Wood Splitter for Household Use

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Abstract: *The article deals with the concrete problem of making a wood splitter that can be used in an individual household which is heated with wood. It goes without saying that there are a lot of types of wood splitters on the market, the important issue being the way of selecting the most useful technical-economic variant. The basis of the article is the choice of the constructive solution, the elaboration of the main design elements of the chosen solution and the simple way of calculating the drive installation, which in this case is a hydraulic drive.*

Keywords: *Wood splitters; Electrohydraulic Mobile; Drive*

1. Introduction

1.1 Elements for defining the subject

One of the traditional and extremely widely used energy resources has been and unfortunately still is the wood obtained by cutting forests. After the production of productive equipment for cutting trees, it seemed that the only problem left was the problem of cracking those logs, which for a long time was done with the axe. In this sense, mechanical means of breaking wood for fire began to appear in the world. In 1978 a model of a machine with a rack driven by a heat engine was patented, and in 1990 the wood crushing machine with a conical screw was patented. From this moment when the methods of breaking wood with a knife blade or with a conical screw were imposed, the problem of the operating variant of the system arose, which must be fast, strong, efficient and economical. The variants to be analyzed were mechanical, electrical and hydraulic.

1.2 Physical-mechanical properties of wood

In order to determine the quality of the wood, both the physical-chemical properties and especially the physical-mechanical ones are used. Among all these most important properties for understanding the operation and choice and design of cracking machines are [1]:
- The apparent density which represents the ratio, expressed in g / cm^3, between the apparent mass and the volume of the wood. It varies from one species to another, but can also vary in the same species depending on a lot of conditions, including humidity.
- Moisture represents the water content, expressed as a percentage, of the weight of the wood. From the experience of the times it is known that wood is hygroscopic and as a result the humidity varies depending on the conditions.
- Elasticity is the property of wood to deform under the action of external loads and to return to its original shape after removal.
- Plasticity is the property of wood to deform under the action of external loads and to maintain its new shape after their removal.
- SPLIT RESISTANCE occurs due to the property of wood to divide under the action of feather-shaped cutting tools. Strength depends on the apparent density, structure of the wood and its defects (twisted, inclined fiber, knots).
- The hardness of wood is the property of opposing the penetration of a foreign body stronger than it, which could deform its surface.

1.3 Density of wood to be cracked

Depending on the species, the density of wood is between 0.04 g / cm³ and 1.40 g / cm³ with the specification that the density of wood in Romania varies between 0.35g / cm³ and 0.98 g / cm³ [2].
There is in the literature the division of wood types into several classes and subclasses:
- light ones (with several subclasses) having a density up to 0.60 g / cm^3; for example, alder, fir, chestnut, red fir, juniper, spruce, walnut, pine, poplar, willow, linden, etc.;
- the semi-gray ones that have a density up to 0.70 g / cm³; for example, hazelnut, maple, cherry tree, mulberry, larch, birch, great maple, plane tree;
- heavy ones with a density of 0.70 g / cm^3; for example, mountain alder, hornbeam, horn, beech, ash, field maple, great maple, plum, acacia, oak, elm, yew, etc.

2. Technical solutions for wood splitters

2.1 Selection criteria

The choice of a wood splitter starts from the needs of the amount of heat that each user has and therefore from the amount of wood to be processed. In this sense, a first choice starts from the energy consumption of the machine [3].
• Wood splitter with a maximum power of 2 kW - it is suitable for heating 1-2 rooms per day, for which a maximum of 10 m^3 of wood is used. For this, you can also use the traditional method of cracking wood with an axe;
• Wood splitter with a minimum power of 2 kW - it is used for homes of 100-120 m^2, which have a minimum of 3 stoves or which use wood-fired heating plants for which between 20 and 25 m^3 of wood are used.
• Wood splitter with a power of at least 3 kW - ideal for homes with high wood consumption, with a need of 25-30 m^3. Generally, these types of devices are electric or gasoline.
Another criterion for choosing a wood splitter is the one that is made according to the crack resistance of the wood to be split and which determines the size of the tonnage of the machine which is practically the maximum pressing force necessary to crack it. Starting from this criterion for solving the problems addressed by this article, it can be considered that it is good to choose:
• Heavy-duty wood splitter (over 7 tons) - ideal for thick and freshly cut logs;
• Medium tonnage wood splitter (4-7 tons) - suitable for normal wood in diameter and already cut to lengths below 50 cm [2].

2.2 Operating variants of wood cracks

Currently the market offers three types of wood splitters in the class of those approached by the article: electric, with thermal and manual motors. In the manual ones, which work on the basis of human strength, the effort is great, but the price of the product is low. Its advantage is that it can be used anywhere and anytime, without the need for expensive traditional energy sources, but effort and time can be totally restrictive criteria [4].
Electrically operated equipment is therefore dependent on a power source, and if more than 3 kW is needed, power problems are complicated for small and medium-sized households [5].
Heat-powered machines have the advantage of productivity and mobility, but also the disadvantage of price.

3. 2.5 kW mobile electrohydraulic splitter

The role of the equipment is to replace the efforts made manually, with the axe, in the activity of cracking, or breaking wood of lengths between 20 cm and 60 cm and thicknesses (diameters) of up to 30 cm. Although the solution is for any user of cracked wood, it is good for the staff working with the machine to specialize in such work.

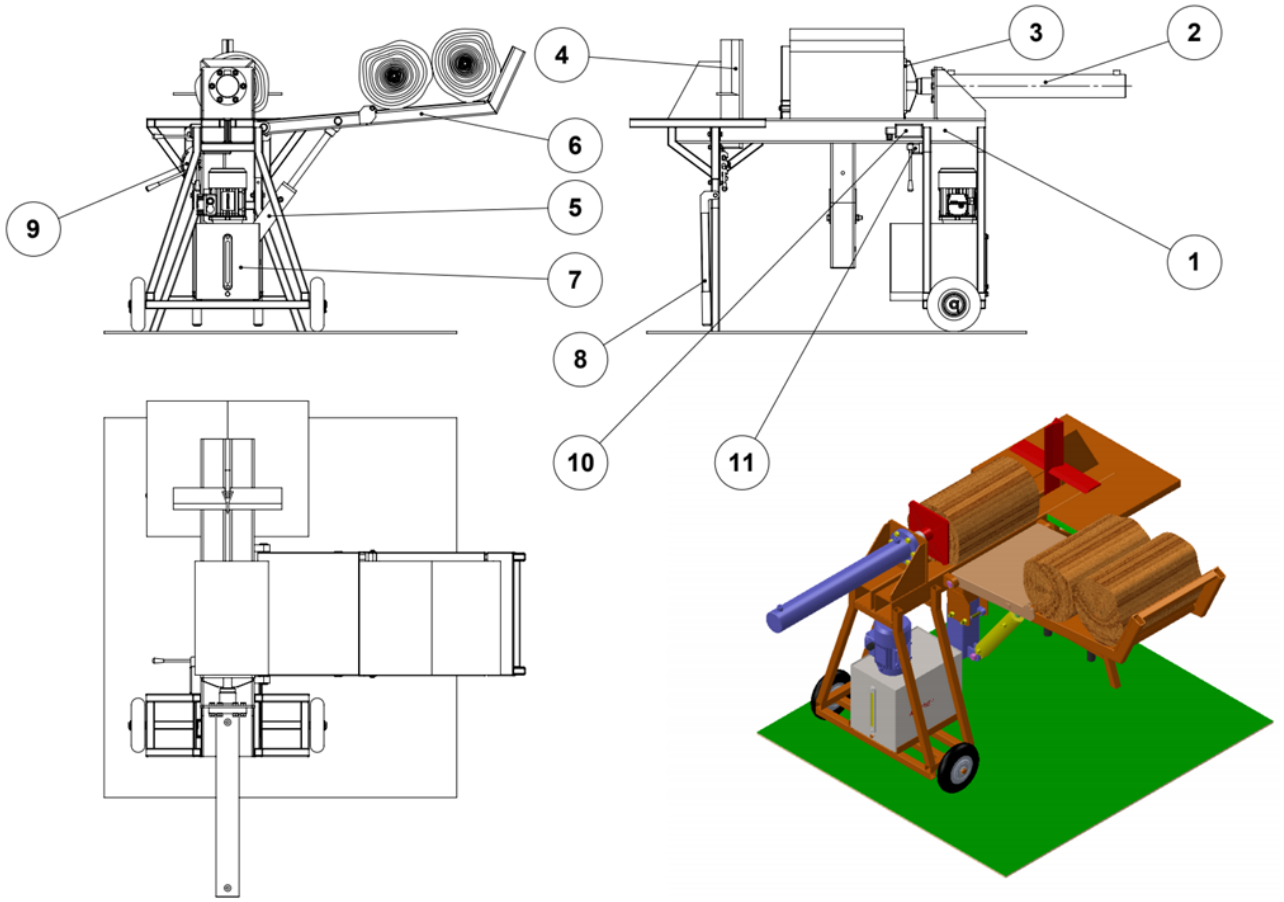
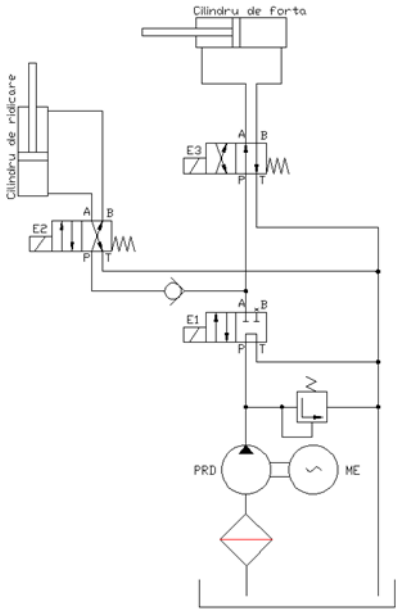


Fig. 1. Splitter overview diagram

Fig. 1 shows a general assembly of the proposed wood splitter solution. The whole assembly is placed on the frame (1), which in turn is equipped with two transport wheels and a set of lifting arms (9) for transport. Transport can be done by pushing by workers, by tying to a low-power vehicle, or even by pulling with the help of animals. When the machine is positioned for work, a large enough place is chosen to be able to carry out all the phases from loading to completion. The mains supply does not require special preparations but the normal ones for starting any 2 ... 3kW machine. The first phase in the working mode is to start the hydraulic group (7) and then to lift 2…4 wood with the help of the lifting platform (6) at the maximum level, meaning at 30 degrees above the horizontal. From here a wood is transferred manually on the frame. The next step is to position the knife (4) in the appropriate position in height by means of a lever. Next, the hydraulic directional control valve (10) is actuated to start the movement of the working cylinder towards the wood. Immediately the wood is pushed towards the knife by the pusher plate (3) and the wood will be cracked. If cracking does not begin immediately, the force in the cylinder (2) will increase by increasing the working pressure to 150 bar. This pressure will increase the pushing force up to 7 tf, sufficient for any type of wood. After the wood has cracked, it is ordered by means of the directional control valve (10) to remove the cylinder rod and the pusher plate while the broken (cracked) wood is thrown on the ground.
For the exact understanding of the operation, the hydraulic diagram from fig. 2 can also be used.



Splitting force (tonnage), F, 5tf

Splitting length (cm) , L , 50

Splitting diameter (cm), d , 25

Electric motor power (W), N_e, 2 kW

Type of single-phase motor 230V, …50Hz

Splitting speed (cm/s),… 5

Retraction speed (cm/s),…9

Fig. 2. Hydraulic schematic diagram

4. Calculation elements for the 2.5 kW mobile electrohydraulic splitter

The splitting consists in the penetration of a wooden feather in the direction of the fibre, which it crushes and compresses in the transverse direction.
Splitting force - is the pressing force generated by the hydraulic cylinder. This depends on the internal section of the hydraulic cylinder and the pressure in the hydraulic system [6].
The splitting force varies within very large limits depending on the structure of the wood, its length and diameter, knots, the length of the splitting feather, species, fibre distribution, etc.
For the calculation of the dimensioning of the splitting equipment, the force necessary for the splitting process is started (1).

$$F = k \cdot p \cdot L \cdot d \tag{1}$$

where:
k - a coefficient that takes into account the feather angle and the state of sharpening, the species of the wood, the humidity of the wood and the dimensions of the support on which the splitting wood is placed; indicative values between 0.003 and 0.009;
p - specific resistance to splitting; the resistance to compression parallel to the fibre has values between 30 - 90 N/mm^2, depending on the essence of the wood.
L, d - length and diameter of the wood that splits;

For the calculation, slightly above average values will be chosen (2):

$$F = 0.005 \cdot 70 \cdot 500 \cdot 250 \tag{2}$$
$$F = 43750N = 4375 \text{ kgf}$$

For the calculation we consider:

$$F_{max} = 5000 \text{ kgf} \tag{3}$$

To achieve this force, a hydraulic cylinder will be used that admits a maximum pressure of 200 bar (kgf / cm^2).

$$D_p = \sqrt{\frac{4 \cdot 5000}{3.14 \cdot 200}} = \sqrt{31.84} = 5.64 \text{ cm} = 56 \text{ mm} \quad (4)$$

where D_p is piston diameter

We choose a series cylinder with:

$$D_{p_a} = 60 \text{ mm}, \text{ where } D_{p_a} \text{ is chosen piston diameter} \quad (5)$$

$$D_{t_a} = 40 \text{ mm}, \text{ where } D_{t_a} \text{ is chosen rod diameter} \quad (6)$$

For the calculation of the pump flow, Q_n it is considered that the maximum speed of the force cylinder, v_{cf}:

$$v_{cf} = 5 \text{ cm/s} \quad (7)$$

Using the actual area of the cylinder, A_{rc}:

$$A_{rc} = \frac{\pi}{4} D_{p_a}^2 = 28 \text{ cm}^2 \quad (8)$$

$$Q_n = A_{rc} \cdot v_{cf} = 140 \text{cm}^3/\text{s} = 8400 \text{cm}^3/\text{m} = 8.4 \text{ l/min} \quad (9)$$

For the calculation of the pump, it is considered with the rotative speed of the electric drive motor, n:

$$n = 1500 \text{ rev /min} \quad (10)$$

$$V_g = \frac{Q}{n} = 5.6 \text{ cm}^3 \text{ / rev, where } V_g \text{ is geometric volume} \quad (11)$$

We choose a pump with $V_{ga} = 6$ cm^3 / rev (chosen geometric volume) that will give a maximum flow (real), Q_r:

$$Q_r = n \cdot V_{ga} = 9 \text{ l/min} \quad (12)$$

The electric motor has the power, N_e :

$$N_e = \frac{p \cdot Q}{612} = \frac{200 \cdot 9}{612} = 2.94 \text{ kW} \quad (13)$$

A 3-kW single-phase electric motor with a speed n = 1500 rpm will be chosen.
The equipment also has a lifting device that uses a hydraulic cylinder with a much lower force approx. 200 kgf, which from the calculation would be with D_p between 10 and 15mm, but taking into account the working conditions will be chosen by ϕ32 or ϕ 40.
All hydraulic equipment will be chosen by size Dn 6.

5. Conclusions

The variant proposed for the realization of the horizontal wood splitter, with hydraulic drive, has a 2-kW single-phase electric motor, easy to connect to any household network.
The machine can be equipped with directional control valve with electric or manual control of nominal size Dn6.
The machine is designed to be able to develop higher forces for short periods than those stated in the data sheet.

The article is a practical solution for designing and making wood splitting equipment, easy to maintain and use by households that use wood for heating.

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