Machine Dynamics Research
2015, Vol. 39, No 1, 15 - 20

Modification of Joints in Polymer Timing Belts

Grzegorz Domek[1)], Andrzej Kołodziej[2)]
[1)] Kazimierz Wielki University in Bydgoszcz, e-mail: gdomek@ukw.edu.pl,
[2)] Higher Vocational State School in Kalisz, e-mail: a.kolodziej@ip.pwsz.kalisz.pl

1. Abstract

Teeth deformation measurements in the connection area indicate that each method of welded joint improvement, decreases deformation and thus improves power transfer capacity of joined belts. In the selected study it means deformation of the connection zone. The difficulties with preparation of strenghtening element significantly reduced selection of solutions. The best results were obtained within belts with connected cord ends and in solutions with restricted load-carrying layer. Depending on the structural solution applied in the cord ends connection, the force transfer capacity is from several to several dozen percent higher. As indicated by the proposed equations, the engagement conditions between belt and pulley can be improved by using pulleys with maximum possible number of teeth, in standard version or even with increased lateral gap.

Keywords: polymer timing belts, welding process quality, transmission gears, joining area

1. Introduction

Replacement of a timing belt causes lots of trouble for their users. It requires disassembly of the entire machine or introduction of the belt in form of a band followed by its joining once it is mounted on the pulleys [Domek 2012]. Welded joining of a belt in a machine requires use of special equipment or sometimes can even be impossible.

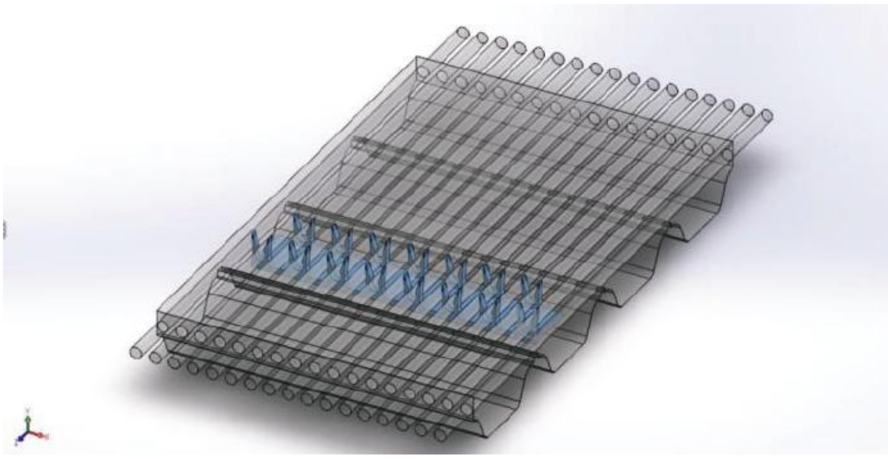

Fig.1 Modification of welded joining

A joint significantly reduces belt capacity to transfer torque. It is reduced up to 50% in the solutions used so far, depending on the pressure welding process quality [Domek 2011c, Domek 2013b]. Structural needs are so high that designers return to solutions of joints that have been abandoned for a long time.

2. Joints of timing belts

Like other joints in mechanical engineering, belt joints can be divided into permanent (Fig.1) and disconnected ones, however number of solutions is much smaller here. There are two types of permanent joints: pressure welded and glued. Type of the joint is partially determined by material the belt is made of. Disconnected joints can be divided into screwed joints, pin joints and clamp joints (Fig.2). For all types of belt joints designers seek design modifications enabling increase of the power transmission capacity and shorter installation time. All joint types can be found in belts made of thermoplastic materials. If the polymer belongs to hardening plastics, then it is only possible to make glued or disconnected joint.

In timing belt gears the force is transmitted from the pulley through teeth to load-carrying layer [Dressing, Holzweissig, 2010]. The quality of the load-carrying layer determines mechanical properties of the belt. The neutral axis of cord coincides with the bending axis where belt and pulley pitches are measured. Appropriate connection should cause the lowest possible reduction of the tensile strength of the load-carrying layer as well as maintenance of the belt pitch at the joint area [Domek, 20011c].

Fig. 2 Clamp joints of the ATN system (*source Mulco Gruppe*)

In case of screwed joints the problem appears in the proper preparation of the belt ends to be joined and clamping them with screws so as to make the tooth rigid. In clamp joints the cord ends are clamped using special connector to prevent them from displacement in relationship to each other [Domek 2011a, Domek 20011b]. The load-carrying layer is clamped inside teeth or after partial removal of teeth. Recently observed return to pin joints results solely from the fact that it is very easy to prepare such joints (Fig.3). A simple fitter's workstation is sufficient to do that. However the joint is characterized by many disadvantages.

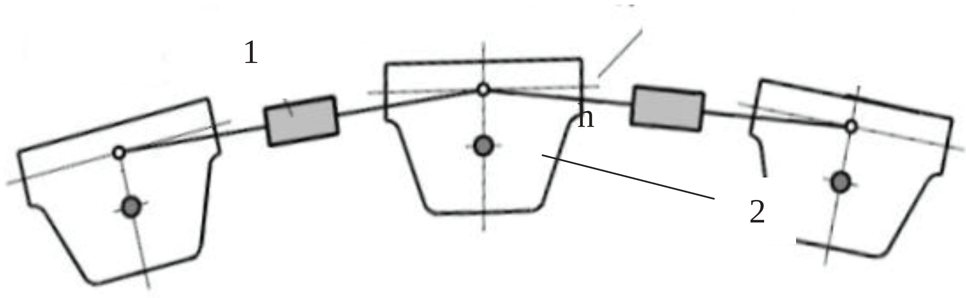

Fig. 3 Timing belt joint: 1- at the cord height, 2- pin joint inside the belt tooth, h- the distance of the pin in the tooth from the neutral axis of the load-carrying layer

Insertion of pins inside a tooth shortens the belt pitch ΔP at the pulley arc of contact. This depends on the distance of the pin from the neutral axis of the load-carrying layer as well as the number of teeth at the pulley contact arc z_o(1).

$$\Delta P = -\frac{2h\pi}{z_o} \quad (1)$$

Such connections can transmit small peripheral forces only. Their pretension force should also be significantly lower than the nominal one. In order to reduce the belt pitch shortening effect and the peripheral force increase effect, the pin joints are provided with hinges located at the load-carrying layer [Bodnicki et al. 2011, Domek 2013a].

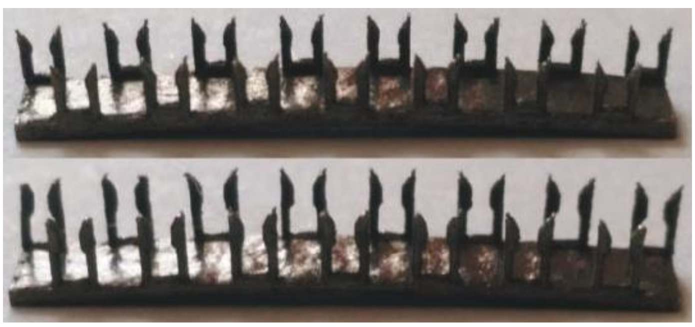

Fig.4 Pin for welded joining.

Depending on the type of cord, different hinges are applied: metal one for steel cord and plastic one for glass fiber, polyester and carbon cord (Fig.4). The most common way of joining belt ends is welding (Fig.5), where belt manufacturers use different types of belt end preparation. There are straight and offset finger ends as well as straight and skew triangular ends. Most of these solutions are known from other connections of drive and transport belts.

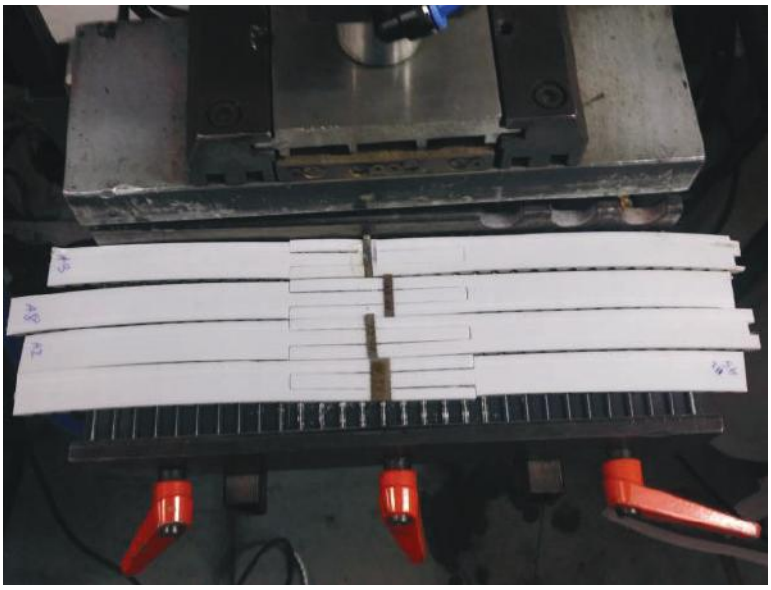

Fig. 5 Welding process.

In case of timing belts, those operations are aimed at limiting teeth deformation in the area of the connection. The peripheral force and the pre-tensioning force increase the deformation in the belt connection area in comparison to the remaining part of the belt. The connection between ends of the load-carrying layers consists of polymer only, while displacement of the load-carrying layer resulting from the rheological processes causes tooth deformation.

Depending on the number of teeth engaged with the pulley, the engagement process in the connection area becomes difficult. In case of "tangential" transmission gears, where only one tooth of the pulley is engaged with the belt, the measure of the deformed pitch Pl, cannot exceed the pitch in the transmission gear increased by the lateral gap on the pulley. Once that value is exceeded, the belt does not fit in the tooth space any more and thus the belt teeth start to jump over pulley teeth. If there is higher number of teeth at the arc of contact, even for relatively small value of pitch, deformation causes problems with the belt engagement with the pulley. The sum of deformed pitches cannot exceed the sum of pitches at the arc of contact of the pulley - ΣPo and two-fold lateral gaps -Ls. Once that value is exceeded ΣPl, the teeth of the belt and the pulley start to interfere, which causes belt breaking (Fig.6).

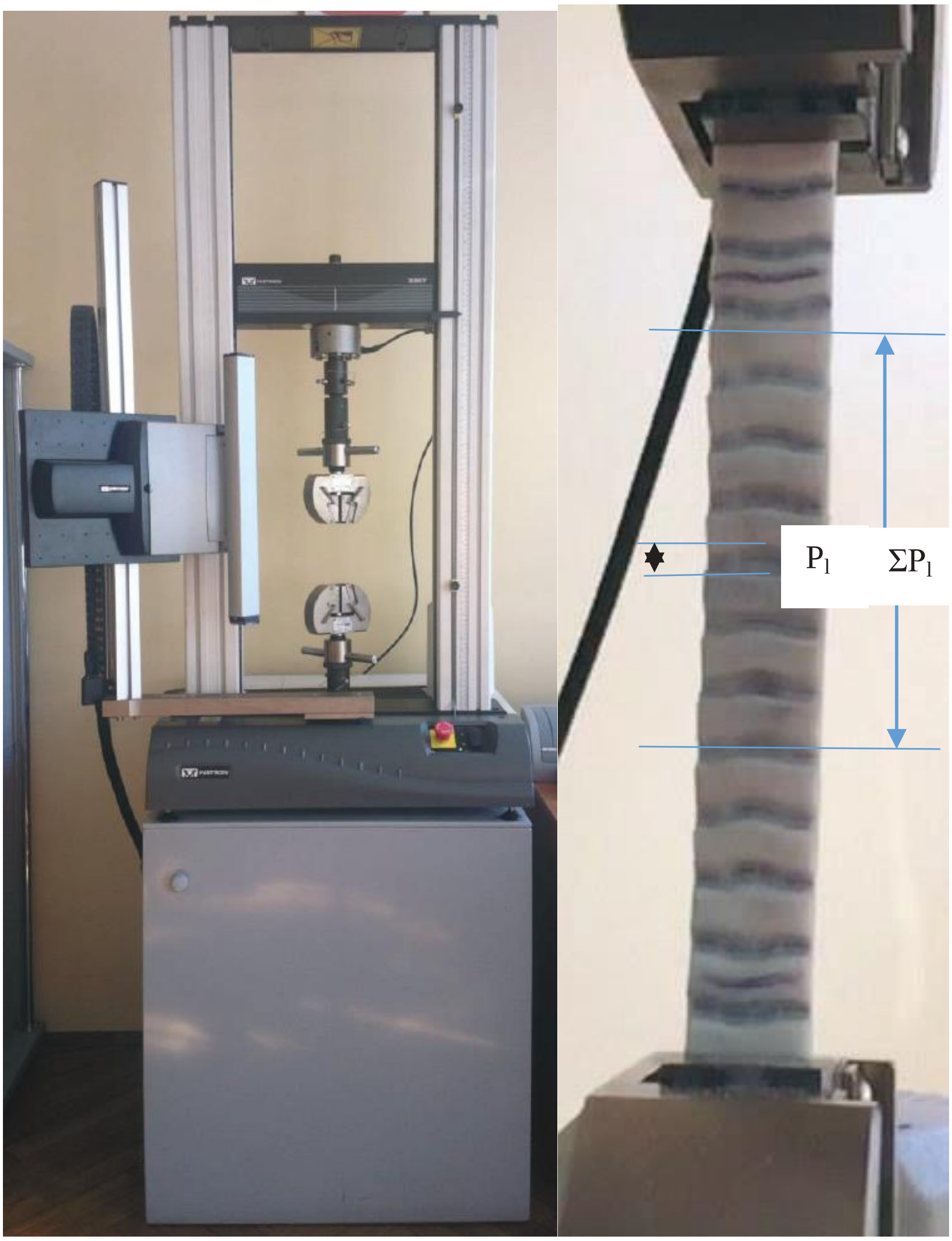

Fig. 6 Breaking test of a mesh-reinforced belt, P_l- deformed pitch, ΣP_l- sum of deformed pitches in the connection area

$$\Sigma Pl \leq \Sigma Po + 2Ls \tag{2}$$

Deformation of the whole joining area has an influence on the coupling process especially with big amount of teeth taking part in meshing. The deformation of a single tooth is important in case of "short" connections. In order to prevent displacement of the load-carrying layer, one uses different methods of cord strengthening and connection. Solutions aimed at teeth stiffening in the area of the joint are additionally used.

References

Bodnicki M., Pochanke A., Szykiedans K., Czerwiec W.: Experimental and Simulation Test of Dynamic Properties of Stepping Motors, Proc. 9th International Conference MECHATRONICS 2011, *Recent Technological and Scientific Advances, Springer Verlag*, 2011, pp. 25-34

Domek G., Motion analysis of timing belt used in control systems, *American Journal of Mechanical Engineering*, vol 1, No.7 2013.

Domek G., Dudziak M., Kołodziej A., Timing belt gear design for mechatronics system, *Procedia Engineering* 96, 2014, 39-43.

Domek G., Trends in development of timing belts for new application areas, *Journal of Mechanical and Transport Engineering, Wyd. Politechniki Poznańskiej*, Vol 1. 2014.

Domek G., Meshing model in gear with timing belt, *Journal of Advanced Materials Research*, Vols. 189-193, 2011a, pp 4356-4360.

Domek G., Meshing in gear with timing belts, *International Journal of Engineering and Technology* (IJET), vol. 3, no. 1, pp. 26-29, 2011b.

Domek G., Research on the Contact Area between the Timing Belt and the Timing Pulley, World Congress on Engineering ,WCE 2011c, *Lectures Notes in Engineering and Computer Science*, Vol. III, s.2242-2244.

Domek G., Timing belts dynamics model approach, *Journal of Mechanics Engineering and Automation*, 2012, Vol.2 N.8, p 495-497**.**

Domek G., Timing belts in glass processing systems, *International Journal of Emerging Trends in Engineering and Development*, Issue 3, Vol.4, 2013b, p.108-111.

Dressing H., Holzweissig F., Dynamics of Machinery, Theory and Applications, *Springer Verlag*, Berlin Heidelberg 2010.