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[1.] Vasil VLASEV

POTENTIAL FOR INCREASE OF THE LOAD OF CUTTING MECHANISMS OF SOME WOODWORKING MACHINES THROUGH SPECIFIC APPLICATION OF SAWING REGIMES

[1.] UNIVERSITY OF FORESTRY, FACULTY "FOREST INDUSTRY", SOFIA, BULGARIA

ABSTRACT: *The sawing regimes of some woodworking machines have been analyzed, and it has been found out that there are cases when the load of their cutting mechanisms can be increased. The period of operation for which these regimes have been established has been analyzed. When there are lower requirements for the quality of the sawn surfaces, it has been recommended to develop the sawing regimes step by step, for the whole period between two sharpenings of the cutting blades. This allows making a better use of the cutting power of the sharp cutting blades.*
KEYWORDS: *sawing regime, cutting capacity, feed rate, productivity*

INTRODUCTION

The sawing regimes of woodworking machines with mechanized feed such as band saws, circular saws, gang saws and etc. are developed on the basis of common methodology. A basic element of this methodology is establishing the feed rate in accordance with sawn surfaces' quality, tooth gullet capacity and available cutting power. A necessary condition for developing these regimes is calculating the cutting speed, the parameters of the cutting blade and the cut height (the depth of sawing).

The feed rate calculated in accordance with the available cutting power of a band saw with raker teeth has been obtained using formula (1) (Filipov 1977). (This study does not present formulas and analyses for the above mentioned machines. The results and conclusions are analogous but with the characteristic features for the machines).

$$U^{(N)} = \frac{\frac{N_p}{H} - \frac{a_\rho . p . b}{t}\pi Dn}{kb + \alpha_\lambda H}, \; m.s^{-1} \qquad (1)$$

where $U^{(N)}$ is the feed rate in accordance with available cutting power, $m.s^{-1}$;

N_p – *cutting power, W;*
H – *cut height, m;*
a_ρ – *coefficient of tooth blunting;*
p – *fictitious specific load on tooth back, $N.m^{-1}$;*
t – *band saw tooth pitch, m;*
D – *drive wheel diameter, m;*
n – *drive wheel rotation frequency, s^{-1};*
k – *fictitious specific load on tooth face, Pa;*
b – *cut width, m;*
α_λ – *coefficient of raker teeth.*

The feed rate in accordance with sawn surfaces' quality $U^{(H)}$ has been calculated using a table (Filipov 1983); the feed rate in accordance with tooth gullet capacity $U^{(O)}$ has been calculated using the parameters of the band saw and the cut height (Grigorov 1978). The calculated feed rates have been used for the graphic dependencies shown in Figure 1 for cut heights H1÷H5, thus obtaining two feed rate curve lines, $U^{(O)}$ and $U^{(N)}$, and straight lines parallel to the abscissa, restricting the feed rate in accordance with the sawn surfaces' quality $U^{(H)}$ (Obreshkov 1995; Filipov 1977).

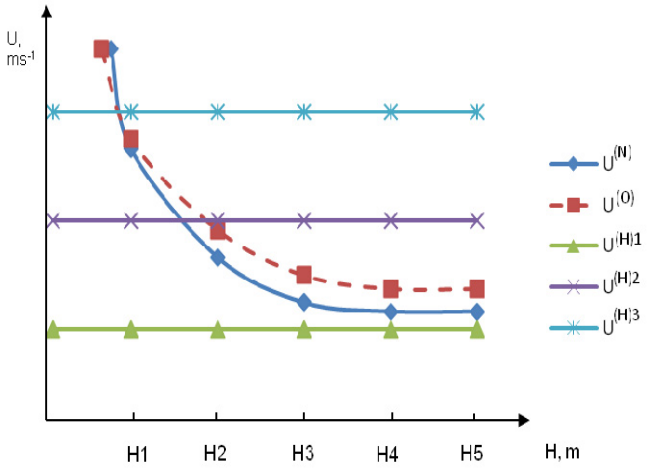

Figure 1. Graph showing the feed rate in accordance with available cutting power, tooth gullet capacity and sawn surfaces' quality

Although the research literature contains a lot of examples for developing sawing regimes using a number of features, there are some more significant characteristics for the practical use.

One of these is the period of operation of the cutting blades used to calculate the feed rate in accordance with available cutting power. Bershadsky (1992) developed models of sawing regimes for sharp and blunt teeth; another study by the same author presented sawing regimes for a band and circular saws for sawing periods of 2, 3.5 and 4 hours. Genchev (1978) established the available cutting power for a period of 0.5÷4 hours. For a band saw, Filipov et al (1983) developed a sawing regime for 4 hours of operation of the cutting blade, and Gochev (2005) recommended that this period should be 8 hours.

Very important for the establishment of the feed rate is the mutual position of its curves in accordance with tooth gullets capacity $U^{(O)}$ and available cutting power $U^{(N)}$. Because the two curves cross, according to Gochev (2005), for small cut heights, the feed rate is

restricted by the tooth gullets capacity, and, for larger ones – by the available cutting power. According to Filipov (1977) the feed rate curve in accordance with available cutting power $U^{(N)}$ should be in the entire working range above the feed rate curve in accordance with tooth gullet capacity $U^{(O)}$. In order to better utilize the potential of a cutting blade, the two curves should be close to one another. If the feed rate is established by the curve in accordance with available cutting power, there is no risk of overload of the cutting blade (Filipov 1979).

Of the three restrictions for the feed rate: the sawn surfaces' quality, tooth gullet capacity and available cutting power, the one which has the lowest value is chosen (Grigorov 1978). When the feed rate in accordance with available cutting power $U^{(N)}$ is higher than that in accordance with desired quality $U^{(H)}$, the feed rate is established in accordance with sawn surfaces' quality. In this case the motor load is below its nominal power (Filipov 1974, 1979).

Some of the sawing regimes' recommendations made above do not allow, in some cases, rational use of the available cutting power.

The aim of this study is to analyze the sawing regimes while taking into account the period of operation of the cutting blade between two sharpenings, and to investigate the possibilities for better use of the cutting power in cases when there are lower requirements for the quality of the sawn surfaces.

ANALYSIS AND RESULTS

Developing sawing regimes is performed in cases of machine construction, selection of a machine for a technological process and availability of a machine with given cutting power for which a suitable cutting blade has to be selected for a particular cut height. Let us focus on the last case.

The literature available to the author of this study does not contain a well-grounded estimate of the period of operation of the cutting blade for which the feed rate in accordance with available cutting power is calculated. This period is crucial for the position of the feed rate curve in accordance with available cutting power $U^{(N)}$ in relation to the position of the curve in accordance with tooth gutter capacity $U^{(O)}$. Grounds for this statement may be found in the analysis of formula (1). The feed rate in accordance with available cutting power directly depends on the coefficient of tooth blunting a_ρ. This coefficient is calculated in accordance with the length and time of cutting, and its lowest values are right after the sharpening of the cutting blade (Grigorov 1978). Therefore, when using formula (1) for a shorter period of operation, the feed rate curve $U^{(N)}$ will be positioned higher. At the same time, the feed rate curve in accordance with tooth gutter capacity $U^{(O)}$ will not change its position with regard to this period because it is calculated using the parameters of the cutting blade and the cut height (Filipov 1977).

The analysis made so far shows that the statement that the two feed rate curves $U^{(N)}$ and $U^{(O)}$ should be close to one another (Filipov 1977) is possible only at the given moment of time for which the calculation is made. At another moment of time between two sharpenings of the cutting blade, the feed rate curve $U^{(N)}$ will change the height of its position. Two possibilities follow: (1) a feed rate curve $U^{(N)}$ calculated for blunt cutting blades, for example for 4-hour period of operation; and (2) a feed rate curve $U^{(N)}$ calculated for sharp cutting blades, for example for 1-hour period of operation. The changed positions of the feed rate curve $U^{(N)}$ for both cases are shown in Figure 2 and Figure 3 for periods of operation of 1, 2, 3 and 4 hours. The feed rates for these periods are, respectively, $U^{(N)1}$, $U^{(N)2}$, $U^{(N)3}$ and $U^{(N)4}$.

In the first case, the feed rate curve $U^{(N)4}$ is close to the feed rate curve in accordance with tooth gutter capacity $U^{(O)}$, and is positioned below it. The feed rates for the first three hours $U^{(N)1}$, $U^{(N)2}$ and $U^{(N)3}$ which are positioned above it allow a higher feed rate, but the restriction of the curve in accordance with tooth gutter capacity does not allow it. This shows that, if sawing is performed using feed rate curve $U^{(N)4}$, for the period of time to the third hour, the motor works below its nominal power.

In the second case, the increase of the time of operation leads to curves $U^{(N)2}$, $U^{(N)3}$ and $U^{(N)4}$ which are positioned lower on the graph, and the feed rate decreases. As Figure 2 and Figure 3 show, the second case can be applied because the motor is loaded all the time.

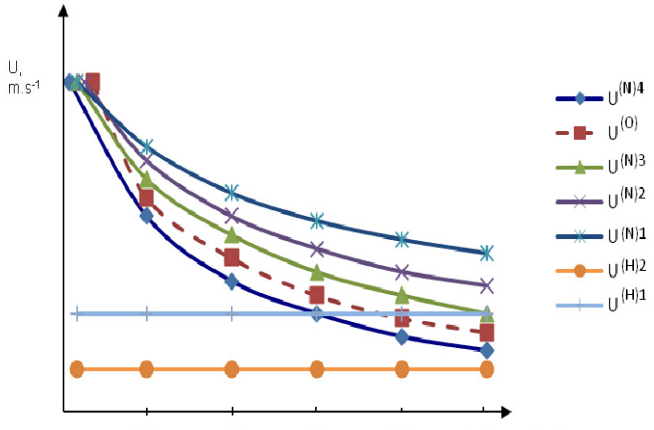

Figure 2. Graph showing the feed rate in accordance with tooth gullet capacity and available cutting power of a motor loaded below its nominal capacity

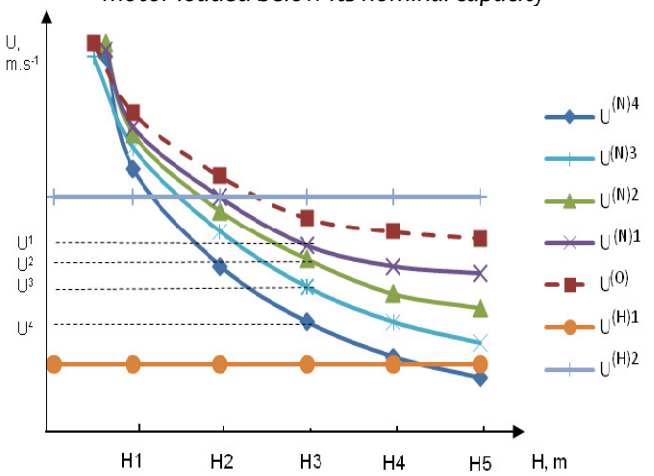

Figure 3. Graph showing the feed rate in accordance with available cutting power, tooth gullet capacity and sawn surfaces' quality of sawing regimes developed step by step

In the practical work, very often the feed rates in accordance with tooth gutter capacity $U^{(O)}$ and available cutting power $U^{(N)4}$ cannot be close to another (Figure 3). The reason for this is that the parameters of the machine do not match the parameters of the cutting blades which cannot always be chosen in the best possible way. In some cases obtaining cutting blades for a particular working regime is not economically justifiable.

The performed analysis has provided the grounds for suggesting that sawing regimes should be developed step by step. This involves calculating the feed rate in accordance with available cutting power for 1, 2, 3 and etc. hours of operation of the cutting blade (or other intervals). As a result, several feed rate curves $U^{(N)}$ are obtained; these correspond to the respective time of operation and can be used in the practical work.

The effect of developing sawing regimes step by step for distanced feed rates in accordance with tooth gutter capacity and available cutting power can be seen on Figure 3, for example, for a work piece with a cut height of H3. The feed rate established using the traditional method of feed rate curve $U^{(N)4}$ for 4 hours of operation is U_4. This feed rate should be used for 4 hours. If the four feed rate curves are used, the productivity will increase significantly as $U^1>U^2>U^3>U^4$.

Sawing regimes developed step by step can be applied only in cases when there are lower requirements for the quality of the sawn surfaces. In Figure 1, these are the restrictive straight lines $U^{(H)2}$ and $U^{(H)3}$ and in Figure3 - $U^{(H)2}$. In case of high quality requirements, i.e. lower feed rate restricted by $U^{(H)1}$, this restriction should be met.

For achieving the highest productivity, the feed rate curve in accordance with available cutting power for the sharpest cutting blades should be close to the curve in accordance with tooth gullet capacity.

CONCLUSIONS

1. Feed rates in accordance with tooth gutter capacity and available cutting power can be close to one another only for the moment of time for which they are calculated during the sawing regime.
2. As a result of the blunting of the cutting blades, the feed rate curve in accordance with available cutting power changes its position, which allows to make the suggestion that sawing regimes should be developed step by step.
3. The suggested step-by-step development of the sawing regimes when there are lower requirements for the quality of the sawn surfaces, and there are distanced feed rates in accordance with tooth gutter capacity and available cutting power, allows working with higher feed rates and better loading the motor when working with sharp cutting blades in comparison to the traditional sawing regimes.

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