[1.]Milan RADOŠEVIĆ, [2.]Sebastijan BALOŠ, [3.]Dragan RUŽIĆ

METALLOGRAPHIC TESTS AND STRENGTH OF THE MATERIAL OF CHAINS SNOW

[1-3.]University of Novi Sad, Faculty of Technology, Novi Sad, SERBIA

Abstract: Driver safety in winter conditions depends not only on the technical correctness of the transport vehicles, but also on winter equipment used. Snow chains, in addition to technically correct vehicles and tires, are one of the most important factors for driving safely on snowy roads. This paper presents an analysis of the quality of materials and anti-corrosion protection of snow chains that are frequently used in Bosnia and Herzegovina, Croatia and Serbia. For the purpose of analysis several tests were performed on tensioning the chains (at room temperature and at a temperature of -200C), hardness of the chains (Vickers method) as well as the test of the thickness of galvanized layer (metallographic method). All tests were performed in accordance with the relevant standards such as EN ISO 6507-1:2005; EN ISO 6892-1:2009; EN ISO 1461:200.
Keywords: metallographic test, straining, hardness, snow chains, safety and security in traffic

INTRODUCTION

Safety and health of all road users represents a topic that has a very important role on the global level. In addition there is the fact that every day a variety of organizations around the world adopt new regulations when it comes to traffic safety, bring new acts and laws and so on. Agencies such as the AAA Foundation for Traffic Safety (founded in 1947), the World Road Association-PIARC (established in 1909), the Fédération Internationale de l'Automobile - FIA (founded 1904), and many others contribute to the rapid and successful development of the base for the adoption of legal directives in terms of traffic safety. The report of the Commission for Global Road Safety presents individual cases of successful countries such as Norway, Japan, Sweden, Australia, etc., in terms of the road safety. An example of good practice is certainly Vietnam, whose policies on the road safety in 2008 successfully reduced traffic accidents with the consequences of injuries by 12.2%, while the death consequences were reduced for 24.3% [1-5].

This work is divided into two parts. The first part will be related to the theoretical overview on the impact of snow in traffic accidents and factors affecting accidents during this period. The second part refers to the analysis of tire chains that are most common on the market of Bosnia and Herzegovina, the Republic of Serbia and the Republic of Croatia. The question proposed by the authors of this research was whether products, offered on the market, provide sufficient quality that allows traffic safety during their utilization. For the purposes of the chains' analysis the authors tested a straining (at room temperature and at a temperature of -20^{0}C), hardness of the chains (Vickers-method), and the galvanized layer thickness by metallographic method.

THEORETICAL BACKGROUND

As the focus of the paper is directed on winter conditions, in the continuation of the research we will focus on the elements that are involved in that annual period. Since in winter period there are a significant number of accidents because of poor road conditions, it is important to note that in addition to the drivers, on more factor influence the number of accidents. Those are other road users - pedestrians. In their study Knoblauch, Pietrucha, & Nitzburg [6] conducted a survey in which it was included 7123 pedestrians. It was found that during the winter pedestrians are moving significantly slower than in other weather conditions, and particularly pedestrians whose age exceeds 65 years. Their speed of movement in winter conditions is amounted to 0.9 m/s in ratio to other weather condition, when the average speed was 1.2 m /s, while the younger population speed was 1.5m/s, and during the winter 1.2m/s.

Another factor affecting the traffic accidents are certainly the weather conditions. Hildebrand (2003) explored the visibility of signs in conditions of frost and snow. A very interesting study of other factors of snow on segments such as designing horizontal curves, the maximum rates of super elevation, etc., was issued by the Institute of Transportation Engineers [7].

Literary review does not provide a significant number of works dealing with the topic of the influence of using snow chains on car accidents, as well as the theme of the quality of tire chains that are on the market. Also, in the review of the available information by the European Commission - the EU's road safety policy, we cannot find a specific directive that deals with the topic of quality of snow chains. Only in the Commission directive 94/78/EC it is noted that „the manufacturer shall certify that the vehicle is so designed that at least one type of snow chain can be used on at least one of the types of wheel and tire approved for the drive wheels of that type of vehicle" [8].

Olszewski et al. [9] presented a numerical analysis of the stress distribution in the car when the tires are snow chains, and they did not deal with the quality of chains. The authors have defined the snow chains as „an optional equipment of the vehicle consisting of two sections covering the rim of the tire, connected by a series of chains or plates overlapping crosswise the tread".

Another definition of snow chains is given by the European Commission where the snow chains are as defined 'snow traction device'. „Snow traction device means a snow chain or other equivalent device providing traction in snow, which shall be able to be mounted onto the vehicle's tire/wheel combination and which is not a snow tire, winter tire, all-season tire or any other tire by itself" (Commission regulation (EU) No 1009/2010) [10]. Their primary function is to increase the traction of the vehicle in contact with the snowy or icy road.

Topolnik et al. [11] in his study analyzed the likelihood of passing vehicles by applying the appropriate equations and graphs, but this paper also does not include weather conditions and any additional equipment like snow chains. Tominc & Šebjan [12] showed that environmental and external factors have a significant impact on fatal injuries in road traffic accidents. According to them „traffic density and bed road conditions (wet and slippery road) lead to more cautious driving – individuals involved in an accident, where heavy traffic or wet and slippery road is the cause of accident, are approximately only half as likely to suffer from severe injuries as compared to those accidents where normal traffic density and dry road have been observed".

As previously mentioned, the authors of this research decided to explore the level of the quality of snow chains that are provided by producers, which are presented on the market.

METALLOGRAPHIC TESTS AND STRENGTH ANALYSIS

For the purpose of testing the hardness we used the device for testing by Vickers hardness test "VEB HPO-250" in accordance with EN ISO 6507-1:2005. Measuring the thickness of galvanized layer was carried out with the light microscope " Leitz Orthoplan ", while for the purposes of the straining testing at room temperature and on the temperature of -20°C, the authors used a mechanical testing machine "WPM ZDM 9/91" of the maximum force of 50 kN, in working range of 25 kN, in accordance with standard EN ISO 6892-1:2009.

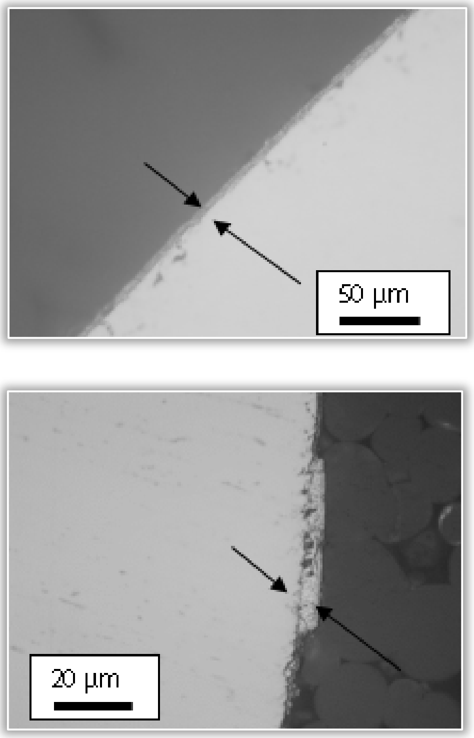
Measuring in the ambient of room temperature was carried out under controlled conditions at a temperature determined by the standard 23°C ± 5°C, while for the purpose of measuring a temperature from -20°C the liquid nitrogen is used. Measurements were performed for each chain, with the thickness of 9mm, 12mm, and 16mm. In order to obtain a more precise measurement, for each complementary chain there are carried out 10 measurements, and for the final information the mean value of the rupture was taken.

To protect the discretion of the manufacturer, whose chains were used in the analysis, snow chains in the analysis will be labeled with "RS" – a manufacturer of snow chains is the company in the Asian region. Table 1 provides an overview of the surveyed value of breaking force in the [N], and measured hardness of the snow chains.

Tabel 1. Mean value of the breaking force and hardness of the snow chains, for n=10 measurements for each chain (source: the author)

Chain type	Thickness (mm)	Breaking force at (23°C ± 5°C)		Breaking force at (-20°C)		Hardness - HV30	
		No. of measure-ments	Mean value (N)	No. of measure-ments	Mean value (N)	No. of measure-ments	Mean value
A	9	10	3498	10	4773	10	217
	12		6245		6932		466
	16		15042		11935		415

Figures 1a and 1b show the surface galvanized layer. The thickness of this layer ranges from 0.002 to 0.02 mm (2 to 20 µm). Figure 1b presents variations of the thickness of galvanized layer.



a)

b)

Figure 1. Galvanized (zinc-coating) layer of the chains (thickness 9 mm)

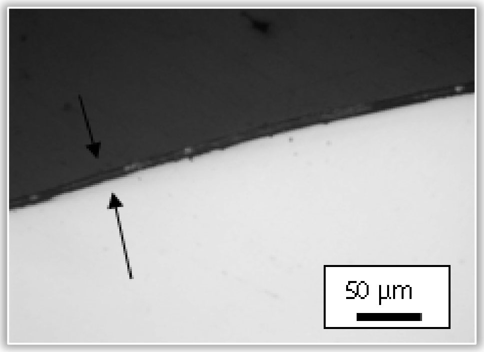


Figure 2. Galvanized (zinc-coating) layer of the chains (thickness 12 mm)

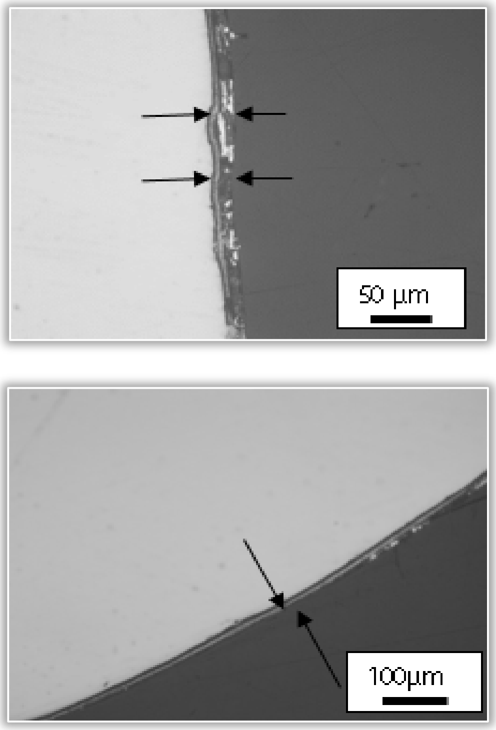


Figure 3a and 3b. Galvanized (zinc-coating) layer of the chains (thickness 16 mm)

Measured values of the galvanized (zinc-coating) layer of the chains of the thickness of 9mm (figure 1) ranges from 0,002 to 0,02 mm (2 do 20 µm), in case of the thickness of 12mm (figure 3) ranges from 0,006 to 0,009 mm (6 do 9 µm), and in case of chains with the thickness of 16mm (figure 4) it ranges from 0,012 to 0,025 mm (12 do 25 µm), which is significantly less than the value proposed by Standard EN ISO 1461:2009. This standard proposes the thickness of the layer (for chains from > 3mm to ≤ 6mm) of 55 µm do 70 µm. Also, on several samples there were evident variations in the thickness of the galvanized layer (figure 1b and 3a). These variations (unevenness) in the thickness of the galvanized (zinc-coating) layer are probably related to the poor quality of the process of zinc coating or low quality of the preparation of material before zinc coating process.

CONCLUSIONS

The analysis of the tightening of the chains at the room temperature and at a temperature of -20°C pointed that there is an inconsistency in the thickness of the individual chains. For the chains of 9mm thickness it can be concluded that the chains at room temperature having an average value of tensile strength of 3498 N and at temperatures below 4773 N, which is a good ration and preferred values for the operating conditions. Chains with the thickness of 12 mm at room temperature having an average value of tensile strength of 6245 N and at temperatures below 6932 N which is a good, but not so great ratio of differences of the values for the operating conditions.

Also, these chains have twice higher hardness compared to chains of 9mm thickness. 16mm chains at room temperature having an average value of the tensile strength of 15042 N at the lower temperatures 11935 N which represents a very unfavorable ratio and values of operating conditions. In other words, chains of 16 mm thickness have a significantly lower exploitation value, and lower hardness in relation to the chains of 12mm thickness. The study found significantly lower values than those recommended by the standard EN ISO 1461:2009, which recommended zinc-coating thickness for elements of a thickness from > 3mm to 6mm ≤ of 55 µm do 70 µm. Also, some samples were found to have unevenness in the thickness of the coated layer.

During the analysis of new snow chain it has been noted that on some chains there is the presence of corrosion, which the maximum measured thickness is 0.2 mm (200 µm). The presence of corrosion is probably the result of poor thickness of galvanized layer which is not in accordance with the standards SRPS EN ISO 1461:2005, identical to EN ISO 1461:2009 and which is prescribed by the Institute for Standardization of Serbia. Also, there have been observed unevenness in the thickness of the zinc coating layer which indicates a low-grade galvanizing or poor preparation of the material before the process of galvanization. The corrosion would certainly have a more aggressive development on the chains and the quality of galvanized layer in real conditions (the influence of water – snow, salt on the roads).

Based on the above mentioned, it is concluded that the quality of snow chains which are the most common on the market is quite questionable. As a continuation of the research authors will provide a comparative analysis with other snow chains that are present on the market of Bosnia and Herzegovina, Serbia and other countries in the region.

Note

This paper is based on the paper presented at 13th International Conference on Accomplishments in Mechanical and Industrial Engineering – DEMI 2017, organized by University of Banja Luka, Faculty of Mechanical Engineering, in Banja Luka, BOSNIA & HERZEGOVINA, 26 - 27 May 2017.

References

[1] Fastenmeier, W., Gstalter, H. (2007) Driving task analysis as a tool in traffic safety research and practice. Safety Science, vol. 45, no. 9, pp. 952-979.

[2] Ewing, R., & Dumbaugh, E. (2009). The Built Environment and Traffic Safety A Review of Empirical Evidence. Journal of Planning Literature, vol. 23, no. 4, pp. 347-367.

[3] Bojić, Ž., Radošević, M., Ćosić, I., Morača, S., Avramović, N., Antić, A. (2017). The analysis of the impact on the safety of traffic participants and causing the accidents of working machines – tractors. Tehnički vijesnik – Technical Gazzete, vol. 24, no. 5 (accepted paper)

[4] Make Roads Safe, A Decade of Action for Road Safety. London, Commission for Global Road Safety, 2011 http://www.makeroadssafehellas.com/images/stories/publications/decade_of_action_report_lr.pdf

[5] Elvik, R., Vaa, T., Erke, A., Sorensen, M. (2009). The handbook of road safety measures. Emerald Group Publishing, 2009.

[6] Knoblauch, R., Pietrucha, M., & Nitzburg, M. (1996). Field studies of pedestrian walking speed and start-up time. Transportation Research Record: Journal of the Transportation Research Board, vol. 1538, pp. 27-38.

[7] Institute of transportation engineering. (2016). Traffic engineering handbook. 7th edition, Wiley
[8] Commission directive 94/78/EC (1994). Official journal of the European Communities, No. L 354, pp. 10-15
[9] Olszewski, Z., Waluś, K., Krawiec P., Warguła L. (2015) Numerical Analysis of Stress Distribution in a Car Tire Equipped with Snow Chains, Machine Dynamics Research, vol. 39, no. 1, pp. 135-142
[10] Commission regulation (EU) No 1009/2010, Official Journal of the European Union, Vol. L292, pp. 21-29
[11] Topolnik, D., Zebec, Z., Horvat, R. (2000). Overtaking as indicator of road traffic condition. Traffic safety. vol. 12, pp. 213-216
[12] Tominc, P., & Šebjan, U. (2015). The Impact of Selected Individual and External Factors on the Occurrence of Severe Injuries: Case Study of Slovenia. PROMET-Traffic & Transportation, vol. 27, no. 4, pp. 325-334.

ACTA TECHNICA CORVINIENSIS BULLETIN OF ENGINEERING
ISSN: 2067-3809
copyright © University POLITEHNICA Timisoara,
Faculty of Engineering Hunedoara,
5, Revolutiei, 331128, Hunedoara, ROMANIA
http://acta.fih.upt.ro