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REDESIGN OF THE LIVE AXLE IN ARTICULATED LUMBER TRACTORS

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Abstract: *The present study describes the redesign of the 7.5-tone live axle of the Romanian articulated lumber tractor. Problems with the circuit transmitting the power from the engine to the wheels were signaled in approx. 20% of the products in a family of Romanian lumber tractors. Another cause underlying the redesign was the environmental impact. Consequently, the redesign of the live axle has increased the engine torque transmitted to the wheels with approx. 20%, has solved the faults within the motion-transmission system from the engine to the wheel and has caused a series of positive effects upon the environment. The modernization of the machine is the result of the cooperation between the manufacturing company and The Technical University of Cluj-Napoca.*
Key words: *Redesign, lumber, axle, torque*

1. INTRODUCTION

Forestry tractors are subject to major strains. Problems with the circuit transmitting the power from the engine to the wheels were signaled in approx. 20% of the products in a family of Romanian forestry tractors. Such problems were caused by the fact that the circuit transmitting the power from the engine to the wheel had not been correctly dimensioned (Radulescu, 1986). Likewise, a redesign was also necessary, as the engine torque that the engine could transmit to the wheel could have been higher than the current engine torque. An increase in the engine torque automatically leads to an increase in the machine output.

The continuous increase of the tractors output has been a general trend and it explains the main orientations of the manufacturers within this field. The power increase has enhanced the option of moving on to the 4x4 drive with all four driving wheels. Such a technical solution is needed because of the following advantages:

- In 4x4 drive tractors the entire operating weight is adherent;
- The 4x4 drive tractors have a 15-30% higher output;
- The propulsive efficiency is higher and the fuel demand lower as compared to the tractive power. (Dobre & Barbu, 1998)

Depending on the type and size of the forces and torques exerted on them, the wheels can be: driven (geared) wheels: these are wheels which work due to the action of the power flow received from the engine through the gear; - freewheel (drive-free wheel): these are wheels that work under a pushing or pulling force having the same direction as the cars travel speed, exerted on them by the cars frame or body; -brake wheels: these are the wheels that work under a braking moment created in the braking mechanisms of the wheel (active braking), or by the engine set in geared motion (handbrake). In case of two-axle vehicles the drive can be realized as a 4x2 or 4x4 solution, whereas the first figure indicates the total number of the wheels and the second one the number of driving wheels. For the 4x2 drive the live axle can be place in the front or at the back, and for the 4x4 drive both axles have driving wheels. The live axles, as compared to the non-live axles, ensure the transfer of the self-propelling power flow depending on the drive type, from the driven shaft of the gearbox or from the longitudinal drive mechanism to the driving wheels. During the self-propelling process the interaction between the driving wheels and the path gives birth to reacting forces and moments. The axle's role is to take over all these forces and moments and to transmit them to the elastic elements of the suspension and the frame or the body of the vehicle. A building assembly of the axle, called the wheel-steering system, performs such takeover of the forces and the moments and their transmission to the frame or the body of the vehicle through rigid directions. The steering system defines the kinematics of the spring-suspended wheel by means of the suspension. Rigid axles and articulated axes are thus defined. According to the position within the vehicles configuration we distinguish between front axles and rear axles(Vasu&Buladra, 1980).

2. THE INITIAL CONSTRUCTION OF THE AXLE

The axle is part of the drive assembly of the Articulated Lumber Tractor, having a 4x4 drive, i.e. both axles have driving wheels. We deal with a rigid drive with self-locking differential. While the power is transferred from the engine to the driving wheels, the flow undergoes a series of adjustments, such as:

- Geometric adjustment determined by the relative position between the plane in which the engines crankshaft spins and the plane in which the driving wheels rotate;
- Kinetic adjustment determined by the need to ensure the transmission ratios necessary for the motion of the tractor;
- Splitting of the received power flow in two branches, one for each of the driving wheels of the axle.

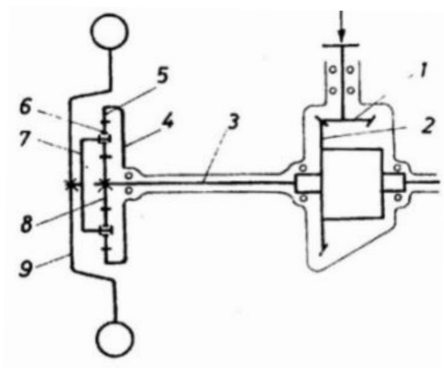

Fig. 1. The kinetic representation of the double main drive(Fratila, 1982)

In order to perform the previously mentioned functions the mechanisms transferring the power flow in the live axle are: the main drive, the differential and the driving wheels.

3. REDESIGN OF THE DRIVE AXLE

The redesign of the drive axle in order to increase the engine torque transmitted to the wheels with approx. 20%. In view of the said objective we have applied the principles of “Integrated Engineering” and the method of “Parametric Modelling”, while using the dedicated software “Autodesk Inventor Professional 2008”.

Fig. 2. Motion-transmission system in the Romanian articulated lumber tractor

Apart from the tehnical and technological factors we need to follow aswell the economic component and the correlation of the accuracy between the price factor and the time factor. It is far-famed the alleged triangle of the pressure quality-price-time limit. (Popa, 2007)

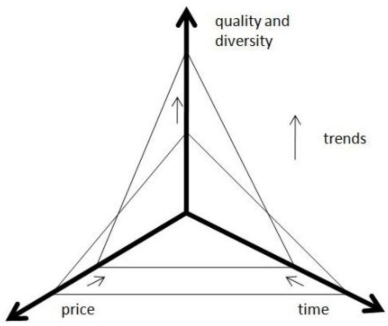

Fig. 3. Alleged triangle quality-price-time (Popa, 2007)

The redesign activity involved up-to-date building solutions as follows: for the first gear of the main drive one has used a curved bevel gear, with the bevel pinion placed between the bearings, which has led to a substantial increase of the transmitted torque and to relatively small dimensions of the parts; one has used a self-locking differential with friction disks which ensure a very good behavior in limit situations, when the angular speeds of the wheels on the axle are different (when turning, driving on rough grounds, when there are differences between the operating diameters of the wheels as a consequence of wear or inadequate pressure in the tyres);The second gear of the main drive has been realized as a final drive while using a planetary gear with three identical satellites, placed directly into the wheel hub. This solution reduces the strains of the constitutive parts with a value in direct ratio with the one of the transmission ratio for this gear.

Before the actual execution one has modeled approx. 141 specific markers, performed an optimal number of digital prototyping trials while analyzing the kinetic behavior of the markers within the assembly they are part of. This approach has enabled us to eliminate all design errors and to optimize the construction of such markers in terms of quality and manufacturing cost-effectiveness, as well. One has made dimensioning and testing computations so as to ensure an optimal use of the execution materials. Likewise, for the redesigned markers, based on the prototypes, one has elaborated processing programs on numerically controlled tools, thus significantly reducing the costs associated with such operations.

4. CONCLUSIONS

The live axle has been redesigned because based on the available bibliography and the documentation within the Romanian manufacturing company for forestry machines and the “National Institute of Research and Development for Machines and Installations in Agriculture and Food Industry” we have noticed that an essential market requirement was called for, i.e. the modernization of the machines used in the field of forestry, while aiming at increasing the output by increasing the engine torque, reducing the faults during the warranty period, increasing operating safety and reducing the negative impact that such machines have upon our environment. In order to achieve our goal we have applied the principles of “Integrated Engineering” and the method of “Parametric Modeling” while using the dedicated software “Autodesk Inventor Professional 2010”.

The computations have shown the following effects:

a) Upon the end product:

- An output increase with about 15 %, by increasing the driving speed;
- Reduction of the pressure exerted by the wheels on the ground: from 225 kPa to 175 kPa, with positive environmental effects, thanks to the use of wider tyres (23,1 – 26, instead of 18,4/15 – 26 ; STAS 8258/1-86).

b) Upon the manufacturing process:

- Reducing assimilation expenses with approx. 20%, as compared to the classical methods;
- Reducing the expenses with the design and the execution of the specialized SDV’s, as a consequence of using group technologies.
- No need for personnel training as the technological processes is similar.

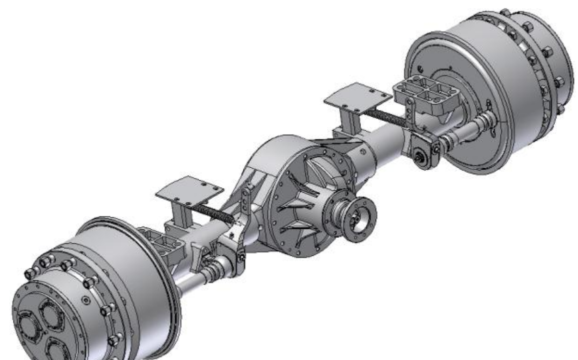

Fig. 4. The live axle redesigned with “Autodesk Inventor Professional 2010”

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