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The impact of selected parameters on the fatigue strength of splices on multi-ply textile conveyor belts

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The publication was financed from the funds of a project realized under the Applied Research Programme in path A, titled “Joints of multi-ply conveyor belts with increased functional durability” No. PBS3/A2/17/2015



Introduction

- The total length of belt conveyors currently used in Poland is over 1100 km. It means that now about 2200 km of conveyor belts, connected by ca. 15.000 joints are in use.
- About 50% of joints are vulcanized or glued connections of textile-rubber belts, mechanical and finger joints while the rest are belt joints with steel cords.
- Strength of belt conveyor joint determines the strength of the whole loop of belt on a conveyor. The strength of multi-ply belt joint is always lower than the belt itself.



Introduction

The paper presents the analyze of reasons causing the reduced strength of multi-ply belt joints tested in the Laboratory of Belt Transportation (LTT) at Wroclaw University of Technology. The employers were domestic and foreign producers and users of conveyor belts.

Some 60 joints, which strength was lower than expected, were selected for the analysis, from all joints tested during last several years.

Method of evaluating the tensile strength of joints ZP-40 tensile testing machine for belt's joints

The extension strength of joints was determined using the samples which were 200 mm wide while their length was equal to the total length of the joint plus the handle parts according to the PN-C-94147:1997 standard requirements [2]. Tests were carried out on joints ripper specially designed for such tests (Fig 1). Tested joints were of different structure what is schematically showed on figure 2.



Fig. 1



Method of evaluating the tensile strength of joints

Schematic layout of joints

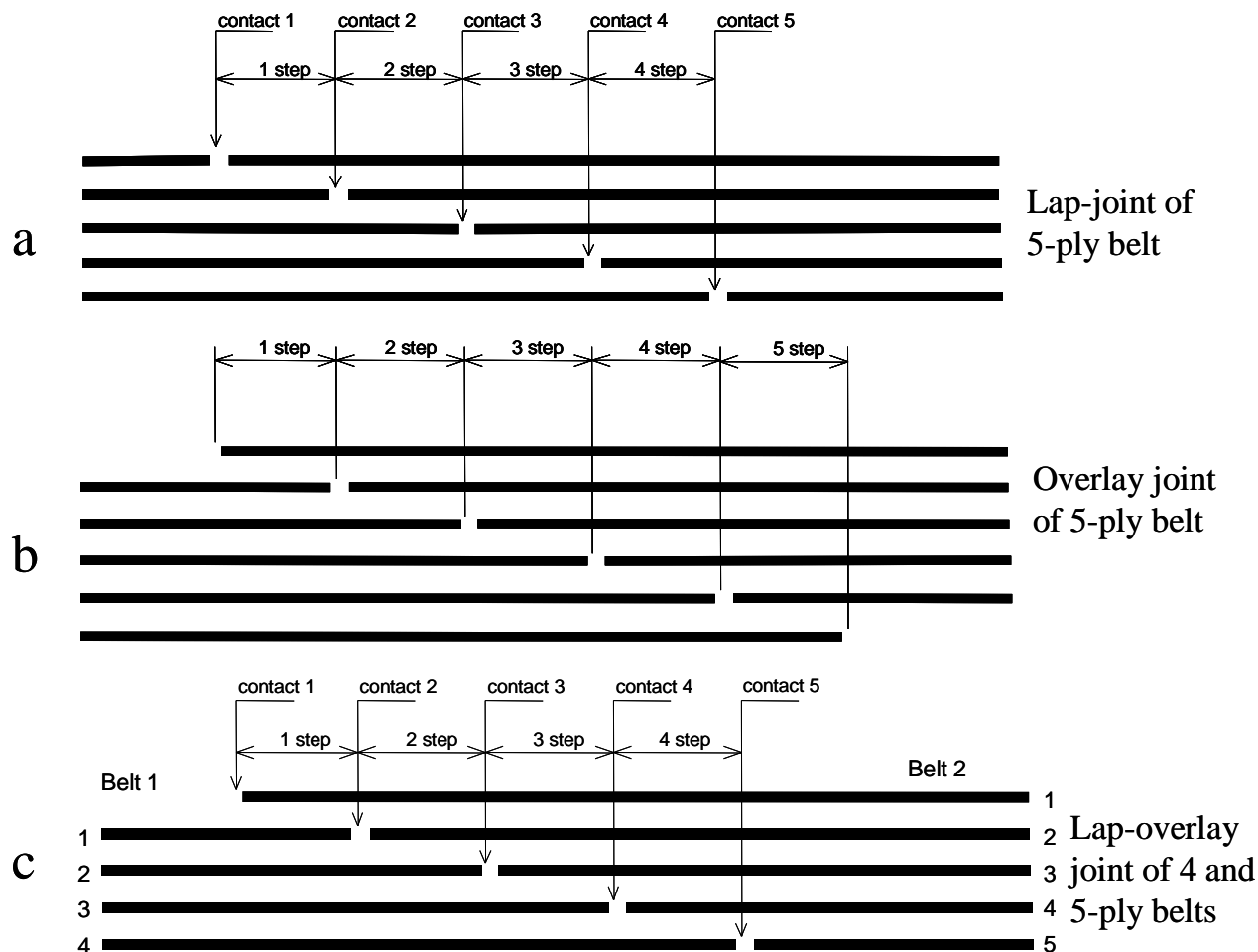


Fig. 2



Method of evaluating the tensile strength of joints

The results of joint strength tests were verified with regard of required strength defined in the standard [1] using the relationship:

$$R_p = 0,85 \cdot R_r \cdot \frac{n_z - 1}{n_t}, \quad kN/m$$

where: R_p – extension strength of joint in kN/m; R_r – extension strength of belt in kN/m; n_z – number of plies in joint ; n_t – number of plies in belt.

In case of connecting the belts with different strengths or with different number of plies, the joint's strength was calculated in both external contacts of plies and the smaller value was used in comparison.

[1] Standard PN-C-94147:1997: Rubber products. Joints of conveyor belts made using vulcanization.

Stresses distribution in belt joint

Dynamic tests of conveyor belt connections

Distribution of shear stresses in adhesive-bonded joint

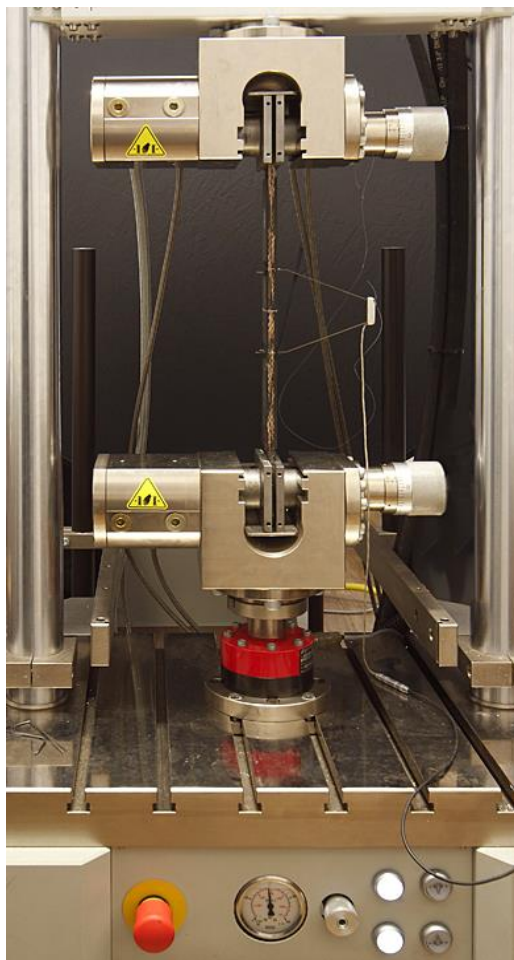


Fig.3. Dynamic machine ZD-25 Zwick/Roell

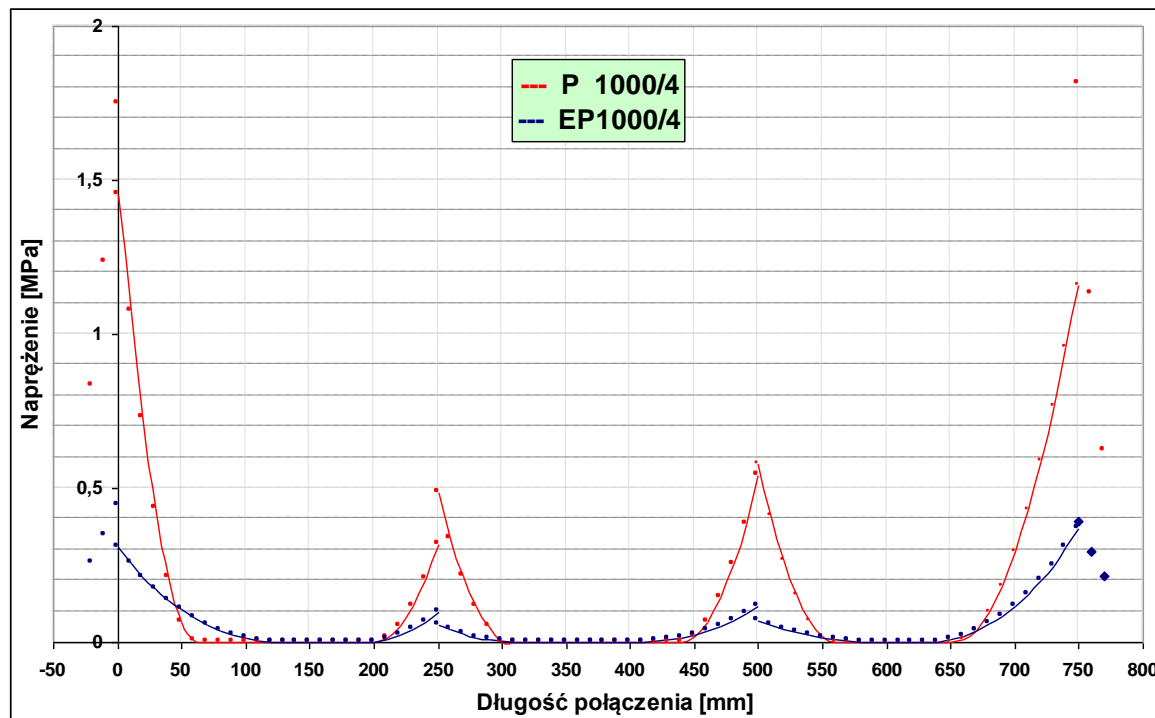
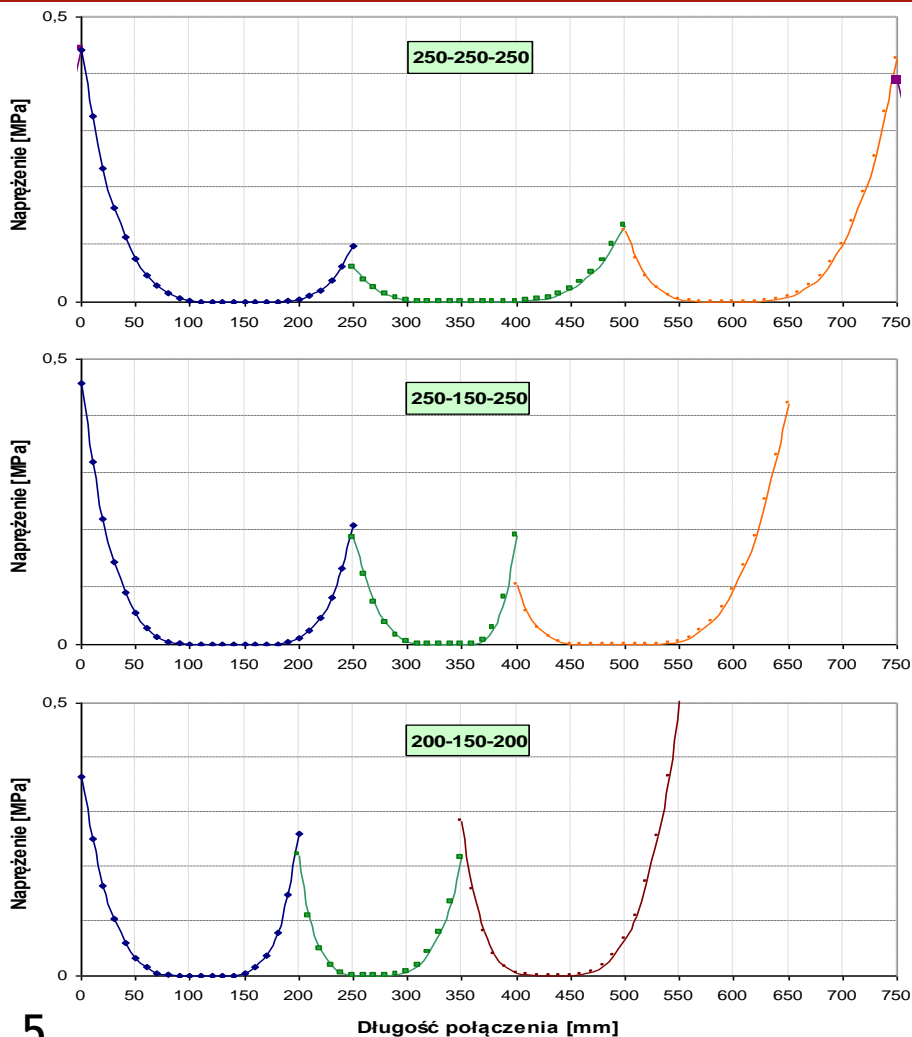


Fig.4. Distribution of shear stresses in adhesive-bonded joint of belt EP 1000/4 and P 1000/4 connection loaded by the force equal 15% of belt strength

Stresses distribution in belt joint

Distribution of shear stresses in adhesive-bonded joint of tape EP 1000/4 connection depending on the length of connections



- The first graph is showing stresses in the standard joint 750 mm long. One can see the very uneven distribution of stresses
- - high stresses on outside joints and small on internal.

Simultaneously large areas which don't participate in the transfer of stresses are appearing.

- The shortened joints for 200 mm in arrangement 200 + 150 + 200 is more beneficial schedule of stresses. Stresses on outside joints didn't grow, and areas not moving forces decreased.

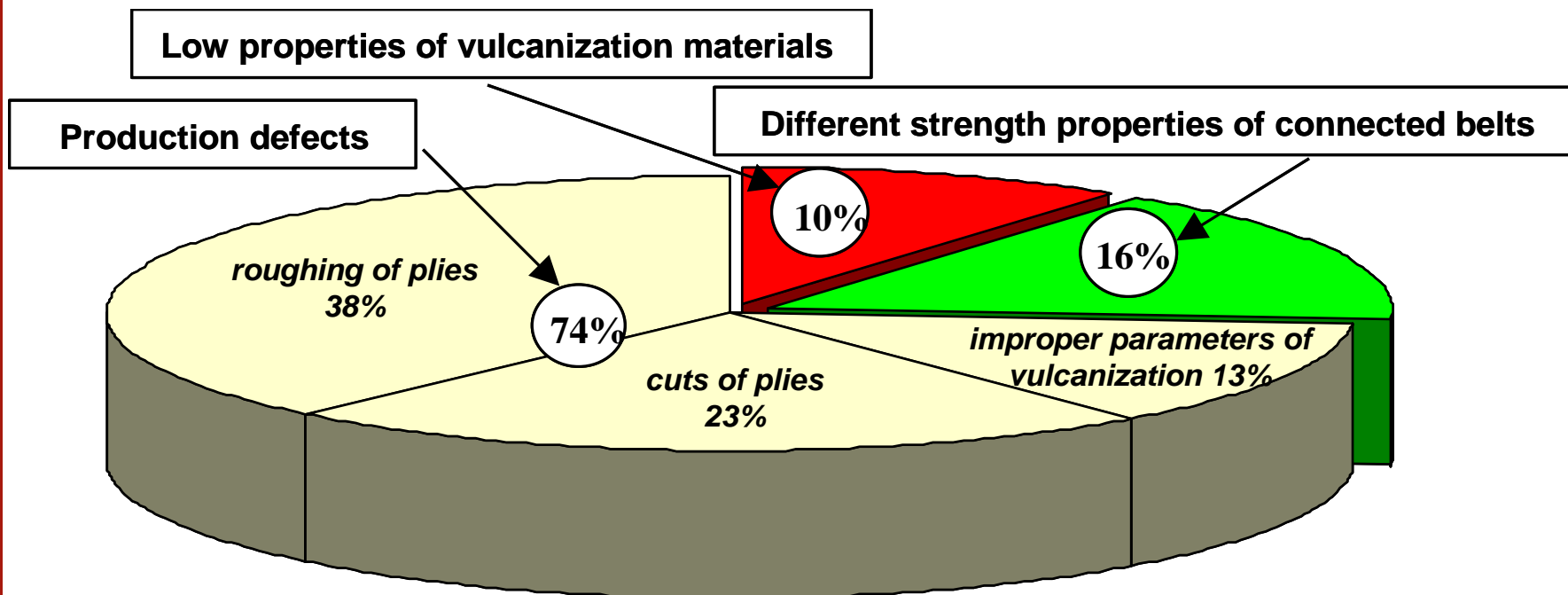
Fig. 5

Długość połączenia [mm]

Results of tests on reduced strength of joints

Classification of reasons of joints reduced strength

Some 60 joints, which strength was lower than expected, were selected for the analysis, from all joints tested during last several years. The percentage of individual reasons of reduced strength of joints is presented on figure 6.



Among the production defects are roughing of plies, cuts of plies or improper parameters of vulcanization. Roughing of plies destroyed the structure of plies what in turn reduced their strength. This defect occurs most often during removing the friction rubber from ply. Cuts of plies arising during benching the joints, generally occur at the connections of joints and therefore they increase the accumulation of stresses occurring there. Those defects reduced the joints strength by about 30%. Improper parameters of vulcanization are mostly insufficient pressure of vulcanization resulting in rubber porosity or improper temperature of vulcanization.

Fig. 6



Results of tests on reduced strength of joints

different strength parameters

Within the group of belts having different strength parameters, two types of them can be mentioned:

- joint of belts with equal number of plies and having the same strengths but different extendability,
- joint of belts having different strength parameters and different number of plies.

Results of tests on reduced strength of joints

different strength parameters

Example of the first type is a joint of a EP type belt with a polyamide belt. While testing the tensile strength of such joint it was found that failure of joint occurs in two stages; first the plies of EP belt are broken and afterwards of the polyamide one. Example diagram of tensioning such joint is presented on figure 7. The similar pattern of failure have the joints of the second type. Average strength of such joints reaches about 65 % of required value.

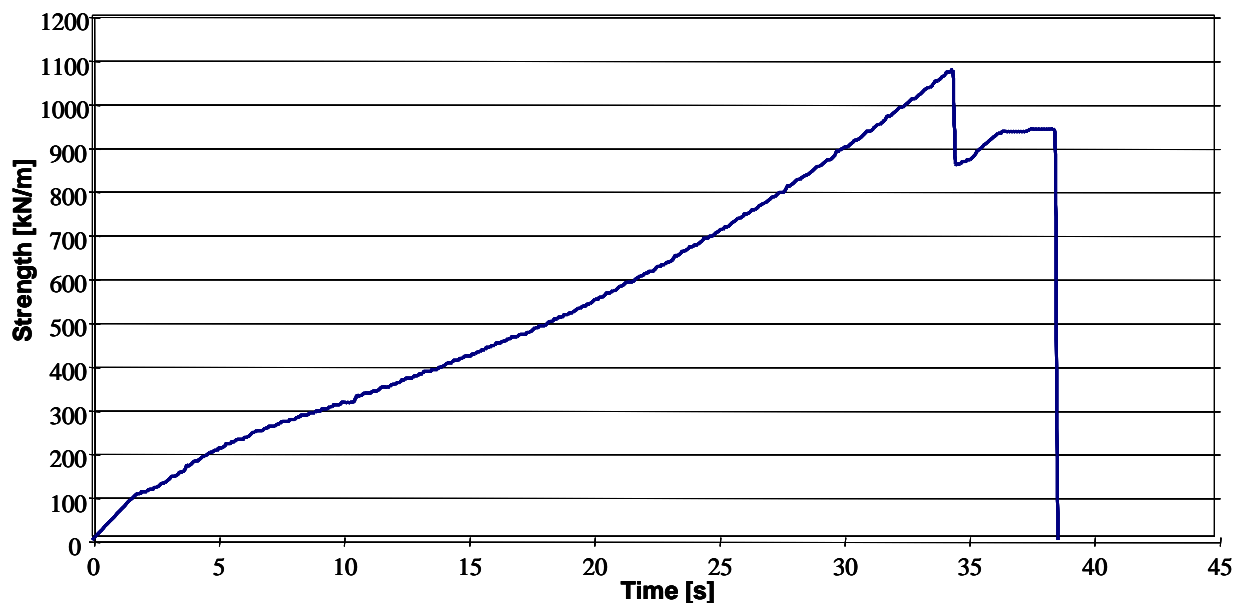


Fig. 7. Diagram of tensioning the joint of polyester and polyamide belts



Summary

- Strength of conveyor belts plies determines the strength of the whole belt loop on a conveyor.
- Loss of strength on the area of properly made joint is from 30% to 45%, depending on the number of belt plies. If the joint is made incorrectly or belts having different strength parameters are connected, then the additional weakness of joint may reduce its strength by further tens of percent and may cause the sudden failure of the belt.
- The biggest strength will have the joints of belts having the same strength parameters and made without the damage of a ply textile. In properly made joint the failure is located at the contact of the first or the last step of the joint. Different pattern of failure evidences the occurrence of defects.