ANALYSIS OF THE SELECTED TECHNICAL PARAMETERS OF SKIDDERS

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Basic information on the extraction-production process, including felling, skidding, handling and transport of wood, which is fully mechanized and automated. The aim of the article is to highlight the technical equipment and new possibilities in timber skidding. It covers general information, technical and dimensional specifications of machinery for skidding with or without choker. The paper analyses the current state and overview of forest wheeled skidders on the Slovak and foreign markets. Most importantly, it contains tables and graphs comparing the weight and size parameters of various types. Based on the above selected technical parameters of skidders, a statistical analysis has been carried out using regression analysis that informs about the compactness of the machine, as well as the performance parameters of the selected machines.

KEYWORDS

forestry machinery, wheeled skidders, timber skidding, technical parameters.

1 INTRODUCTION

Vital part of all forestry activities is the transport process which is closely related to human labour. After about 1945, crawler tractors and later also wheeled tractors began to be more widely used for timber skidding [Majdan 2012]. After 1960, special forest wheeled skidders were developed with exceptional technical and technological features that enabled them to overcome the greatest obstacles. They were able to work on slopes where until then only horses or cable cars had been used. The machines are equipped with powerful winches that can skid semi-suspended load [Hnilica 2015a]. Forest wheeled skidders became popular in forestry especially for skidding whole trunks. Their principal part is the winch. They are particularly helpful in uplands and mountains where tractors themselves cannot be used, only their parts. Timber skidding is extracting trees out of the stand and on a skid road or open area. Timber extraction is an operation that includes the removal of timber from the point of harvesting and its subsequent processing on a skidding trail. For the purpose of extraction and removal, various types of tractors have been developed. The most significant factors are terrain features, slope inclination and surface, and ground bearing capacity. Natural factors such as weather conditions (rain, snow, temperature) and the state of vegetation are of key importance, as well.

Tractors can be divided into groups according to certain technical and design parameters that determine their availability, stability, type of work based on the dimensions and weight of a tractor [Kováč 2011]. Technical parameters include:

a) type of tractor,
b) engine power (pulling force),
c) dimensions and weight,
d) speed,
e) load capacity,
f) suitability of a machine for a given technology.

Design parameters include:

a) climbing ability, stability and kinematics,
b) type of chassis,
c) suitability for skidding operations,
d) speed of working parts,
e) operating space.

1.1 Basic Technological Features of Tractors

Around 60% of timber skidding is done by forest wheeled skidders and about 30% by universal wheeled skidders. The power output of forest wheeled skidders (LKT) is normally up to 73.6 kW and the most commonly used models are LKT 81 and LKT 81 Turbo. Tractors with higher power output have not come in useful since the engine power of 85 kW has proved sufficient. From among universal tractors, the ones with the power output of 40 to 55 kW are the most widely used [Stanovsky 2006]. The ratio of the weight of a machine to the power of an engine not only reflects the technical level of a tractor but it also points out its economical or technological parameters. Regarding heavy forest machinery, especially tractors, it is important to analyse their movement capabilities in terrain as well as to optimise their functionality in technological activities. Basic technical and technological features that enhance the efficiency of forest wheeled skidders compared to universal wheeled skidders are:

a) four- or more-wheel drive,
b) easy operation,
c) great passability through terrain,
d) lower pressure on land,
e) control of all axles,
f) simple and quick loading.

Tractors (skidders and carriers) of various types, output and design are manufactured by a number of companies all around the world. The best-known are Timberjack, Caterpillar, John Deere. In Slovakia forest wheeled skidders are produced by LKT s.r.o. Trstena and Equusa.s. Banska Stiavnica. Universal and forest wheeled skidders vary not only in basic design parameters but also in the conditions they perform in. [Lukac 2003]. Technical and technological features as well as the output of forest wheeled skidders depend on the tensile and speed variable, and the economy of operation [Mastinu 2014].

2 MATERIALS AND METHODS

To examine the technical parameters of forest wheeled skidders, we have chosen to assess the engine power, weight and dimensions (length and width) of the machine, which are important parameters for categorising skidders within regression analysis. Regression analysis examines the linear relationship between two quantitative variables and is a specific case of multiple regression [Kovac 2011a, b]. Simple regression estimates regression coefficients β_0 and β_1 in the equation:

$$y_i = \beta_0 + \beta_1 . x_i + \varepsilon_i \qquad (1)$$

where: y_i - the value of the dependent variable *Y* (criterion) in the i-th observation,

x_i - the value of the independent variable *X* (predictor) in the i-th observation,

β_0 - regression constant (the intersection of the regression line with the axis x),

β_1 - regression coefficient (the slope of the regression line),

ε_i - random error in the i-th observation.

Providing that the data as a random sample of the population, the regression coefficients and correlation coefficient are calculated out of the best point estimates of unknown parameters. In addition, it is possible to test hypotheses (null hypothesis that the coefficient is equal to zero indicates that there is no relationship between the variables in the basic group) and to produce their interval estimates. Hypothesis testing and interval estimates of regression coefficients suggest that errors ε_i are independent of each other (which means that the y_i are independent as well), are normally distributed with the average *0* and with the same variance for all values *x*.

A database file has been created that contains different types of forest wheeled skidders manufactured all around the world today. They are ranked in ascending order according to the manufacturer; special attention is paid to the skidders most frequently used in forestry, Tab. 1.

Table 1. Selected technical parameters of forest wheeled skidders

Parameters / Type of machine	Engine power [kW]	Total weight [kg]	Total length of tractor [mm]	Total height of tractor [mm]	Max. winch force [kN]
John Deere 540H	118	11 760	6662	3020	193
John Deere 548H	118	12720	6662	3020	193
John Deere 540 G II	96	10 355	6662	3020	164
John Deere 540 D	90,2	10155	6330	3000	118
Tigercat 610C	142	15420	7000	3150	181,4
Tigercat 604C	142	11 795	6500	3050	181,4
Tigercat 630D	194	16 895	7495	3330	164
HSM 805S	104	9 300	6210	2800	2x100
HSM 805	100	7600	6210	2930	2x80
HSM 805H	104	10900	6410	3114	2x80
HSM 805HD	104	11500	6610	3158	2x100
HSM 904	135	9200	6800	3245	2x100
HSM 904H	136	12300	6950	3245	2x100
LKT 81C	74	7065	5700	2780	2x80
LKT 81	85	7300	5800	3050	2x80
LKT 82C	93	7650	5900	3100	2x80
LKT 82C	93	9230	5600	2260	2x80
LKT 90A	75	7 400	6250	2780	2x80
LKT 90B	75	8300	6950	2780	80
EQUUS 175N	125	12000	6678	2870	2x140

3 RESULTS

Not every type of forest tractor has the same power or type of engine since tractors with lower power are designed for less extreme conditions, as opposed to those more powerful ones. Having implemented the proposed methodology, regression graphs were created depending on various parameters of forest wheeled skidders listed in Tab. 1, comparing different manufacturers.

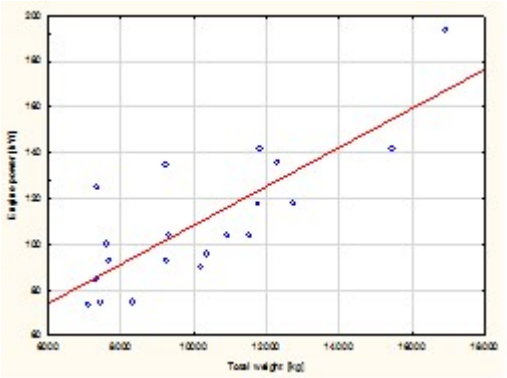

Figure 1. Regression graph based on the output and total weight of skidders

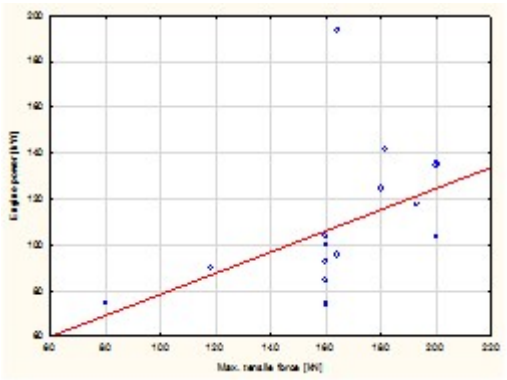

Figure 2. Regression graph based on the output and max. tensile force of skidders

Fig. 1 is a regression graph representing the output and total weight of selected skidders as each skidder has different weight, which means that even with the same output but lower weight, the value of specific output will increase. Greater weight is an advantage because the machine can pull heavier load; on the other hand, fuel consumption increases with

weight, so in that respect it is taken as a disadvantage. When comparing the output and the total weight of a machine, tractors with the output of up to 120 kW excelled. Figure 2 shows that maximum tensile force of skidders is 160 kN (2 x 80kN) in relation to engine power up to 120 kW.

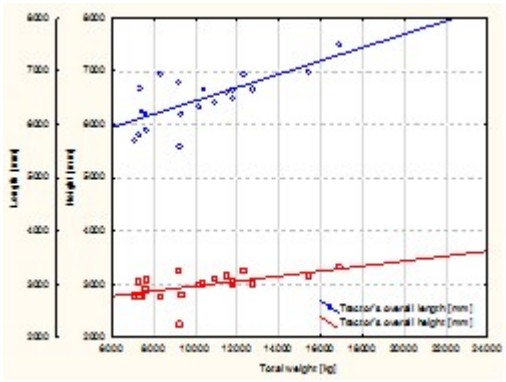

Figure 3. Regression graph based on total weight in relation to total length and width of skidders

In Fig. 3 the regression graph provides an overview of the relation between the dimensional parameters and the total weight of the machine, allowing to assess the manoeuvrability and possibility of the skidder. The above values show that the dimensional parameters of skidders have a significant impact on the overall weight of a machine and thus its stability, as well.

4 DISCUSSION

The obtained results provide a closer look at the power and dimensional parameters of forest wheeled skidders. Our conclusions are based on [Irwin 1986], [Rao 1992] and whose works describe mathematical processing of data in detail and the way may be used of form mathematical models. Other authors dealing with similar matters are [Bukoveczky 2007], [Stollman 2009] who categorise the mechanisms only based on two parameters, namely the output and the weight. They do not take into consideration the complexity of concurrent technical parameters (the weight), output parameters, and operation requirements. In the paper we took into account all these factors, which resulted in a much closer look at the skidder as a whole, manufactured either abroad or in Slovakia. Forest tractors operate in extreme conditions - whether it is frost in winter months or rain causing mud in summer months. Therefore it is crucial to test the machines properly before putting them in operation [Hnilica 2015b]. In addition to this assessment, the methodology may be enhanced by economical factor, namely the increasing price of the skidder.

5 CONCLUSIONS

There are many types of forest wheeled skidder all around the world. Each of them has a design based on the same principle of arrangement of individual units. It is only up to the producer how the tractor is equipped for the operation in a forest and extreme conditions, and how they can sell its qualities and strengths on the market.

The paper analyses the current state and overview of forest wheeled skidders on the Slovak and foreign markets. Based on the statistical analysis, this report might be useful for operators in forestry who are deciding on which type of forest wheeled skidder to purchase.

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