(REFEREED RESEARCH)

COMPARATIVE STUDY ON THE CONDITIONS OF THICKENING WOVEN FABRICS WITH A VIBRATING REED

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ABSTRACT

The results of measuring the load of a warp thread with a beating-up force and the density of weft threads obtained in a woven fabric using both a vibrating and rigid reed were presented. The improvement of the conditions of thickening weft threads as a result of using the vibrating reed was indicated. A simulation model of the thickening zone of a woven fabric was presented. The influence of the parameters of vibratory motion of the reed on the improvement in the conditions of thickening woven fabrics was analyzed.

Keywords: Weft beating-up force, vibratory beating-up, thicken of wefts, vibrating reed

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1. INTRODUCTION

Thickening the weft threads in a woven fabric using a vibrating reed, which has besides its basic to-and-fro movement a second oscillating motion [1, 2] of a significantly smaller amplitude and higher frequency, gives two possibilities:

- Reduction of the resistance force of the weaving with a beating-up force, which is a force with whom the reed is loaded during the thickening of weft threads, enables to reduce the destructive effects of the reed on the textile material, especially on the warp thread, and to reduce the dynamic load of the slay mechanism enabling to lighten its structure and the whole weaving loom, as well as to improve the conditions of its work [3].
- Widening of possible to obtain thick structures of the woven fabric produced, [4].

Studies on the vibratory thickening of weft threads were performed in two ways: tests conducted using a measuring stand and simulation tests. In both cases, the beating-up force and the obtained density of weft threads in the woven fabric produced were analyzed on the basis of a scheme of three research cases: case 1 – beating-up with a rigid reed (R), that is, in a classic way; case 2 – beating-up with a vibrating reed (VR) with a reduced force but with the same density as obtained in case 1; case 3 – beating-up with a vibrating reed with an increased density so as the beating-up force is the same as in case 1.

2. MEASURING STAND TESTS

The influence of some waving parameters on the improving of vibratory thickening of formed woven fabric was analyzed using measuring stand tests. Figure 1 shows a schematic diagram of the testing stand, which consists of the following parts: 1 – exciting device of vibratory motion of the reed, 2 - flexible weaving reed, 3 – sliding slay, 4 - additional elastic element increasing the resonant frequency of the vibrating system, 5 – harnesses, weaving shed, 6 – picking mechanism, 7 – warp beam, 8, 9 - mechanisms controlling tension of a warp thread, 10- wave fabric take-up roller

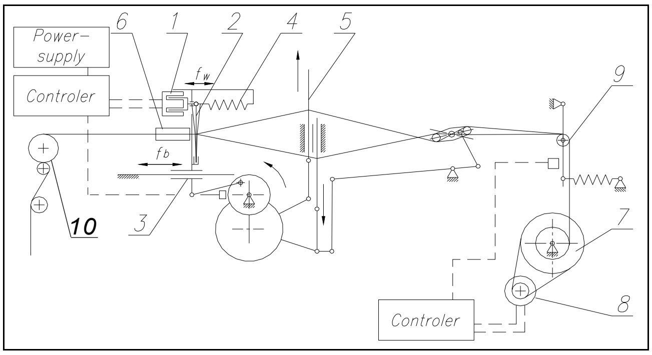

Figure 1. Schematic diagram of a measuring stand.

The tests at the measuring stand were carried out using weft and warp yarns made of staple polyester of 50tex. The change in the tension of warp thread was measured by a momentary position of the whip roller [5, 6]. Figure 2 shows an exemplary course of tension of 100 warp threads Q_{os}. Woven fabric was made with the following parameters: initial tension of the warp thread measured on a closed shed Q_0=22.3N, the amplitude and frequency of the vibratory motion of the reed Y_a=0.3mm, f_w=350Hz. The displacement of the edge of a woven fabric during the contact with a reed *Y*, called a beating-up zone [2, 3, 4, 5], was regulated by value of pitch on the wave fabric take-up roller. The beating-up zone was *Y*=20mm. The character of the courses results from the cyclic opening and closing of the shed. The characteristic leap of the tension presented on the graphs results from the beating-up phase of the weft thread [1]. The beating up force is proportional to this change in the tension (the damping effect of the woven fabric has been postponed) [5, 7]. The beating-up force was appointed in this way. In the green course near the peak values, a pull of a warp thread can be seen which is a result of the vibration of the reed.

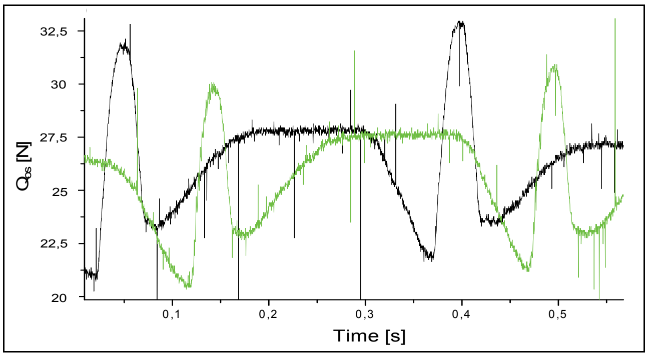

Figure 2. Momentary tension of warp threads during the weaving with a rigid reed (black) and vibrating reed (green).

The results of the tests at the measuring stand are presented in the form of course graphs. Research courses 1 and 2 were compared. Figure 3 shows a course of a relative reduction in the beating-up force Q_d with a vibrating reed in relation to the beating-up force with a rigid reed as a function of the initial tension of a warp thread. The curves determined for three values of a beating-up zone are similar. The greatest advantage in the form of more than 20% reduction in the beating-up force was obtained for the smaller values of the initial tension of warp threads. With an increase in the initial tension of the warp threads, the influence of the vibrating reed decreases.

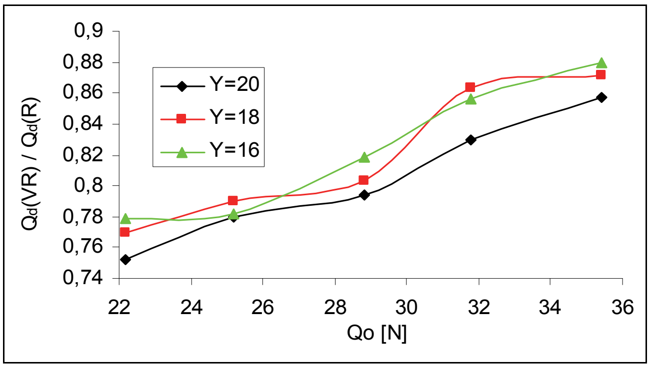

Figure 3. Relative decrease in the beating-up force as a function of the initial tension of a warp thread.

Research cases 1 and 3 were compared. Figure 4 shows the courses of a relative increase in the density of weft threads *Z* in a woven fabric using a vibrating reed in relation to the density obtained with a rigid reed as a function of an initial tension of the warp thread. The courses were determined for three values of the beating-up zone. The greatest advantage in the form of a 7% increase in the density of weft threads was obtained for the smaller values of the initial tension of a warp thread and the greatest value of the beating-up zone. This may result from the number of strokes of the vibrating reed in a single cycle of beating-up.

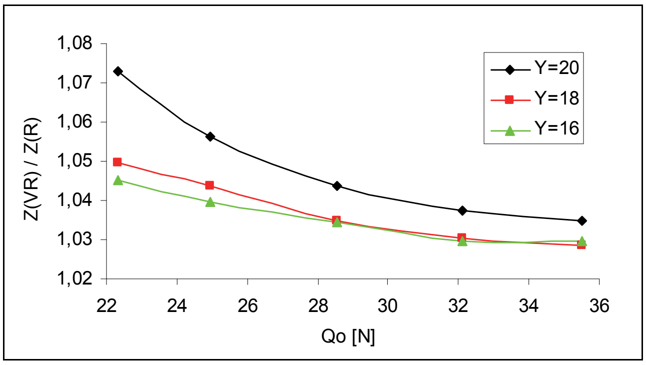

Figure 4. Relative increase in the density of weft threads as a function of the initial tension of a warp thread.

3. SIMULATION MODEL

The impact of the parameters of the reed's vibratory motion on the conditions of thickening of the woven fabric has been simulated and analyzed in simulation tests. The generation of different frequencies of the vibrating motion of the reed is particularly difficult on a test stand. As the result of reed's resonance frequency change is the change of rigidity of the system.

The purpose of the simulation tests was to develop a dynamic model of a thickening zone of weft threads. Figure 5 shows a weft yarn thickened by a reed blade [3 ,8], its initial position and weft yarns introduced in the previous weaving cycles, that is a woven fabric formed. The following parameters were determined: momentary displacement of the weft thread on the warp thread y_1, momentary pitch of weft threads *t*, and a diameter of weft threads *d*.

Figure 6 shows forces acting on the weft thread being thickened [3, 9]. Momentary forces in the front and back warp sheet was marked as F_1.

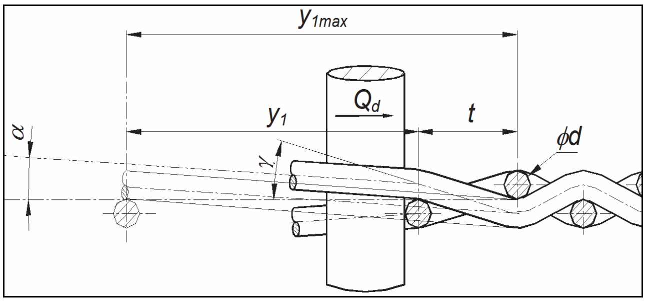

Figure 5. Geometry of introducing weft threads into the woven fabric

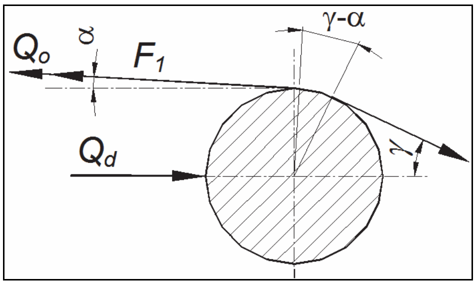

Figure 6. Distribution of forces in the weft thread introduced

Q_d/F_1 ratio as a function of a displacement of the weft thread on the warp thread is presented as the following dependence [3]:

$$\frac{Q_d}{F_1}(y_1) = \cos\alpha - \frac{\cos\gamma(y_1)}{e^{\mu(\gamma(y_1)-\alpha)}} + \frac{Q_s}{F_1}\cos\alpha \qquad (1)$$

$$\gamma(y_1) = arcctg\,\frac{t}{d},$$

where:

Q_s - adhesion force between the threads [10].

Figure 7 shows the course of Q_d/F_1 as a function of the momentary relative pitch t/d (α = 4°, Q_s/F_1 = 0.01). The curves determined for different values of the coefficient of friction between the threads μ [11, 14] are close to each other. The value of the beating-up force is mainly determined by the momentary position of the weft thread in regard to the edge of a woven fabric and to a lesser extent by the frictional properties between the warp and weft threads [4].

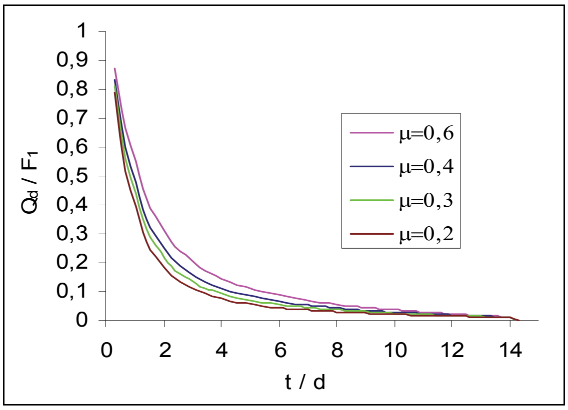

Figure 7. Ratio of force Q_d/F_1 as a function of a momentary relative pitch

The model of the thickening zone of weft threads is shown in Figure 8 [3, 4]. The slay moves with a rotary-reversing motion around its own axis. The flexibility of the reed was shaped with a rotating joint. The vibratory motion of the reed and slay is inflicted cinematically. The momentary displacement of the edge of a woven fabric in the woven fabric-warp thread arrangement is marked as y_2. The momentary displacement of the woven fabric's edge in the contact phase with a reed is the sum of displacements y_1 and y_2 according to the dependence:

$$y_1 + y_2 = \varphi_b(l_b + e) + \varphi_w e\,. \qquad (2)$$

The displacement of the weft thread on the warp thread takes place when a beating-up force is acting, and the dependence (1) is right. From the adopted model of the woven fabric-warp thread arrangement the following dependence results:

$$Q_d(y_2) = y_2(k_o + k_t) + \dot{y}_2(c_o + c_t), \qquad (3)$$

where:

k_o, k_t - rigidity of warp thread, - woven fabric,

c_o, c_t – damping coefficient of warp thread, - woven fabric.

Force in warp threads in the front part of the shed is the sum of the initial tension of a warp thread, the forces resulting from the rigidity of a warp thread and the force resulting from the damping of a warp thread [12, 13] according to the following dependence:

$$F_1(y_2) = Q_0 + \frac{y_2 \cdot k_o}{\cos\alpha} + \frac{\dot{y}_2 \cdot c_o}{\cos\alpha} \qquad (4)$$

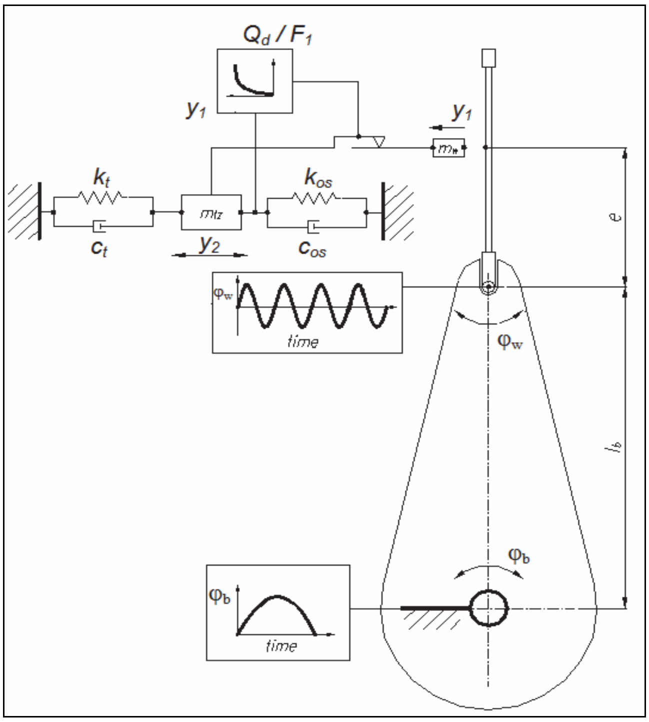

Figure 8. Diagram of simulation model of the thickening zone of weft threads

4. SIMULATION TESTS

Research cases 1 and 2 were compared. The cycles of thickening the weft yarns were simulated with a constant pitch, and the rigid and vibrating reeds of different amplitudes. Figure 9 shows the momentary values of the beating-up force in the cycle (frequency of the slay motion f_b=10Hz, frequency of the vibratory motion of the reed f_w=400Hz). The amplitudes were: in case 1 (black) Y_a=0mm, in case 2 Y_a=0.1-0.5mm.

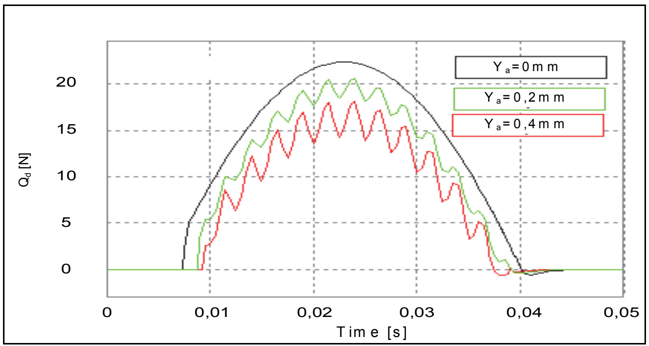

Figure 9. Momentary beating-up forces with a vibrating reed of different amplitudes at a constant pitch

Figure 10 shows the course of a relative decrease in the beating-up force as a function of the amplitude of the vibratory motion of the reed. The results were referred to the average values of the oscillation of the beating-up force; over 20% was obtained.

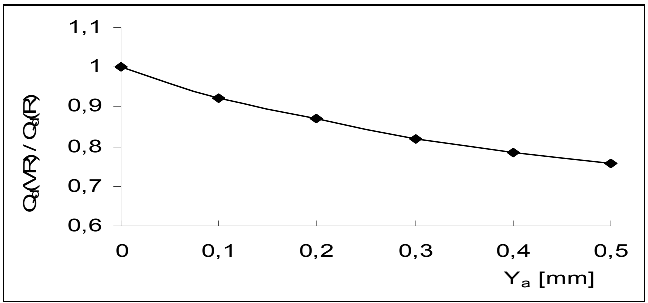

Figure 10. Relative decrease in the beating-up force as a function of the amplitude of the vibratory motion of the reed

Research cases 1 and 3 were compared. The cycles of thickening the weft threads with a determined value of a beating-up force with a rigid and vibrating reed of different amplitudes were simulated. Figure 11 presents the momentary values of the relative pitch of the weft threads thickened in the cycle *(f_b=10Hz, f_w=400Hz)*.

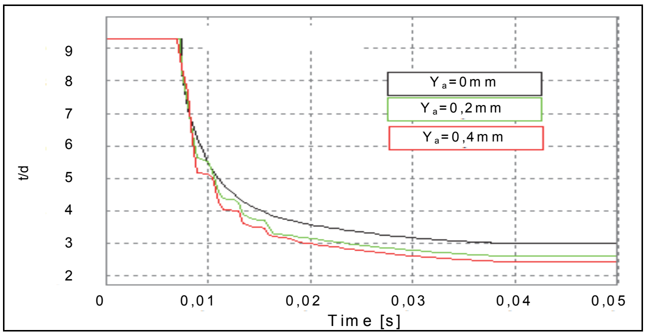

Figure 11. Momentary relative pitch during the beating-up with constant force, with a vibrating reed of different amplitudes

Figure 12 shows the course of a relative increase in the density of weft threads as a function of the amplitude of the vibratory motion of the reed; over 13% was obtained.

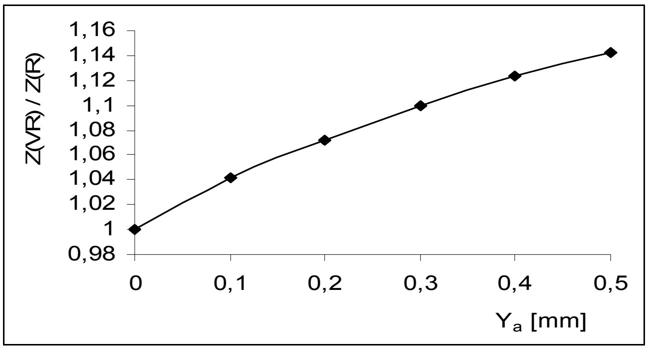

Figure 12. Relative increase in the density of weft threads as a function of amplitude of a vibratory motion of the reed

Research cases 1 and 2 were compared. Cycles of thickening the weft threads with a constant pitch, with a rigid and vibrating reed of different frequencies were simulated. Figure 13 shows the momentary values of the beating-up force in a cycle *(f_b=10Hz, Y_a=0.3mm)*. The frequencies were the following: in case 1 (black) f_w=0Hz, while in case 2 f_w=200-800Hz.

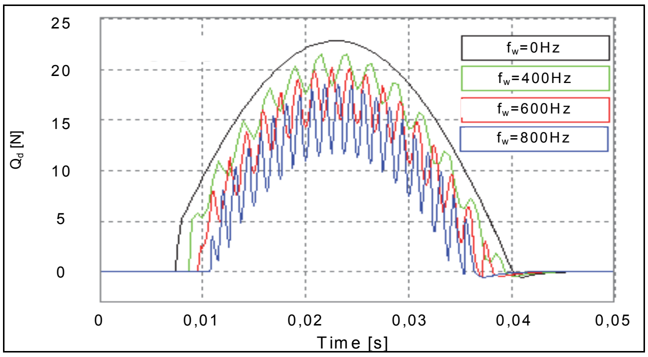

Figure 13. Momentary beating-up forces with a vibrating reed of different frequencies at a constant density

Figure 14 shows the course of a relative decrease in the beating-up force as a function of frequency of the vibratory motion of the reed, over 30% was obtained.

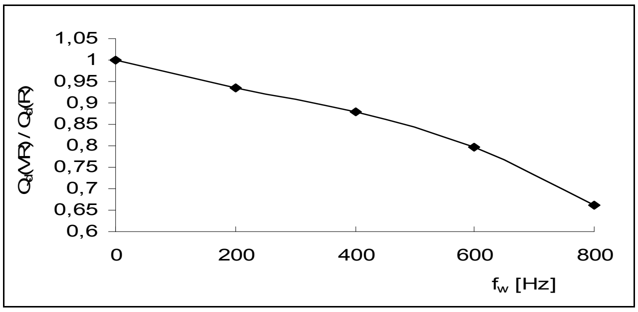

Figure 14. Relative decrease in the force of beating-up with a vibrating reed as a function of frequency of vibratory motion of the reed

Research cases 1 and 3 were compared. Cycles of thickening the weft threads with a determined force, and with a rigid and vibrating reed of different frequencies were simulated. Figure 15 shows the momentary values of a relative pitch of the weft threads introduced (f_b=10Hz, Y_a=0.3mm).

Figure 16 presents the course of a relative increase in the density of weft threads as a function of a frequency of vibratory motion; over 13% was obtained.

5. CONCLUSIONS

1. The improvement of the conditions of thickening weft threads with a vibrating reed occurs with an increase in the area of the beating-up zone and with a decrease in the initial tension of the warp thread.
2. Thickening of weft threads with a vibrating reed decreases a dynamic load of a slay and warp thread with a pitch of the woven fabric predetermined.
3. Thickening with a vibrating reed increases the density of weft threads obtained in a woven fabric with a beating-up force predetermined.
4. The amplitude and frequency of the vibratory motion of the reed improve the conditions of thickening the woven fabric (frequency to a greater extent than the amplitude).
5. A complete analysis of the influence of the reed's vibrating movement parameters on the thickening of the woven fabric cannot fully be carried out, trough to many technical and non technical obstacles at a testing stand. Therefore simulations are essential for any deeper analysis of the described phenomena and as such partially were carried out and demonstrated in the papers.

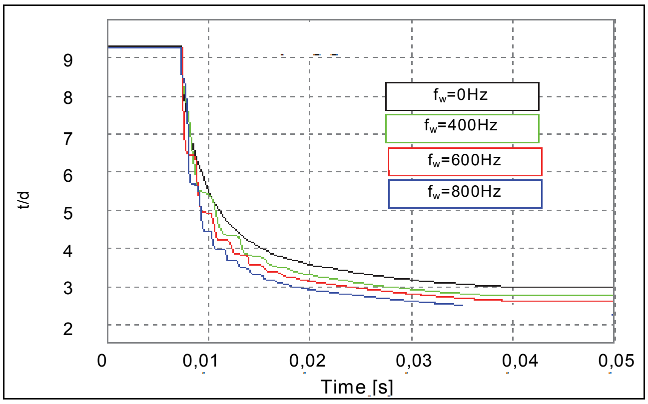

Figure 15. Momentary relative pitch during the thickening with a vibrating reed of different frequencies

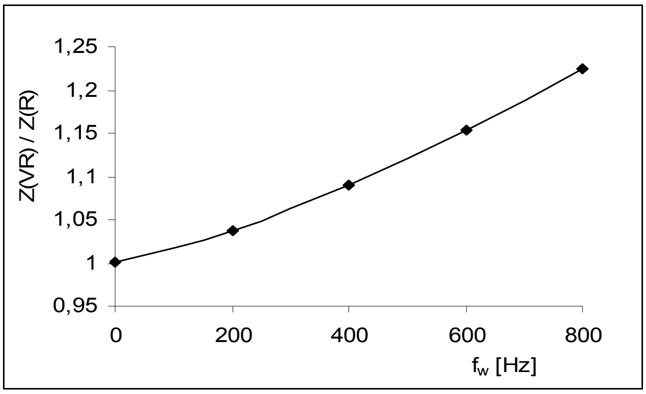

Figure 16. Relative increase in the density of weft threads as a function of a frequency of vibratory motion of the reed

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