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Ivan Kraljević

**Biography**

Ivan Kraljević was born in 1991. He enrolled University of Zagreb Faculty of Textile Technology in 2010. He successfully completed undergraduate university study in 2013, and two years after graduate university study. In 2016 he enrolled doctoral study Textile Science and Technology. Since 2016 he has been employed in the main Croatian factory for socks producing, Jadran Hosiery, where since 2017 he works as a head of knitting and sewing department. Scientifically works within research project IP-2016-06-5278 financed by Croatian science foundation. He published ten scientific papers, whereas his area of research interest is testing and quality control of innovative materials for socks industry and leather.

**Title of dissertation
topic****Study advisor**

Prof Antoneta Tomljenović, PhD

**Date of dissertation
topic defense**

DEVELOPMENT OF METODOLOGY FOR EVALUATING THE ABRASION RESISTANCE OF SOCKS

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Abstract: The abrasion resistance of fine men's socks, made of high content of cotton in full plating by yarns of different composition were tested. The test procedure according to the HRN EN 13770, method 1, was applied, using Martindale abrasion tester and two different specimen holders – standard and modified.

1. Introduction

On the men's socks are placed high demands of usage durability, with particular attention to the abrasion resistance during wearing. In addition to other production requirements, it is very important to harmonize and select yarns for their production [1]. Therefore, the abrasion resistance of fine men's socks, made of high content of cotton in full plating by yarns of different composition (polyamide 6.6, Lycra/cotton and Lycra/polyamide 6.6) were tested in this research. For determination of sock knits abrasion resistance, the test procedure according to the HRN EN 13770:2008 [2] was applied, using Martindale abrasion tester and sampling of socks from the sole and heel. Using the same methodology (determination of specimen breakdown), the comparison of test results obtained using two different specimen holders – standard and modified were carried out, with the purpose of determining the applicability of modified holders made within this research and adapted to the requirements of the HRN EN 13770:2008, method 1.

2. Experimental

The research was carried out on three groups of calf length fine casual, black coloured men's socks of the same size (EU 42). The socks were made using plain stitch on Lonati sock knitting machine E14 of cylinder diameter 95 mm (3 ¾") with 168 needles and ironed at a temperature of 120 °C using a Cortese machine in Jadran Hosiery. Characteristics of socks are shown in Tab 1, including values of fibre content, weight of one sock and mass per unit area of knits.

Table 1 Characteristics of three groups of calf length casual man's socks

Sock sample	Fibre content (%)			Plating yarn		Weight of sock (g)	Mass per unit area (g/m ²)
	Cotton	PA 6.6	Lycra	Foot and leg	Toes and heel		
1	78	21	1	PA 6.6	PA 6.6	19.9	189.9
2	91	6	3	Lycra/cotton	PA 6.6	19.8	199.9
3	78	19	3	Lycra/PA 6.6	PA 6.6	19.9	237.6

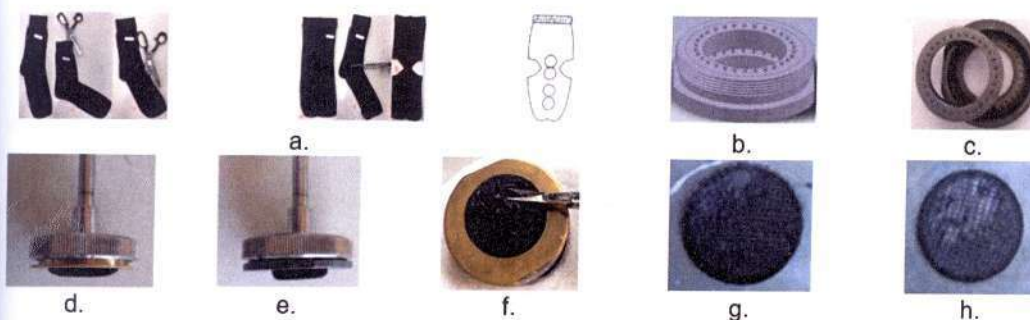


Figure 1 Testing of abrasion resistance: a. Sampling of socks; b. Presentation of the designed; c. produced lower part of modified specimen holder; Sock plain knits; d. standard specimen holder with foam backing; e. modified specimen holder with rubber sphere; f. Removing the pills during the specimen inspection; Appearance of g. hole; h. specimen thinning

The abrasion resistance of socks, Fig 1, was tested by Martindale abrasion tester using two different specimen holders - standard according to the HRN EN ISO 12947-2 and modified according to the HRN EN 13770, where circular plain knit specimens of diameter 38 ± 5 mm were abraded against the reference wool abradant with a cyclic planar motion in the form of a Lissajous figure, loaded with the corresponding weight of 12 kPa.

End point is defined as occurrence of hole (developed when one thread is broken) or significant thinning (when cotton spun staple yarn wears away leaving a base of the synthetic polyamide multifilament yarns) what is periodically checked. During the inspection, pills were removed with sharp scissors with curved blades. The number of rubs to reach endpoint were recorded.

3. Results and Discussion

Lycra plating threads change the structure of sock plain knits as the construction of such socks (of almost the same weight) were tighter and of higher mass per unit area, Tab 1.

Table 2 Abrasion resistance of heel and sole area of socks - determination of specimen breakdown

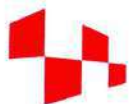
Sock sample	Standard specimen holders, HRN EN ISO 12947-2		Modified specimen holders, HRN EN 13770, method 1	
	Description of the endpoint/ number of rubs to reach endpoint			
	Heel	Sole	Heel	Sole
1	thinning/35000	thinning/35000	thinning/6500	thinning/6500
2	thinning/35000	hole/30000	thinning/6500	hole/6000
3	thinning/35000	thinning/45000	thinning/6500	thinning/7000

In the socks of the first and third group, that contain higher amount of polyamide plating threads, it is worth mentioning the higher abrasion resistance of knits from the sole area of the socks, Tab 2, indicating their better usage durability. Sock sample 3, plated with Lycra wrapped with polyamide 6.6, shows the highest abrasion resistance in the sole area. Only by sock sample 2 with the highest content of cotton, plated with Lycra wrapped with cotton, endpoint was determined with the appearance of a hole. Uniformity was found in the test results for knits sampled from the heel of socks, which was made in the same way in all sock samples. By applying of modified holders adapted to the requirements of the HRN EN 13770, method 1, a lower number of rubs to reach endpoint is required, because the tested specimens are equally stretched over a flattened rubber surface of Martindale specimen holders.

4. Conclusion

The application of modified specimen holders according to the HRN EN 13770 is confirmed because it more faithfully simulates the load of sock knits during wearing and reduces the influence of knit elasticity on the obtained results. In the continuation of the research, the abrasion tester for socks will be developed..

Acknowledgement



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