Influence of the silent chain link geometry on the link / chain guide contact

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Abstract. The mechanical behaviour of the chain drive transmissions is influenced of the contacts between elements being in relative motions, as: sprockets and links, links and pins and links and tensioning guides. These contacts have a complex behaviour and due to that it is required to be analysed separately, in order to find out their influences on the dynamical behaviour and on the tribological properties of the entire transmission. The article presents the analysis of the influence in the case of silent chain link geometry on the link/chain guide contact. It is studied the variation of the local normal maximum pressures and the variation of the contact area’s width with the main radius of the chain link and with the normal applied force. The analysis is based on the finite element modelling. Finally there are given conclusions regarding the practical applications of the obtained results.

1. Introduction

The efficiency of the mechanical transmissions is influenced mainly by the lubricants used in order to reduce the friction between the elements being in contact, by the materials used in the construction of the mechanical parts and by the local geometry (dimensions and shapes) of the contact zone between the mechanical elements being in relative motions [1, 2, 3, 4, 5, 6].

Chain drives are characterised by high loading capacities. Due to this characteristic, the chain drive transmissions are used widely in the automotives industry and in the construction of the mechanical systems as industrial robots, machine tools and machines use in agriculture and mining industry. The main problems are represented by their efficiency and the noises developed during their functioning [7, 8, 9, 10]. The literature offers directions in order to reduce the friction and the noises [11, 12, 13]. One solution is represented by the silent chains; in this case the chains links have teeth with are gearing with the sprocket and, due to this, a reduction of the noise is obtained.

Generally, the friction developed in a chain drive transmission can be split in the friction in the chain links, the friction between the chain links and the sprockets and the chain links and the tensioning guide [7, 1, 12, 14]. Regarding the tensioning guide, the active part of it is made by polyamides which are characterised by small friction coefficients in combination with steel elements, small wear, high endurance and good mechanical behaviour at high loadings and high temperatures [15, 16, 17, 18, 19, 20].

The frictional behaviour of the chain link – tensioning guide contact (the mechanical efficiency, the wear and the level of the noises) is influenced by the geometrical characteristics of the contact area [8, 10, 12]. According to this, the paper studies the influence of the toothed chain link geometry on the contact with the tensioning guide.

2. The model

The theoretical analysis is achieved by using the finite element method based software Ansys 15.0; the geometrical model is made in Catia V5R18 – figure 1. The toothed chain link is in contact with a tensioning guide made by a polyamide type material which has the radius $\boldsymbol{R}$=120 mm.

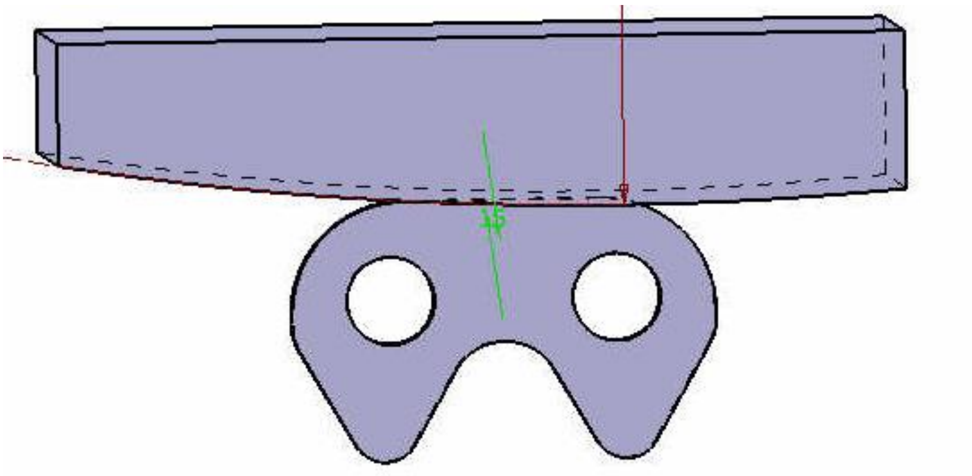


Figure 1. The geometrical model.

The geometry and the dimensions of the toothed chain link are presented in figure 2. For the finite element based analysis only the radius $\boldsymbol{R}$=4 mm is considered variable with values in the range of: 3.5; 3.75; 4; 4.25; 4.5 – figure 3. Other main dimensions are kept frozen in order to keep unmodified the values of the chains pitch, the height, the length and the width of the link, the diameters of the pins.

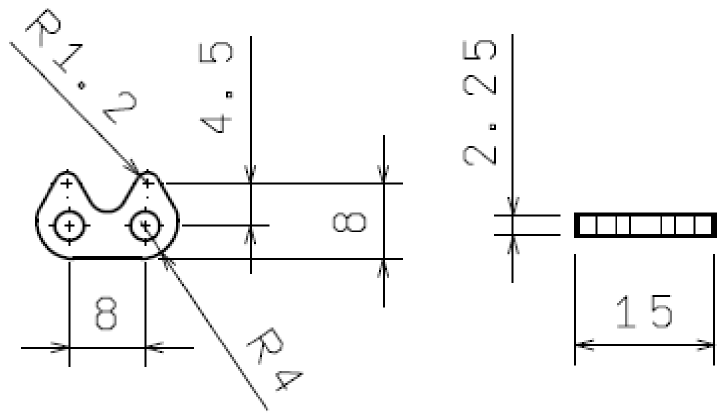
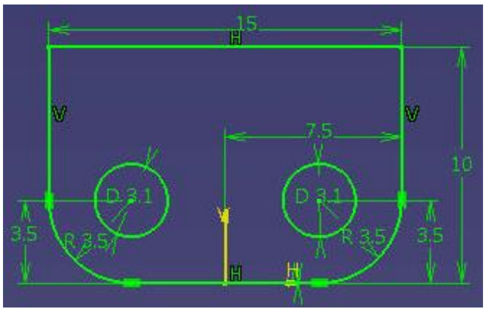


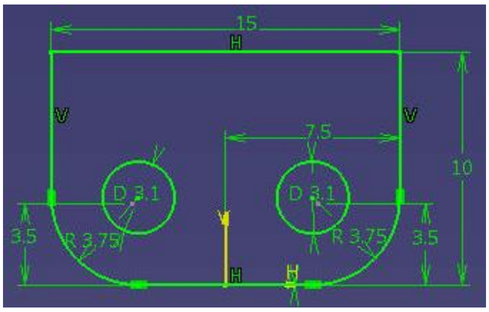
Figure 2. The toothed chain link.

By reducing the radius, the length of the contact zone between the link and the guide increases; high value of the radius produce a decrease of the length for the contact zone between the link and the guide.

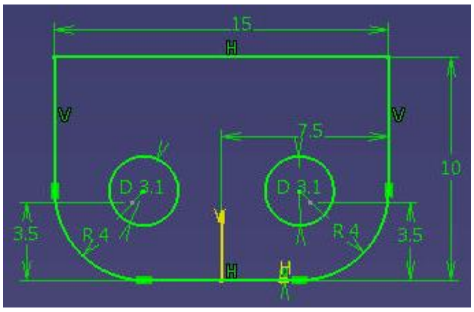
Figure 4 presents the finite model of the link/guide contact. The tensioning force which is applied on the guide has the values of: 10 N, 15 N, 20 N, 25 N, 30 N; the holes where the pins are mounted are clamped. The links are made by steel and the guide is made by polyamide. The material data are: $\boldsymbol{E_1}$, $\boldsymbol{E_2}$ represent the Young's modulus for the skate and the link and $\boldsymbol{\nu_1}$, $\boldsymbol{\nu_2}$ represent the Poisson's coefficient of the two materials (for steel – the link, $\boldsymbol{E_1}=2\cdot10^5$ MPa, $\boldsymbol{\nu_1}$=0.266; for plastic – the skate, $\boldsymbol{E_2}=2.2\cdot10^3$ MPa, $\boldsymbol{\nu_2}$=0.38 [21]).



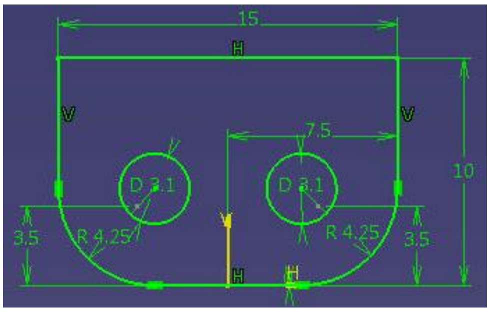
R=3.5 mm



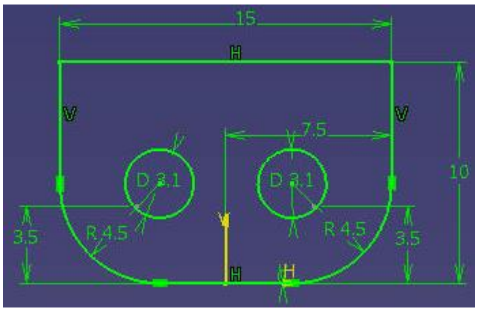
R=3.75 mm



R=4 mm



R=4.25 mm



R=4.5 mm

Figure 3. The link shapes.

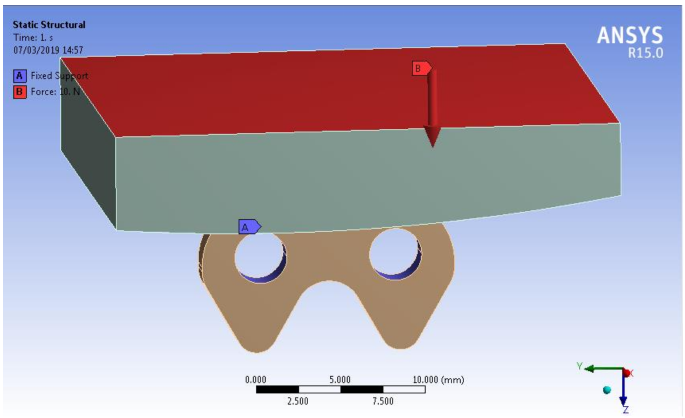


Figure 4. The finite element model.

3. Results and conclusions

The results of the finite element analysis presents as graphs, the variation of the contact pressure and of the contact areas half width with the normal tensioning force and the radius of the chain link.

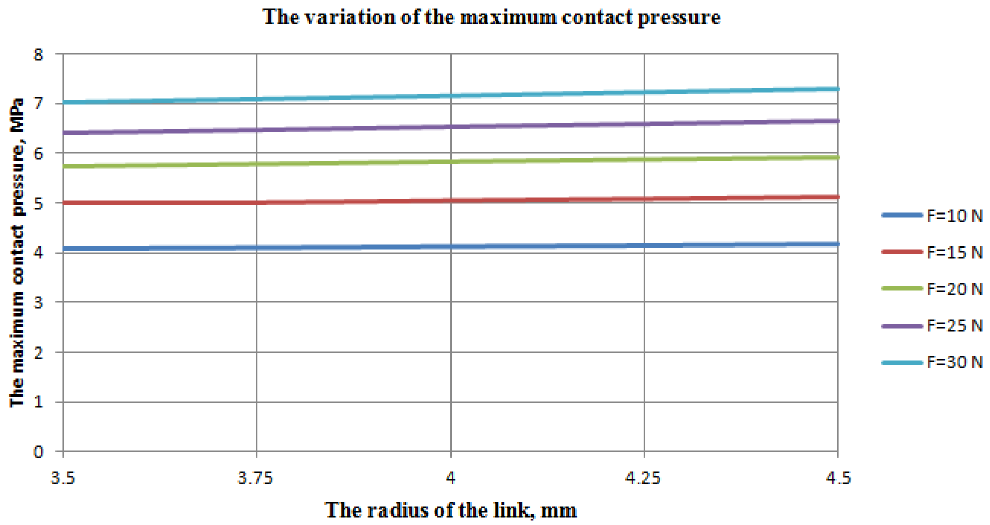


Figure 5. The variation of the maximum contact pressure.

Figure 5 presents the variation of the maximum contact pressure with the normal tensioning force which is applied on the guide and the radius of the chain link. The value of the maximum contact pressure increases with the increasing of the normal force and increases slightly with the increasing of the chain link's radius; higher values for the increasing of the contact pressure with the chain link's radius are obtained for higher normal forces.

The variation of the width of the contact area is presented in figure 6. The value of the width increases with the increasing of the normal force but is decreases slowly with the increasing of the chain link's radius; higher values for the decreasing of the width with the chain link's radius are obtained for higher normal forces.

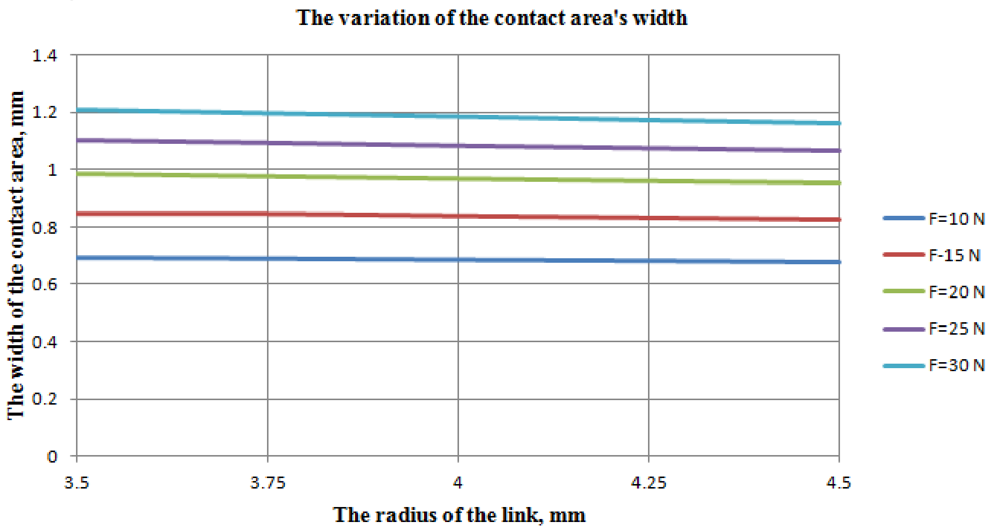


Figure 6. The variation of the width of the contact area.

According to the results, small values of the contact pressures are obtained in the case of small values of the chain links radiuses and these results offers the conditions for good lubrication of the contacts between the chain links and the guide; also small values of the width of the contact area are obtained in the same conditions. The minimum values of the chain links radius could be chosen depending on technological and dynamics behaviour constraints, while the variation of the radius is influencing the inertial characteristics if the chain.

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