BOARD CROSS-SECTION ERRORS WHILE SAWING ON TWIN SHAFT MULTI-RIP SAWS

Kazimierz A. Orlowski – Roman Wasielewski

Abstract
In the paper sawing accuracy analyses of experimental results obtained on the twin shaft multi-rip saw MULTIBI 18 are presented. The common geometrical – motional structure design version of the twin shaft multi-rip saw is described. Circular saws of a new design and the traditional issue ("Multix" type) were simultaneously tested in industrial plant conditions during sawing of frozen birch flitches (Betula L.). Furthermore, this paper examines of how the step depth value in the sawn board cross–sections, while sawing on twin shaft multi-rip saws, may affect a rough green target size.

Key words: *wood cutting, multi-rip saw, sawing accuracy, step depth*

INTRODUCTION

Environmental restrictions and increasing log costs have caused many sawmills to look at new ways to extract more value from their raw material. One of the more traditional ways to accomplish this aim is to increase volume recovery. Firstly, a saw kerf can be reduced through improvements in saw design that reduce either the saw blade thickness or the side set of the saw (Maness and Lin 1995, Wasielewski et al 2007). However, it has been shown that changes in these two saw design factors can lead to increased within-board sawing variation, or deviation through the cut (Maness and Lin 1995). Those phenomena may be caused by decreasing either the saw blade specific stiffness or the saw blade operating stiffness due to the loss of saw blade stability (Orlowski 2003). The latter also may be an effect of the temperature increase owing to passage of chips between the saw blade and kerf walls (Wasielewski 2007). Secondly, in the case of gang saws changes in the kinematic system may allow the user to apply narrower saws (Orlowski 2003).

GEOMETRICAL – MOTIONAL STRUCTURE OF THE TWIN SHAFT MULTI-RIP SAW

Twin shaft multi-rip saws make possible very efficient sawing of wood even in the case of large cutting depths. With regard for that those circular sawing machines are willingly and often used in sawmills of large productivity (Fronius 1989). The spindle arrangement sequences in relation to the feeding direction and circular saw spindle rotational directions enables the designers to construct machine tools with different geometrical-motional structures (Wasielewski and Orlowski 2007).

The configuration of the twin shaft multi-rip saw shown in fig. 1 is the most common version applied in the practice. In this design chips from upper and lower circular saws are carried away downwards, which is an advantageous phenomenon. Decomposition of cutting forces F_d and F_g on the feed speed direction and on the perpendicular direction F_{Nd} and F_{Ng} (fig. 2) reveals that the resultant force acting on the feeding direction is not large because these forces compensate partially each other. Moreover, the resultant force on the feed speed direction is turned indirectly, which does not cause of the dangerous phenomenon of pulling the workpiece in, and ipso facto there is not a need for the stiff feeding system. Components of cutting forces acting on the perpendicular direction to the feed speed direction F_{Nd} and F_{Ng}, on both spindles are downwards directed, which guarantees a safe holding down of the workpiece to the guidance system (without undermining). It can be seen that directions of cutting force decompositions, in this case of sawing, are favourable.

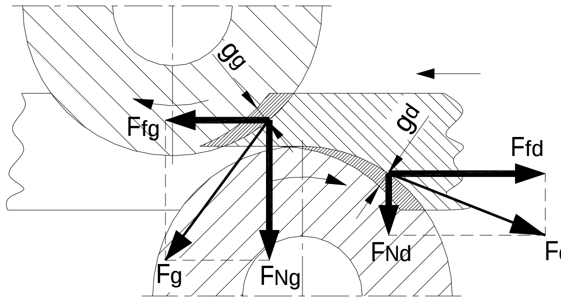

Fig. 1 The most common version of the two shaft multi-rip saw geometrical-motional structure with decomposition of cutting forces and thickness of the cut during wood sawing

a)

b)

Fig. 2 Collar clamped circular saws: a – "Mutix" type, b – a new design

In the European conditions, on those machines collar clamped circular saw blades of the "Multix" type are frequently applied (fig. 2a). They are designated for ripping of hard and soft green wood. Except for traditional carbide teeth on the rim, the saw is equipped additionally with four scraper carbide tools. Producers of those tools advertise that the "Multix" type circular saws provide fast removal of shavings from the cut space. Nevertheless, there are known some cases of catastrophic damages of saw blades due to the passage of chips between the saw blade and kerf walls (Wasielewski, 2007). For this reason a new circular saw design has been developed (fig. 2b). The new circular saw has larger static and dynamic stiffness, hence, protects a saw blade against deviations through the cut. Furthermore, special scrapers prevent the saw blade from heating by the uncontrolled chip flow (Wasielewski et al 2007, patent pending). Experimental results and carried out analyses have revealed that standard deviations of the board thickness, such as within-board standard deviation S_W, between board standard variation S_B and standard total variation S_T (Brown 2000), are considerably smaller for elements shaped with circular saws of the new design than for boards sawn with traditional "Multix" circular saws (Orlowski et al 2007). Nevertheless, in every case in the board cross-sections steps smaller or larger are visually noticed. For that reason, both the total sawing variation and also the maximum step value should be taken as an indicator of how accurately a sawing machine cuts lumber.

The goal of this paper is to examine of how the step depth value in the sawn board cross–sections, while sawing on twin shaft multi-rip saws, may affect a rough green target size *RGTS* which can be calculated from the following general relationship:

$$RGTS = FS + PA + SA + \sum S_T + SD \qquad (1)$$

where: *FS* – lumber finish size, *PA* – planner allowance, *SA* – shrinkage allowance, *ST* – total standard deviations in the upper and lower part of the board, *SD* – step depth.

However, the presence of particular components in the Eq. 1 depends on their value and should be determined for the examined rip sawing machine experimentally.

MATERIAL AND METHODS

Circular saws of the new design and the traditional issue ("Multix" type) were simultaneously examined in industrial plant conditions on the twin shaft multi-rip saw MULTIBI 18. Frozen birch flitches (*Betula* L.) of moisture content of 30% were sawn. Every 30 min. approximately, during one 8 hour shift, sawn lumber was measured with the digital caliper. Measurements were executed in 3 points (at the points: 100 mm from each end, and in the middle of the board) on the upper (down sawing) and lower measurement line (climb sawing) respectively. The basic size for the upper measurement line was $A = 25.96$ mm, and for the lower measurement line $B = 25.81$ mm (Orlowski et al 2007). Obtained measurement results were used for determination of the within-board standard deviation S_W, the between board standard variation S_B and the standard total variation S_T accordingly with formulae (Brown 2000, Orlowski et al 2007).

Some samples, randomly chosen amongst sawn boards, were additionally inspected to determine a value of the step depth on both the right and the left side (fig. 3a, b). The step value was measured on the Zeiss Vista CMM (the measuring machine, fig. 3c) at the Department of Manufacturing Engineering and Automation. Measurements have been done at the front end and the rear end of the samples. The front end was consistent with the feeding direction of the rip saw.

RESULTS AND DISCUSSION

In figure 4, step depth values obtained during boards' measurements on the Zeiss Vista CMM are shown. The step depth of each board cross section has a different value at the front and the rear end on both sides of the samples. It means that it is not a result of the wrong circular saw position on the spindle caused by the distance sleeve dimensions but it is an effect of circular saw snaking phenomenon. The latter might be caused by the number of factors (Orlowski 2003) which are sources of transverse forces affecting the saw blade. The mentioned back force sources may be divided into three groups connected with: a tool (teeth and saw blade), cutting conditions and raw material (workpiece) features. The step depth value besides the circular saw blade operating stiffness may be very sensitive on the following factors: saw blade position in relation to the workpiece, feed speed direction in relation to the saw blade, static and dynamic stiffness of the feeding system, geometrical accuracy of the sawing machine, technical state of the sawing machine, anatomical faults of the raw material (knots, curly or wavy grains, compression wood, etc.), and workpiece shape (parallelism of bottom and upper surfaces of sawn flitches). The latter seems to be very important in the case of rip saws because a lack of parallelism of the flitches' surfaces is a source of the flitch twisting moment (circular saw blades bending) caused by the pressure rolls and a track of the feeding system.

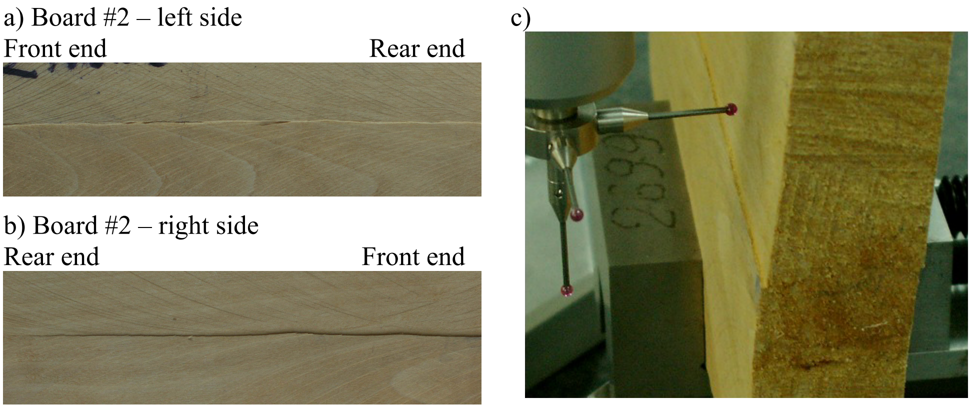

Fig. 3 Views of the examined sample steps on the left side (a) and the right side (b), and the sample position on the measuring machine Zeiss Vista CMM (c)

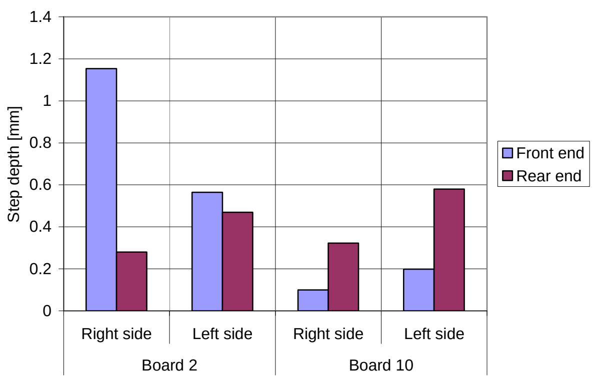

Fig. 4 Step depth value changes in a function of the intersection position

Additionally, average values and standard deviations of step depths were calculated. For the left side the step depth arithmetic average value is equal SD_{LSav} = 0.45 mm, and a standard deviation is s = 0.18 mm, and for the right side it is SD_{RSav} = 0.46 mm and s = 0.46 mm. In the case of the small trial number, additionally, both an uncertainty of the single random measurement S_x and standard deviation of the step depth arithmetic average S_{av} have to be calculated:

$$S_x = t_n \cdot s \tag{2}$$

$$S_{av} = S_x \frac{1}{\sqrt{n}} = \frac{t_n \cdot s}{\sqrt{n}} \tag{3}$$

where: t_n – Student's distribution critical value (t_n = 2.3534 for a significance level α = 0.1, and n = 4 (Szydłowski 1981)). Those estimators were calculated for each board's side independently:

- the left side: the uncertainty of the single random measurement S_{xLS} = 0.42 mm, and standard deviation of the step depth arithmetic average S_{avLS}: = 0.21 mm;
- the right side: the uncertainty of the single random measurement S_{xRS} = 1.08 mm, and standard deviation of the step depth arithmetic average S_{avLS}: = 0.54 mm.

Thus, in the analyzed sawing case, on the left side the step depth is equal SD_{LS} = 0.45±0.21 mm, and on the right side the step depth is SD_{RS} = 0.46±0.54 mm.

The above obtained values are useful for determination of the board rough green target size *RGTS* according to the eq. 1. In the estimation of the *RGTS* dimension, maximum values of both the standard total variation *ST* (Orlowski et al 2007) and side step depth *SD* ought to be taken into account. In the examined case of sawing on the twin shaft rip saw the sum of a lumber finish size *FS*, a planner allowance *PA* and a shrinkage allowance *SA* must be increased by:

$\sum S_T + SD = S_T^{lower\max} + SD_{RS}^{\max} = 0.42 + 1.00 = 1.42$ mm An additional detailed explanation on the increase resulted form the rip saw sawing inaccuracy is shown in fig. 5.

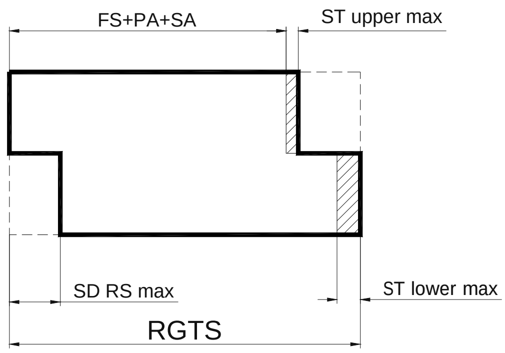

Fig. 5 Estimation of the board rough green target size

The presence of components in the Eq. 1 depends on their value, which ought to be determined experimentally for the examined rip sawing machine.

CONCLUSIONS

Based on the results of this study the following conclusions can be drawn:

- besides of the standard total variation S_T of the both board's parts, in the estimation of the rough green target size, while sawing on the twin shaft multi-rip saws, the step depth should be taken into account to have machining (sawing) allowances optimized;
- the presence of components in the relationship for the determination of the rough green target size depends on their values in the examined sawing process and must be analyzed in every case experimentally;

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