work tact of the sorting,
- required dimensions of a sorter.

Selection and design of a suitable sorter for specified requirements is very important and difficult process. In practice, there are sorters which can work either continuously at the back of the saw, or the sorter is made as an external device. In the case of continuous sorters, the most difficult requirement is to meet the required work tact which is given by feed velocity of the saw. The external sorters are often used in the case of a limited space at the production hall, where is a lack of space for the timber sorter placement directly at the back of the saw. Disadvantage of this solution is the necessity to transport of a sawed group of the timber towards assorting line and the necessity to solve a timber batching.

This paper deals with the design of a sorter which has been intended for continuous work at the back of double-wheel saw D9 from StrojCad Company. Designed device is intended for a timber grading to the individual groups according to its cross-section. This device represents an alternative of existed assorting systems which StrojCad Company uses at the back of the saw. In Fig. 1, the assorting lines from StrojCad Company are shown.



*Figure 1. The timber assorting lines from StrojCad Company
a) the transverse sorter with a jib and an extension chain conveyer,
b) the assorting manipulator, c) the terrace timber sorter*

MATERIAL AND METHODS

Design of the assorting line is based on the technical parameters of double-wheel saw D9 (Fig. 2). This saw represents a new generation of a double-wheel trunk saw with a movable clamping carriage and the possibility of a variable change of the sawed dimensions length. The saw is characteristic of a stationary cutting mechanism which is created by two rotary saw, perpendicular to each other, where one rotary saw is oriented

in horizontal direction and the second one is oriented in vertical direction. Represented sawing method allows us to create a finished edged timber in a high quality by only one transit of piece through the cutting mechanism. The saw is managed by one operator who has the opportunity to interactively choose the suitable cutting scheme which takes into account parameters of a trunk as well as parameters of a required timber (Fig. 3).



Figure 2. Double-wheel angle saw D9

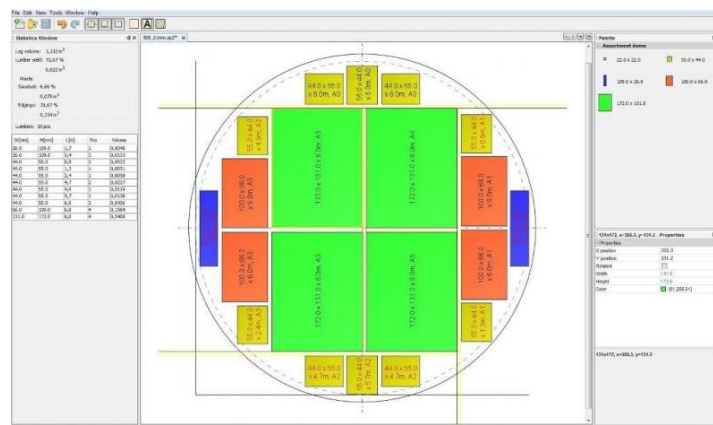


Figure 3. A cutting scheme

For a design of the assorting line, the highest effect from all technical parameters has a possible length range of processed trunk. The length of a cutting trunk directly affects the time of cutting and so required tact of assorting line work. Represented saw allows us to cut a billet with the range of lengths $l_r = 2 \div 8.3$ m. Minimum time of cutting which is important for a design of device is the lowest at cutting of the billet with the lowest length ($l_r = 2$ m). Cutting time also depends on kind of the cutting billet (soft or hard wood). From these information is clear, that minimum times of cutting will be different for hard and soft wood. The saw is able to cut the billet from hard wood with minimum length $l_r = 2$ m, which corresponds with minimum time of cutting $t_m = 5$ s. Sawing soft wood, there is not cut the billet which is shorter than $l_r = 4$ m, which corresponds with time of cutting $t_m = 8$ s.

One of the main aims of this paper is to provide a solution of the timber sorting which allows us to sorting in the biggest range. From this reason, we have focused on the timber length in range $l_r = 4 \div 8.3$ m.

The work principle of the designed sorter line is based on the motion combinations of different transport and manipulation devices which create a compact unit. The assorting manipulator which performs a process of sorting by its motion is a central part of device. The main part of the assorting manipulator is a shear mechanism which provides a lift of the graded billet into required height by its motion. Range of lift is divided into three height levels, where each one represents a different assorting group. Maximum value of lift is $h_{max} = 1200$ mm, which is the value for grading into the third height level. For grading into the first height level, there is required to perform the lift $h_1 = 305$ mm and into the second level $h_2 = 745$ mm. In practice, a hydraulic drive or mechanical drive unit is used for ensure the shear mechanism lifting. A linear hydraulic with a velocity of a piston disengagement $v_h = 0.25 \text{ m}\cdot\text{s}^{-1}$ was used for lifting of the shear mechanism in described solution. For achievement of required maximum lifting, determination of the piston disengagement value is required. Necessary value of the hydraulic piston disengagement was computed according to the following equation:

$$x = \sqrt{l^2 - m^2} - l_1 \quad (1)$$

where:

- l [mm] - length of a shear jib (distance of jib pin axes),
- m [mm] - distance of jib pins at down position of mechanism,
- l_1 [mm] - distance of jib pins at maximum lifting.

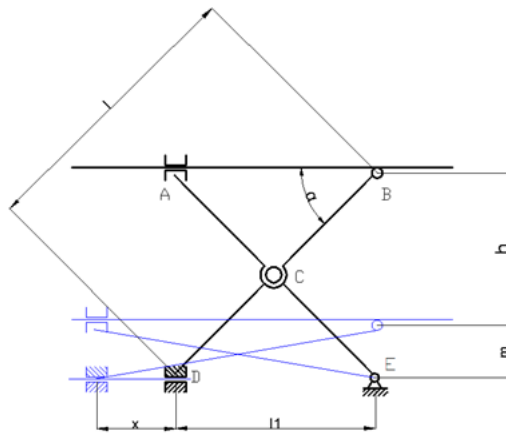


Figure 4. A kinematic scheme of the shear mechanism

Construction of designed shear mechanism consists of bottom welded construction (1), shear jibs (2), top welded construction (3) and linear hydraulic (4). The shear jibs are able to linear motion on one side which is represented by a linear line; on the second side, they are pinned. Due to the stability increase, fit of the shear jibs is designed in order to their asymmetry against to its centre in bottom position of the manipulator and their symmetric position at maximum lifting (Fig. 5).

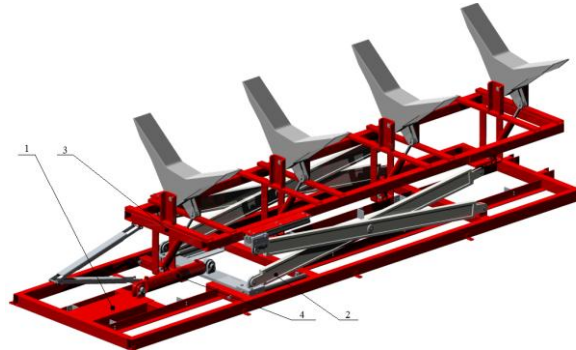


Figure 5. The assorting manipulator

The second important part of the assorting manipulator is a tipping device which is situated at the top of construction. The tipping device consists of a working spoon and linear hydraulic. The working spoon is able to rotate around the rotation axis in angle $\alpha_L = 60^\circ$ by linear hydraulic. Fully, four working spoons with own drive are situated in a row in construction of the shear mechanism. Span between the working spoons is chosen in order to grade the timber with the lowest length $l_r = 2$ m. A possibility of the working spoon rotation in two sides allows us to grade the timber at three different height levels into six groups. When the shear mechanism obtains a required height, the tipping device is taken into motion. Subsequently, the working spoon is rotated according to the grade requirement on the one side or on the other side. Rotating the spoon, an inclined plane appears, where the graded billet is taken into motion by own gravity and it slides to line which transports it into appropriate collecting basket (Fig. 6).

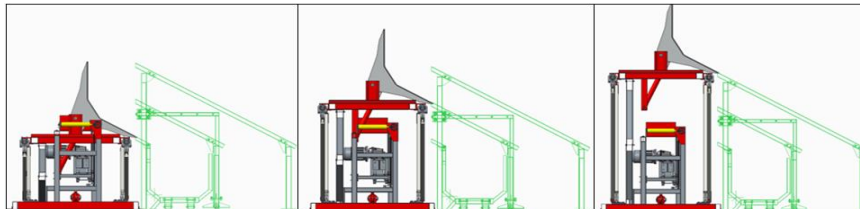


Figure 6. A timber grading into individual height levels

In next part of this paper, we deal with a problem of the billet transport from a conveyer to the assorting manipulator. The billet should be transported over the working spoons. The roll train is the best way of this transport. This roll train is divided into four parts and it is situated directly in the assorting manipulator. Owing to the simple plug of the working spoon under rolls level, construction of the conveyer is divided into individual spans. Individual parts are powered by electric motor and chain gear. Due to the accurate position of the rolls against to geometric centre of the working spoons, individual parts of the conveyer are centred by trips (Fig. 7).

Using of “Rollerdrive” rolls, which would abbreviate the construction of the roll train, was also taken into account at the design of a conveyer power. Due to their low power, using of these rolls could not be possible.

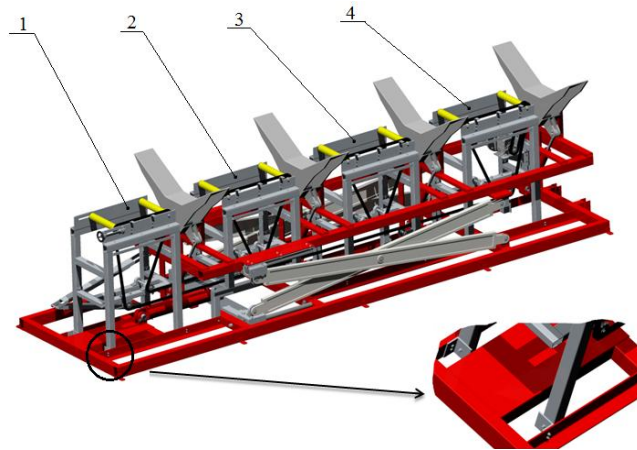


Figure 7. A constructional solution of the roll train

The most important parameter for design of the conveyer was dimension of the billet which can appear at output of the saw D9. Also, the length and cross-section of the billets have a variable character. Due to this, there was necessary to determine critical dimensions of the timber from overall possible range which directly affect the span and stiffness of the rolls. The lowest length of the billet which can appear at output of the saw was the most important property from the view of the conveyer rolls span. Maximum cross-section and length of the billet are important properties from the view of the rolls stiffness. Span of the rolls was chosen according to the rule of minimum three rolls under the shortest piece of the billet which has had length $l_r = 2$ m.

In next part of this paper, we deal with the design of individual parts of the assorting manipulator. During the work, the manipulator is loaded by the billet gravity which is the subject of manipulation at this moment. At computation, we considered with a gravity of the biggest billet G which can be processed by the saw D9. Determination of the manipulator critical positions, in which maximum load appears, is necessary from the view of individual parts design. Firstly, the reaction forces at the top construction by the tipping device were computed in position at the angle of spoon rotation $\alpha_L = 0^\circ$ and $\alpha_L = 60^\circ$. The billet gravity G was evenly divided into each spoon.

A diagrammatic drawing of the tipping device, considering the billet gravity in a position at the angle of spoon rotation $\alpha_L = 60^\circ$, is in Fig. 7-a. In next step, the reaction forces in connections C and D were computed at the angle of spoon rotation $\alpha_L = 0^\circ$ and $\alpha_L = 60^\circ$ which were applied as loaded forces F_G at member of the shear mechanism (4) (Fig. 7-b). Subsequently, the reaction forces in connections A and B were computed at member (4). These reaction forces were used as loading forces of the shear mechanism jibs in next step of computation. The reaction forces, appeared in individual connections of the jibs, were computed in four positions of the mechanism, concretely at the values of lifting $h_0 = 0$ mm, $h_1 = 305$ mm, $h_2 = 745$ mm and $h_{max} = 1245$ mm. Due to the knowledge of a force course at hydraulic motor F_h which was necessary to fix the shear mechanism in required position, computation of the reaction forces was performed in different positions of the mechanism. The equations of a static equilibrium at the jibs were being solved according to the following equation:

$$\begin{pmatrix} 1 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & -1 & -1 & 0 & 0 \\ \frac{l}{2} \cdot \cos \alpha & 0 & -\frac{l}{2} \cdot \sin \alpha & 0 & 0 & 0 \\ -1 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 1 & 0 & 0 & 1 \\ \frac{l}{2} \cdot \cos \alpha & 0 & \frac{l}{2} \cdot \sin \alpha & 0 & 0 & 0 \end{pmatrix} \cdot \begin{pmatrix} R_{Cy} \\ R_{Ey} \\ R_{Cx} \\ R_{Ex} \\ R_{Dy} \\ F_h \end{pmatrix} = \begin{pmatrix} R_{Ay} \\ 0 \\ R_{Ay} \cdot l \cdot \cos \alpha \\ R_{By} \\ -R_{Bx} \\ -R_{By} \cdot l \cdot \cos \alpha - R_{Bx} \cdot l \cdot \sin \alpha \end{pmatrix} \quad (2)$$

where:

l [m] - length of the shear jib,

α [°] - angle between the shear jib and horizontal plane,

F_h [N] - force at hydraulic motor, necessary to fix the mechanism in required position,

R_{xi} [N] - reaction force in x^{th} point and in i^{th} direction of the shear jibs.

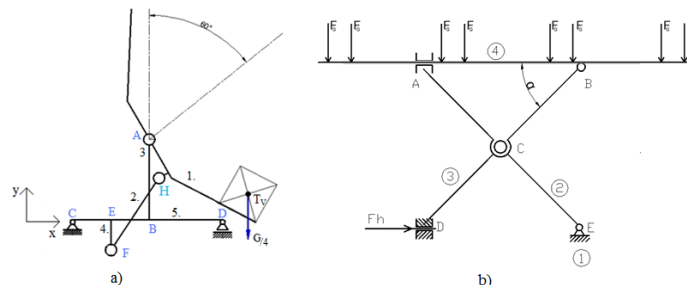


Figure 8. A diagrammatic drawing of loading at the shear mechanism and tipping device

RESULTS AND DISCUSSION

The main aim of the assorting line design was to find a solution which will represent an alternative method of sorting and will allow us to grade the timber in the highest range. It is possible to grade the timber in overall length range from the view of construction dimensions at the designed assorting system. Work tact of the assorting manipulator t_p is also another important parameter which affects a possible dimension range of the graded timber. Due to meet the condition of the sorter continual work, maximum work tact t_p should be lower than the lowest time of the saw cutting. Work tact t_p represents the time which is required to grading and subsequent backspacing of the manipulator into a default position. Work tact of designed device is $t_{pmin} = 8$ s at the chosen velocities of individual drives. During this time, the device picks up the billet into the second assorting group; upsets the spoon; stays in this position for the time $t = 1$ s and subsequently it returns into a default position.

After sorting into six assorting groups, it is necessary to perform maximum lift of the shear mechanism on the third height level. Due to this, the time of device work is extended to the value $t_{pmin} = 11$ s. On the basis of previous times, the sorter is intended for sorting of the billets from soft wood with the length range $l_r = 2 \div 8.3$ m and the billets from hard wood with the length range $l_r = 4 \div 8.3$ m. Sorting the timber with the length $l_r = 2 \div 5$ m, the device allows assortment into four groups and with the length $l_r = 6 \div 8.3$ m it is possible to sort into six groups.

Due to determination of working time of the assorting manipulator for different levels of lifts, determination of the piston extension values in the other positions was also required. Dependence between the lift of the shear mechanism and the piston extension of linear hydraulic was found out by a substitution of the corresponding values into the Eq. 1. This dependence is shown in Fig. 9.

In next part of this paper, a course of needed force F_h which affect to the shear mechanism was found out on the basis of matrix form (2). The force which is required for fixing the mechanism F_h , is maximum at the value of lift $h = 0$ mm (in a default position). In next lifting of the mechanism, decreasing of required force F_h appears. The course of force F_h in dependence on lift is shown in Fig. 9.

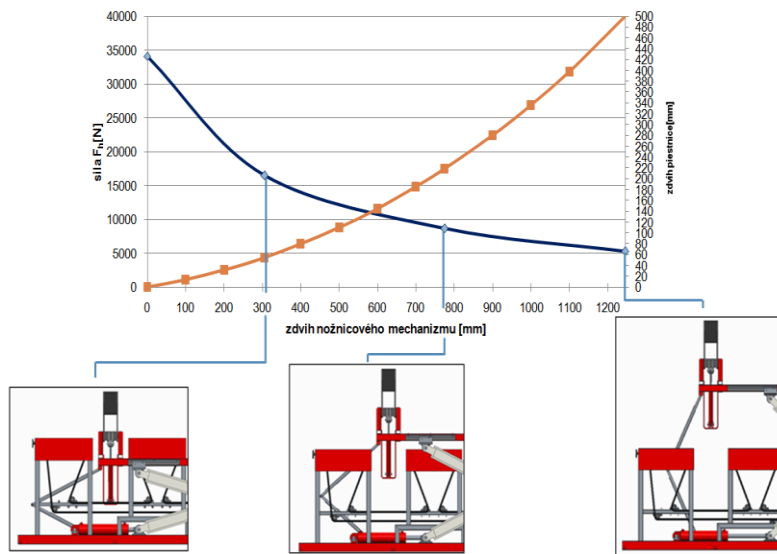


Figure 9. Dependence between the shear mechanism lifting, force F_h and the piston lifting

Table 1. Overview of the resulting reaction forces at the shear mechanism

Force	[N]
R_{AY}	3321,88
R_{BY}	4768,17
R_{BX}	0,00
R_{CY}	-1446,28
R_{CX}	-33315,60
R_{EY}	4768,17
R_{EX}	33315,60
F_h	33315,60

Maximum loading of the shear jibs is at the moment of the mechanism lift height $h = 305$ mm and the spoon of the tipping device is rotated into a side; there is a billet tipping in the first height level. In this position, non-uniform loading of the jibs on the left and right side appears. It is clear, that the jibs are more loaded on the side of the spoon tilting. The values of resulting reaction forces are shown in Tab. 2.

CONCLUSIONS

Constructional solution of the timber assorting line which is described in this paper can be modified according to the concrete requirements. In dependence on requirements, there is a possibility to modify the size of individual lift and to achieve a change of number of the assorting groups. Due to the decrease of device width, there is a possibility to use the sorting only at one side, for example in the case of its application in halls which are characterized by a low width. In represented constructional solution, the timber is transported from the assorting manipulator into the collecting baskets. In many saw technologies, mechanical transport of the timber from a sorter to a stacker is required. In these cases, the collecting baskets can be replaced by suitable means of transport, which can transport the assorting timber to the stacker. By this solution, it is possible to achieve a full automatic manufacturing process.

Also, the work principle of this sorter allows us to find the use in the other industrial branches after performing the suitable adjustments.

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SORTIRANJE TRUPACA ZA DVOSTRUKU TESTERU D9

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Sažetak: U radu je opisana konstrukcija linije za sortiranje trupaca koja je namenjena za sortiranje pozadi dvostruke ugaone testere D9. Osnovne informacije o mogućim primenama i konstrukciji sortirača trupaca su opisane u uvodu ovog rada. U sledećem delu pažnja je posvećena principu rada konstruisanog uređaja zajedno sa definicijom parametara materijala sa kojima uređaj može da radi. Konstruktivna rešenja pojedinih mehanizama koji čine liniju sortiranja su detaljnije opisani. Glavni deo ovog

rada bavi se konstrukcijom manipulatora za sortiranje i valjkastim transporterom. Konstruisani sortirač pokazuje alternativno rešenje za sortiranje iza testere D9 i proširuje mogućnosti današnjih sistema sortiranja.

Ključne reči: manipulacija, manipulator za sortiranje, valjkasti transporter

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