TRANSPORT & *LOGISTICS:*
the International Journal

Article history:
Received 1st July 2022
Accepted 19th September 2022
Available online 20th September 2022

ISSN 2406-1069

Article citation info: Domek, G., Krawiec, P., Talaśka, K.,Tyszczuk, K., New classification of joining in lightweight conveyor and flat belts. Transport & Logistics: the International Journal, 2022; Volume 22, Issue 52, September 2022, ISSN 2406-1069

NEW CLASSIFICATION OF JOINING IN LIGHTWEIGHT CONVEYOR AND FLAT BELTS

Grzegorz Domek [1], Piotr Krawiec [2] Krzysztof Talaśka [2], Krzysztof Tyszczuk [1]

[1] Faculty of Mechatronics, Kazimierz Wielki University, Chodkiewicza 30, 85-064 Bydgoszcz, Poland, e-mail: gdomek@ukw.edu.pl , krzytysz@ukw.edu.pl
[2] Institute of Machine Design, Faculty of Mechanical Engineering, Poznan University of Technology, Piotrowo 3, 90-965 Poznań, Poland, e-mail: piotr.krawiec@put.poznan.pl, krzysztof.talaska@put.poznan.pl

Abstract:
The work addresses the problem of the classification of joining of lightweight conveyor and flat belts. The development of belt construction resulted in a significant qualitative increase in the mechanical properties of the belt rod. Solutions in the field of belt end connections have not been able to keep up with this progress. There is no comprehensive classification of belt connections. all manufacturers classify them and name them in their own way. The use of endless belts limits the design possibilities of machines, because they limit the possibility of mounting and disassembling the belt.

Key words:
industrial belts, power transmission belts, flat belts

1 INTRODUCTION

Driving belts have been used in drive systems from the dawn of torque transmission between shafts. Along with the development of technology, their great advantage has been used, namely the ability to transmit power between many shafts, even if they are in different planes. At the end of the twentieth century, these advantages were relegated to the background with widely available mini and micro drives and drumrolls. In addition, the transmission ratio function began to be replaced by widely available electronic solutions in the form of frequency converters. Belt transmissions remained in drives with high linear speeds, high powers, and synchronous transmission (toothed belts) (Domek et al., 2017), (Krawiec and Marlewski, 2011). Belts also remained in the complex drive systems of paper and textile machines. In the multi-shaft drives, the quality of the belt end-connection was important for the quality of the overall drive operation. This is due to the fact that the belt was inserted into the system as an open-ended band, and only after its ends were joined, it would become a drive belt (Dudziak and Domek, 2004). Flat belts are one of the oldest drive elements and have not lived to see the modern classification of their connections. What can be found in modern literature is only the elaborations of belt and connector manufacturers (Fig. 1).

The problem of quality in regards to the technology of the connection returned, along with the revival of usage of drive belts in new applications, in which they serve additional purposes (Krawiec et al., 2019), (Saga et al., 2020).

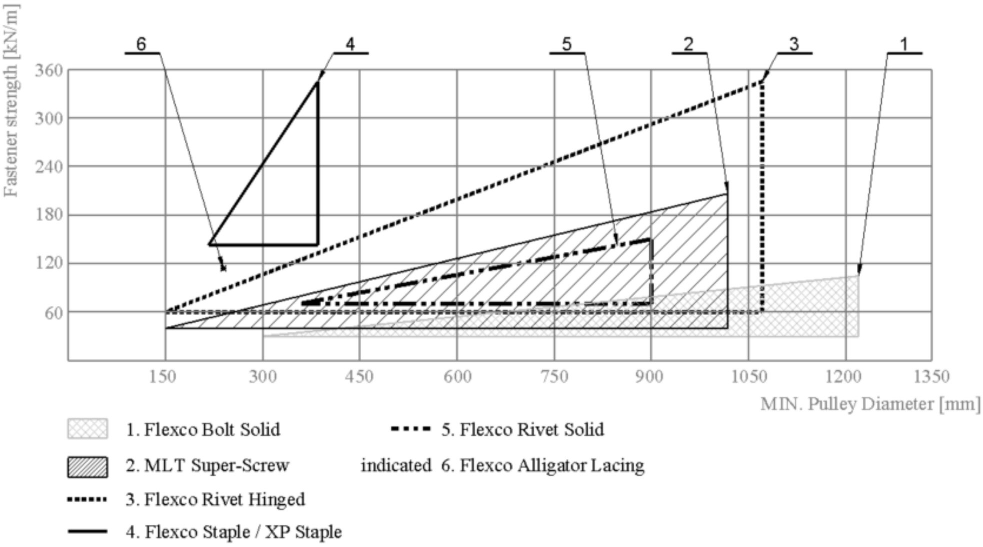

Fig. 1 *Selection chart of a mechanical fasteners in the range of MIN. Pulley diameter from 0 to approximately*
Source: (Konecki et al., 2021)

2 METHODS AND METHODOLOGY

2.1 Development of flat belt design

Over the many years of development of drive belts, it was possible to observe rapid technological and qualitative advancements in their production methods. They were mainly connected to the development of material engineering, only "higher" quality materials would allow for new developments in the field of belt geometry (Fig. 2). Research manuscripts reporting large datasets that are deposited in a publicly available database should specify where the data have been deposited and provide the relevant accession numbers. If the accession numbers have not yet been obtained at the time of submission, please state that they will be provided during review. They must be provided prior to publication.

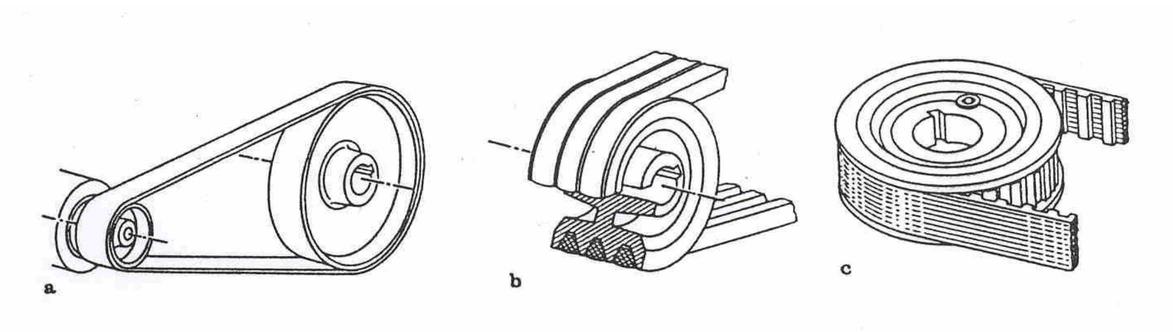

Fig. 2 *Basic types of belts: a) flat b) wedge c) toothed.*

The first belts were made from organic materials, such as skin, textiles, before being reinforced with natural resins, tar, or asphalt. The first generational change followed the development of the rubber vulcanization technology. (Dudziak, M., Anisimowicz, M., 1990), (Ondrušová et. al, 2020). New, higher quality of obtained materials allowed for constructional changes to be made in belts. A whole new array of belts appeared, amongst which there were wedge belts, toothed belts, and toothed wedge belts. (Ondrušová et. al, 2018), (Dudziak and Domek, 2004). In the fifties, other polymers started to be used in belt production: thermosetting polyurethane and then thermoplastic polyurethane were successfully used. Interestingly, development of materials used in belt production were supported by tire producers, as they were also the largest belt producers. The search for new tire constructions resulted in the development of new types of cords (steel, Kevlar, and carbon cord). Methods were developed to improve the coherence of the cord with polymers. That resulted in another milestone, which were the modern design solutions to the load-bearing layer of drive belts. High quality belts that were able to transmit torques in the heaviest machine drives were developed (Dudziak, Domek and Kołodziej, 2016). The use of carbon fibers, often referred to as CARBON, resulted in the belt tension being subject to very little deformation. This reduces the elastic friction in the transmission and reduces deformation used in flat, wedge, and toothed belts. It also allows for the transmission of the heaviest loads through endless belts. However, the problem that arose is appropriate belt connection of band belts.

3 RESULTS AND DISCUSSION

3.1 New classification of belt joinig

Early constructions of drive belts were made from materials with low mechanical durability. The use of a connection to close the band around its circumference would only negligibly worsen the properties of the whole belt. In belts, like in other machine parts, detachable and non-detachable connections were being used (also called glued, and mechanical connections) (Fig. 3, 4, 5). The quality of the connection would guarantee a transmission of torque by the belts, which moved at minute speeds. Constructions of connections were being developed from materials similar to the belt, and research was being undertaken to improve the efficiency and the quality of the connecting process. The introduction of new material solutions in belt construction made the difference between the mechanic durability of endless and joint belt more profound. In modern belts, this difference ranges from 40% to 60%. This is especially bad with toothed belt connections, where the degree of belt wear is determined by the borderline tooth deformation. This deformation is significant enough that the belts' teeth will not fit into the pulley's wedges (Fig. 6). The belt, resting with its teeth on the tops of the pulley teeth, then rapidly elongates and breaks.

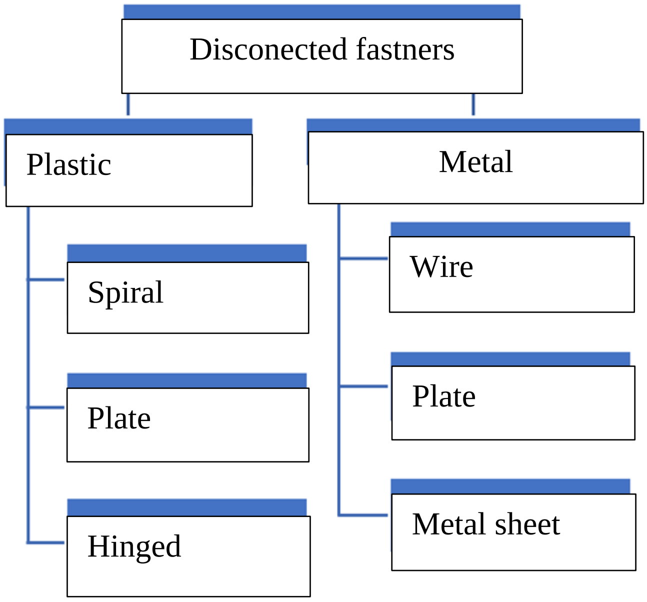

Fig. 3 *Classification of detachable connections with regards to the connecting material*

New belt designs allowed for higher torques to be transmitted, and for the belts to operate at higher speeds. Unevenness of the belt around its joining causes runout on the pulleys and destroys the gears due to the action of dynamic forces. Therefore, there is still ongoing research on non-detachable connection, which would limit the belt's mechanical properties only in the smallest degree.

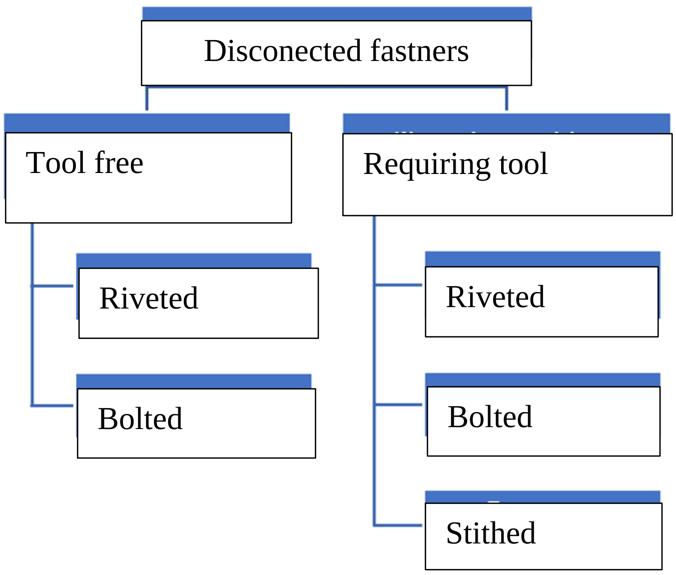

Fig. 4 *Classification of detachable belt connections with regards to the mounting process.*

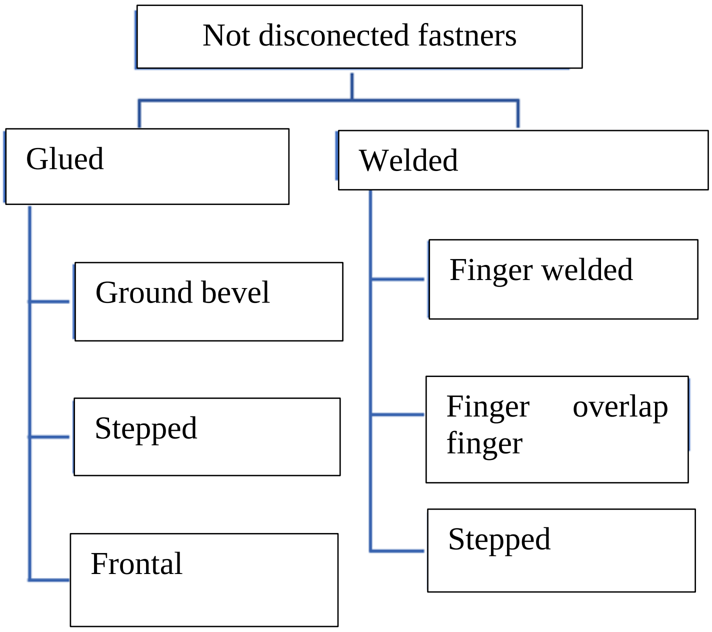

Fig. 5 *Classification of non-detachable belt connections.*

Mechanical properties of belts determine the properties of the load-bearing layer, which in most of the belts is made of materials proven to be notoriously problematic in the belt joining process. It is not possible to thermically join: oriented polyamide, Kevlar, glass fibers, and steel fibers. That is why in most cases, the ends of the belts are adequately pre-prepared so that they can be joined using glue or a mechanical connection. Parallel to that, other solutions emerged which abandoned the idea of connecting the load-bearing layer of the belt. For the connection, a thermoplastic belt material is used. At the ends of the band, appropriately shaped "teeth" are cut out, which, after folding and placing in the welding machine, become fully joined. The stresses between the ends of the active cord are carried by the belt material.

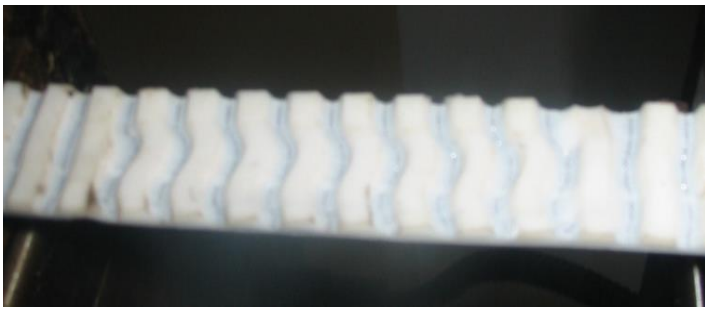

Fig. 6 *Borderline deformation of a toothed belt connection 1(finger welding).*

In belts with this kind of connection, mechanical properties are predominantly dependent on the properties of the belt material. Research on contemporary thermoplastic materials is still underway. Contemporary flat belts, wedge belts, and toothed belts are already made from thermoplastic polymers. This resulted in the emergence of a new group of machine belts: "monolithic", used more commonly in transport. These belts are produced in bands, and their end can be welded so that the belt is uniform all around its circumference.

In the drive belts, such thermoplastic cord is covered with additional materials such as rubber, fabric, etc. As a result, a high-quality belt for carrying the heaviest loads is made.

4. CONCLUSIONS

New solutions to the problem of joining belt ends are sought in all areas of belt design. Solutions are still being developed for flat belts, mechanical, glued, and thermoplastic. Manufacturers of flat belts often use their own names for specific types of joints. An example is the name “FLEXPROOF” used by one of the leading belt manufacturers for a welded finger connection. Modern control systems of the technical condition of the belts, and thus belt end clamps, are being developed in regulation and elevator systems. For wedge belts, made from thermoplastic materials, various end welding methods are being developed, but there are also some mechanical connections. There are also belts assembled from single geometric coupling elements, for example "NUTLINK". In toothed belts, the problem of joining is still prevalent, therefore, optimal forms of welding are sought after. Solutions known for decades, however, such as "Pin-Lock", are also experiencing a contemporary revival.

REFERENCES

Domek, G., Kołodziej, A., Dudziak, M.., Woźniak, T., 2017. Identification of the quality of timing belt pulleys. *Procedia Engineering* , 177, pp. 275-280.

Dudziak, M.., Domek, G., 2004. Gear with timing belts in mechatronic drives, Machine Dynamics Problems. 28 (3), *Warsaw University of Technolog*y, pp. 83-88.

Dudziak, M., Anisimowicz, M., 1990. Relaxation of v-belts stresses, *Res Mechanica*, 29.

Dudziak, M.., Domek, G., 2004. Analisys of antitorque in gear with timing belts. *Materials Engineering*, 11 (1), pp. 121-124.

Dudziak, M., Domek, G., Kołodziej, A., 2016. Variation of static parameters of cooperation in axisymmetric connection. *Procedia Engineering.* 136, pp. 56-62.

Konecki, K., Wojtkowiak,D., Talaśka, K., Kołodziej, A., Domek, G., 2021. Conventional Selection of Mechanical Fasteners for Flat Belts, *Applied Sciences*, *11* (7), 2916.

Krawiec, P., Marlewski ,A., 2011.Spline description of not typical gears for belt transmissions. *Journal of Theoretical and Applied Mechanics*, 49 (2), pp. 355-367.

Krawiec, P., Grzelka, M., Kroczak, J., Domek, G., Kołodziej, A., 2019. A proposal of measurement methodology and assessment of manufacturing methods of nontypical cog belt pulleys. *Measurement*, 132, pp. 182-190.

Ondrušová, D., Labaj, I., Vršková, J., Pajtášová, M., Zvoláneková Mezencevová, V., 2020. Application of alternative additives in the polymer composite systems used in automotive industry. In: IOP Conference Series: *Materials Science and Engineering,* 776. Bristol : IOP Institute of Physics, pp. 1-9.

Ondrušov,á D., Božeková, S., Buňová, L., Pajtášová, M., Labaj, I., Dubec, A., Vršková, J., 2018. Modification of alternative additives and their effect on the rubber properties. In: *MATEC Web of Conferences,* 157, pp. 1-13.

Saga, M., Blatnicka, M., Blatnicky, M., Dizo, J., Gerlici, J., 2020. Research of the Fatigue Life of Welded Joints of High Strength Steel S960 QL Created Using Laser and Electron Beams. *Materials*, 13 (11), 2539.