CONSTRUCTION SOLUTION AND ESTIMATE OF IMPORTANT ELEMENTS ASSEMBLIES OF LOG SPLITTER

Milan TICA1, * - Branislav ĆOLIĆ1 - Slobodan ĆAPLJAK1
1 University of Banja Luka, Faculty of Mechanical Engineering, Banja Luka, B&H

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Abstract: A construction solution of log splitter is developed using methods of modern developed of products. Developed construction solution is optimal from an economic and technical aspect. The results are displayed and constructional solutions of all assemblies and subassemblies of log splitter. Important functional elements and subassemblies are identified. A software package Solid Works was used for modeling and calculations. Calculation and analysis of important functional subassemblies and components was used for the optimization of measuring and testing load. The technical documentation is made and the next step should be a prototype development

Key words: construction solution, wood splitter, estimate

1. INTRODUCTION

Analysis of the market, product price and customer target group was followed by the conception of conceptual design. Answer to the question “How?” (in which principles of mechanical system will perform its function) is obtained by creating conceptual design of mechanical systems. In the first phase (in the abstract form) of construction was determined what mechanical system needs to do and what conditions should it meet. At this stage, the answer to the question of how it works is given. The main function of log splitter is to achieve a sufficient compressive force on the blade to allow the parting of the log. The condition that log splitter needs to fulfill is to be able to split logs in diameter of 60cm and a maximum length of 110cm. Speed of the blade must be adequate so that the splitter have a satisfactory productivity, but the speed shouldn't be too high to endanger controllability. The idea is that the wood splitter should allow installation in two positions, both vertical and horizontal. Analysis showed that the best option is to use tractor engine to drive machinery for the transfer of power should be used hydraulic pump. Hydraulic cylinder with axe blade should be controlled by control unit. All of the mechanical assemblies must be properly sized to withstand all possible stresses (both during operation and during transport), because we need to provide a long-time and safe operation of log splitter.

The first phase includes the development of ideas and data collection in order to define the conditions that the mechanical system should meet. These conditions (requirements and desires) are the result of the current market, customers and manufacturing capabilities. The second phase in the design process provides an answer to the question on which the principle of mechanical system will work. This is the design principles of operation and structure of parts from which the system will consist. The dimensioning and shaping of machine parts is done in a third phase. Adequate materials and methods of making are chosen for each part of the machine. The fourth phase includes examination of stress state, safety and reliability, etc. The fifth phase of the design process includes structural development. Here are made drawings of details, prescribed tolerances, thermal treatment, etc.

![Fig. 1. The flow chart of the process of constructing](image-url)
market, customers and manufacturing capabilities. The second phase in the design process provides an answer to the question on which the principle of mechanical system will work. This is the design principles of operation and structure of parts from which the system will consist. The dimensioning and shaping of machine parts is done in a third phase. Adequate materials and methods of making are chosen for each part of the machine. The fourth phase includes examination of stress state, safety and reliability, etc. The fifth phase of the design process includes structural development. Here are made drawings of details, prescribed tolerances, thermal treatment, etc.

2. CONSTRUCTION SOLUTION OF WOOD SPLITTER

Applying the methods of modern product development, a structural solution for a log splitter is developed (Fig. 2). Wood splitter assembly consists of the following subassemblies:
- Base
- Blade
- Hydraulics cylinder
- Oil tank
- Support pillar
- Hydraulics system

Base (Fig. 3) of log splitter must be dimensioned in such a way to ensure the stability of the machines at work, as well as the stability of the log during operation. The base is designed in such a way to be as simple for production. The base and support pillar are joined by welding and with screws. In addition to these functions, base serves for the closing of forces circle during splitting of the log, so it must endure high pressures.

Blade is sized and shaped to allow penetration into the wood with the smallest force. The angle of the cutting edge is designed to keep sharpness for a long time. Horizontal arched groove is making contact with log and enables easier splitting of the wood. The blade is connected to the piston rod by screw which converts torque into axial loads. Torque occurs due to irregularity in shape of wood.

2.1. Functional analysis of subassemblies

Subassemblies of the log splitter constitute a functional unit that must enable performing all the required function of the log splitter. For this reason, subassemblies of the log splitter are designed and selected to provide long-time exploitation.

Base (Fig. 3) of log splitter must be dimensioned in such a way to ensure the stability of the machines at work, as
The slider allows translational movements of the blade and prevents excessive bending of the piston rod of the hydraulics cylinder. The slider is dimensioned so that there is adequate clearance between the slider and the surface of the basic structure on which the slider moves. Gutter of the slider is made from two sheet metal pieces which are connected with the screws. The slider is dimensioned to enable its sliding without the possibility of jamming.

Bracket for central lever of tractor is multifunctional and it serves as a reservoir for storing of the hydraulic oil that supplies hydraulic system. Carrier is made using technology of bending sheet metal, and it is fixed to the support pillar using bolts and welds through. The carrier has sufficient strength to resist from bending when the log splitter is being transported in a horizontal position. Fuel cap is located at an appropriate position to avoid spillage of fluids when the log splitter is used in horizontal position.

Handle is made from standard tubular profiles and attached to the basic structure by screws. Handle provides good grip for the operator during operation, and moving the handle to another position serves as the delimiter for wood (in a horizontal position).

The connection element (which is prismatic shape) between the cylinders, reservoir and supporting pillar, has a very important function in the assembly of the log splitter. It is designed and dimensioned to withstand high dynamic loads. It is a attached to a supporting pillar by welding, and connected with reservoir by screws. Due to the large loads on the connecting element leads to high stresses in the materials, it is strengthened with additional sheets of high strength. Thermal processing is necessary to increase shock resistance.
3. CALCULATION OF IMPORTANT ASSEMBLIES

3.1. Calculation for hydraulics system
Since it is assumed that the drive machine is the engine of the tractor, which uses hydraulic pump as power transmitter, the next step was to calculate and construct a hydraulic system.

The input data for the hydraulic system are pressure (that blade makes to the log), speed of the blade and maximum stroke of the piston rod.

Input data:
- The power that the blade should achieve: $F = 20 \cdot t$
- Speed of the blade: from 10 cm/s to 20 cm/s
- The pressure in the system: $p = 160$ bar

The value of pressure in the hydraulic system is $p = 160$ bar adopted with respect to existing solutions from competing producers.

Sizing hydraulic cylinder

$F = p \cdot A$ \hspace{1cm} 
$p$-pressure; \hspace{1cm} $A$-area

$A = \frac{F}{p}$

$A = \frac{D^2 \cdot \pi}{4}$

$D = \sqrt{\frac{4 \cdot F}{p \cdot \pi}} = 124.9$ [mm]

$D$ – diameter of piston

On the basis of the calculations adopted by the hydraulic cylinder manufacturers “PRVA PETOLETKA - TRSTENIK”, in standard sizes and shapes.

The oil flow through the system

Input data:
- Speed of the blade: $v = 10$ cm/s
- Number of revolutions on the output shaft of tractor: $n = 1000$ o/min

Based on the speed of the blade, required oil flow $Q$ through the system is calculated.

$Q = v \cdot A$

$Q = 76320$ [cm$^3$]

$Q$ – oil flow in the system

Calculation of hydraulic pumps

$V_{pump} = \frac{Q}{n} = 73,620$ [cm$^3$]

The pump with following tags is adopted: $3115.481.19M$, displacement, manufacturer „PRVA PETOLETKA – TRSTENIK“.

The actual speed of the blade at 1000 [o/min]:

$V = \frac{Q}{A} = 9.05$ [cm/s]

The actual speed of the blade at 1500 [o/min]:

$V = \frac{Q}{A} = 7.21$ [cm/s]
Feed speed of the blade:

\[ V = \frac{Q}{A} = 13.58 \text{ cm/s} \]

Calculations for the distribution valve

Input data:
- The oil flow through the system: \( Q = 66.66 \text{ cm}^3/\text{min} \)
- The pressure in the piston chamber: \( p = 160 \text{ bar} \)
- The pressure in the connecting rod: \( 58.25 \text{ bar} \)
- Control valve (tags: RPR3-06 / J15, manufacturers „ARGO HYTOS“ with maximum flow \( Q = 80 \text{ cm}^3/\text{min} \)) is adopted.

Flow resistance and pressure drop are calculated using diagrams.

The pressure drop: \( \Delta p = 11 \text{ bar} \)
The maximum pressure in the system:

\[ p_{\text{MAX}} = p + \Delta p = 160 + 11 = 171 \text{ bar} \]

The safety valve is set at the maximum pressure value and the certain value is added due to the existence of linear and local losses:

\[ p_{\text{MAX}} = 180 \text{ bar} \]

Valve for pressure relief is adjusted in the starting position to:

\[ p_{\text{relieve}} = 58.25 \text{ bar} \]

Calculation for hydraulic hoses in the system

Input data:
- The oil flow through the system: \( Q = 66.66 \text{ cm}^3/\text{min} \)
- Start viscosity of the oil: \( \nu = 46 \text{ mm}^2/\text{s} \)

Minimum value of hose diameter is calculated from Rennolds number equation, to maintain the laminar flow of fluid in the hose and at the same time to reduce line losses.

\[ R_e = \frac{4Q}{\nu \cdot d \cdot \pi} \]

\[ d = \frac{4Q}{\nu \cdot R_e \cdot \pi} \]

Since the value of Rennolds number must be less than 2000 (\( Re < 2000 \)) follow:

\[ d = 15.36 \text{ mm} \quad d – \text{diameter of hose} \]

Adopted diameter of the hose: \( d = 16 \text{ mm} \) tags 2ST DIN EN 853 SEA100 R2A, manufacturers „CENTRALINVEST“. The hose has an inner diameter \( d = 15.9 \text{ mm} \), submitted a working pressure up to \( p = 250 \text{ bar} \) and have minimum bending radius \( d_{\text{bending}} = 200 \text{ mm} \).

Choice of hydraulic oils

For the known kinematic viscosity from the previous calculations, in order to achieve laminar flow, which corresponds to all components of the hydraulic system, oil type MH-46 (manufacturer „RAFINERIJA ULJA – MODRIČA“) is chosen.

Selection valve for limiting pressure

From the catalog „PRVA PETOLETEK – TRSTENIK“ activation safety valve is selected (valve type: 127.842-02. This valve is adjusted to the pressure of activation \( p = 180 \text{ bar} \)). In the event of excessive pressure in the working stroke, valve regulates the pressure in the hydraulic system and prevents exceeding the maximum pressure and any possibility of system failure.

The pressure in the return line is limited by the safety valve (valve type:127.842-01 – selected from the same catalog) is adjusted to \( p = 59 \text{ bar} \).
3.2. Calculations of capacity

Stresses in machine parts are the main indicator of the mechanical state. Stress and stress changes are the main cause of fatigue of the material structure of mechanical parts, the formation of cracks and fractures. The most important criterium for determining the dimensions of mechanical parts used criterium of strength. Stresses are the most important boundary condition for optimizing the shape of the mechanical parts. They are the primary factor in determining the reliability of mechanical parts and systems, in determining lifetime, load, etc.

Bearing capacity of important elements is calculated in the software package Solid Works in module Simulation Xpress which is based on the FEM (Finite Element Method).

The software analysis enabled selection of adequate materials for all elements. The points of maximum loads are identified, and the values of these maximum loads are calculated. Analysis of the essential elements of the assembly of the log splitter is shown below.

This simulation shows the stresses and deformations of the main supporting pillar. Dimensions of the supporting pillar are in adequate size so the stress do not exceed the critical values for dynamic loading of adopted materials.

The connecting element is dimensioned to withstand high dynamic loads and to transfer them to a supporting pillar. Due to the large loads on the connecting element leads to high stresses in the materials, it is strengthened with additional sheets of high strength. Thermal processing is necessary to increase shock resistance.

Fig. 14. I PROFILE SimulationXpress Study Stress

Fig. 15. I PROFILE SimulationXpress Study Displacement

This simulation shows the stresses and deformations of the main supporting pillar. Dimensions of the supporting pillar are in adequate size so the stress do not exceed the critical values for dynamic loading of adopted materials.

4. CONCLUSION

Construction of machines includes the methodology of transformation achieved level of scientific and technical knowledge in the technical or mechanical system. A construction solution of log splitter is developed using methods of modern developed of products. The process of designing, calculation of important elements of the system and an analysis of the mechanical parts is showed below. A software package SolidWorks was used for modeling and calculations.

Calculation and analysis of important functional subassemblies and components was used for the optimization of measuring and testing load. The technical documentation is made and the next step should be a prototype development.

REFERENCES


