TRIBOLOGICAL ASPECTS OF BOLTED ASSEMBLIES IN LIGHT CONSTRUCTIONS

W.A. Grabon [a*], G. Epasto [b], A.R. Da Costa [c], K. Grochalski [d], M. Osetek [e], G.F. Batalha[f], T.G. Mathia [g]

*Corresponding author: wgrabon@prz.edu.pl, Al. Powstaców Warszawy 8, 35-959 Rzeszów, Poland

[a] Rzeszow University of Technology, Al. Powstańców Warszawy 8, 35-959 Rzeszów, Poland
[b] University of Messina, Messina, Italy
[c] Universidade Federal de Ouro Preto, Ouro Preto, Brazil
[d] Poznan University of Technology, Poznan, Poland
[e] Koelner Rawlplug IP Company - Łańcucka Fabryka Śrub, Łańcut, Poland
[f] Polytechnic School of the University of São Paulo, São Paulo, Brazil[f]
[g] C.N.R.S., L.T.D.S. École Centrale de Lyon, France

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ABSTRACT

Lightweight aluminium structures are widely used in the aerospace and automotive industries due to their favourable mechanical properties, as well as because they can improve the energy efficiency of electrical and hybrid vehicles [1]. One of the most commonly used methods for connecting elements of lightweight structures is bolted assemblies, which, however, pose many problems related to durability and reliability [2,3]. This work aims to investigate the tribological aspects of bolted connections in lightweight structures, such as the influence of friction coefficient, bolt type, lubricants and coatings, geometry, and materials on the performance and safety of the connections.

Experimental methods were used to analyse these aspects, using bolts (M10x60 10.9) with electrolytic zinc coating and aluminium washers on the test machine Schatz model 5413-2777 test machine. The influence of different speeds during the tightening process, as well as the influence of lubricants, coatings, and surface topography, was investigated.

The test results showed that the coefficient of total friction (corresponding to the total torque vs. clamping force relationship presented in Fig. 1 [1]) is very variable and unpredictable and affects the assembly process and the safety of the connections. It was found that increasing the friction under the bolt head improves the resistance to self-loosening but worsens the stress state and causes damage to the surface of the joined materials. Additionally, the presence of native oxide in aluminium alloys introduces complexity to the analysis of friction processes, necessitating a nuanced approach to understanding these interactions. The rapid increase in torque on the bearing surface can damage the coating/surface, leading to incorrect performance by torque control tightening. The influence of macro and microgeometry, as well as the physicochemical properties of materials on the tightening process, was analysed, explained and discussed. In light of these findings, security and safety aspects become paramount, prompting a collective effort to propose new parameters involving surface morphology for new standards. This initiative aims to enhance the predictability and reliability of bolted connections, addressing the challenges posed by the variability of friction coefficients and surface interactions. This research presents a comprehensive methodology for understanding and optimising bolted connections in lightweight structures. It provides recommendations for the selection of bolts, lubricants, coatings, and tightening methods, contributing to sustainable and ecological engineering by reducing material and energy consumption and improving safety and reliability.

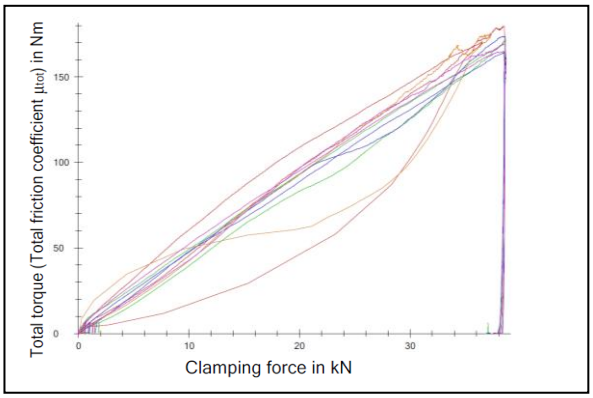

Fig. 1. The relationship between the clamping force and total torque, as well as the friction coefficient.

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