https://doi.org/10.53230/tgm.1310-912X.2023.00001.04

ИЗПЪЛНЕНИЕ НА ШЕВА НА МОТОРЕН КОСТЮМ

Горан Дембоски, Ружица Стевковска Стояновска

SEAM PERFORMANCE OF MOTORBIKE SUIT

Goran Demboski, Ruzica Stevkovska Stojanovska
University "Ss.Cyril and Methodius", Faculty of Technology and Metallurgy, Department of textile engineering, Skopje, North Macedonia
goran@tmf.ukim.edu.mk

Abstract

According findings, the motorcycle is the automobile industry's fastest-growing product globally. Wearing the appropriate personal protective equipment is mandated in many countries to promote motorcyclists safety on the road, since it is essential for their protection and helps to reduce the risks and severity of injuries. The European Standard EN 13595 for "Protective Clothing for Professional Motorcycle Riders" was created and established in 2002. Recently, new standard EN 17092 has been developed, as complement to the EN 13595, which provides improved seams motorcyclists suit. The objective of the paper is to evaluate the performance of various seam types of motorbike suit. The seams investigated are of class 1 and class 5 and the fabrics applied are Kevlar and Coolmax. The results show that seam construction, and combination of fabric and thread properties, influences mechanism of seam failure and seam strength.

Keywords: seam, breaking strength, motorbike suit

Intoduction

Motorcyclists' protective clothing, like trousers, jackets, one and two-piece suits, have intention to provide some amount of security and protection to driver, without significantly reducing its ability to control and master the motorcycle. Therefore, this type of garment is designed to provide competent protection during a fall from a motorcycle or another accident on the road. Certainly, it should be clear that no protective garments could offer complete protection against all types of injuries [1]. Recent investigations claim that motorcycles are one of the fast growing goods in automobile sector worldwide. However, there has been substantial growth in the motorcyclist accidents rate. Some studies of motorcycle crash accidents, found that riders wearing protective clothing spent less time in hospital, than those who do not. In addition, the protected riders are 40% less likely to have suffered a permanent physical disadvantage [2]. Because the motorcyclists often suffer serious injuries in accidents, manufacturing competent protective clothing without impairing mobility while riding is of essential importance [3]. This garment acts as an obstacle between the biker's skin and tarmac surface [4] and in at best it can decrease or prevent hurting soft tissue and at the same time, the risk of complications and infections. The reality is that almost half of world's fatal traffic injuries are related to these unprotected drivers, together with pedestrians and cyclists [5].

One of the most used material for protection is Kevlar, which is aramid fibre, famous for its ballistic properties, heat resistance, high tensile strength, resistance to abrasion, cuts and punctures. It is a very strong fibre, created by DuPont and invented by Stephanie Kwolek in 1965 [6, 7]. Kevlar is relatively light material, which does not melt, able to withstand chemical hazards [8, 9]. In addition, frequently used material in motorbike garments is Coolmax fabric (blend of Polyester fibres), which offers breathability and moisture management, making it an excellent option for consumers looking for the most possible comfort [8].

The manufacturing of high quality clothing is the result of several combinations: design, style, choice of fabrics, patternmaking, sewing and successful finishing [10]. From all of various assembling methods for joining the textile fabrics, stitching is the most frequent used, as it is easy to apply, flexible, cheap and suitable for most applications [11,12]. The characteristics of a properly constructed seam are: strength, elasticity, durability, stability and appearance, which depend on seam type, stitch density, the thread tension and the thread and fabric properties [12]. Because seams hold the pieces of fabric together in a garment, they must be strong enough to maintain this attribute even under extreme conditions, where the garment is subjected to loads or other internal or external forces [13]. The inappropriate choice of stitch or seam type can cause a failure at garment seams [14]. Lock stitch is very common stitch type that can be used for woven and knitted fabrics. It has low thread consumption and it is very secure [11].

Generally, in order to improve the motorcycle safety, many countries mandate the wearing of personal protective equipment. In addition, several standard have been developed aiming to increase safety: EN 13595:2002, EN 13594:2015 and EN 17092:2020. These standards are generally suitable to define the necessary degree of protection in different garment areas. Several studies have investigated the outcome of usage of protectors for motorcyclists [15-17]. The study of Memon *et.al.* confirmed that Kevlar woven & knitted with a combination of 50% polyethylene fibers shows higher damage resistance, favouring its use for sportswear application [18].

The objective of the paper is to evaluate the performance of various seam types of motorbike suit. The first seam is of class 5, sewn

through three layers of knitted fabrics (Coolmax-Kevlar-Coolmax) employing lockstitch stitch type 301 and the second is seam of class 1, employing overlock safety stitch (401.504) for joining two pieces (Coolmax-Kevlar).

Experimental part

Materials and methods

Breaking strength analysis is performed on two different seam types of motorbike suit. The first seam is 5.01.01, stitch type 301 (lockstitch), sewn through three layers of knitted fabrics (Coolmax-Kevlar-Coolmax). The second seam is type 1.01.02, stitch type 401.504 (overlock safety stitch). The second seam joins two pieces consisting of two fabric layers (Coolmax-Kevlar). Stitch type 301 is formed of two threads, needle and bobbin thread. Stitch type 401 is also created of two threads, needle and looper thread, while stitch type 504 is created from three threads [19, 20, 21]. The construction of the stitch types 301, 401 and 504 is depicted in fig 1. The configuration of investigated seam types is shown in fig. 2.

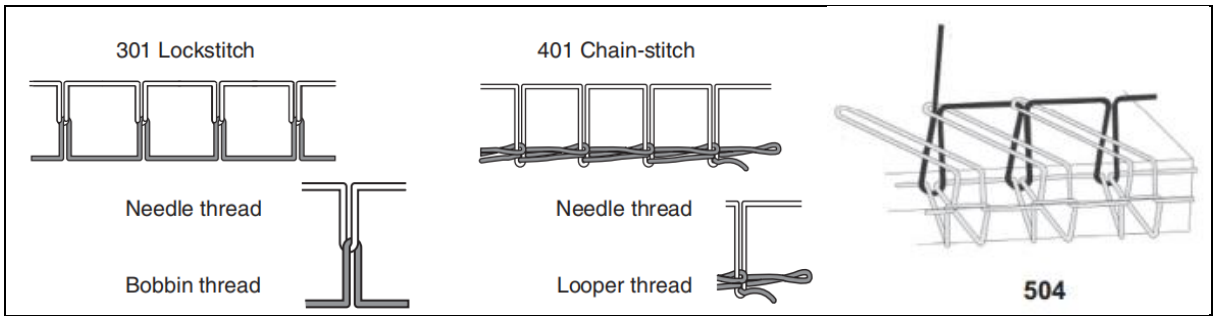
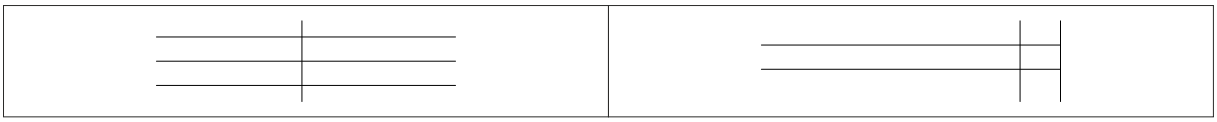


Figure 1- 301 Lockstitsh, 401 Chain-stitch and Overedge chainstitch 504



Seam type 5.01.01 Seam type 1.01.02

Fig. 2. The configuration of seam types tested

The seam strength is defined as a load required for seam failure. The failure of the seam could be the result of the fabric break, the thread break and breaking the fabric and thread [23]. Beside strength analysis of the seams, the breaking strength of the fabrics was also tested.

Methods, apparatus and standards

The newest published standard for seam strength analysis - EN 17092:2020, defines the basic performance requirements advised as essential for motorcyclist's protective garments. As the majority of motorcycle clothing on the market has previously not been certified for seam strength achieving this standard should see an improvement in seams [24]. Still, in this research, the used method for seam strength analysis was according to the standard MKC EN 13594:2016 (standards

for testing motorcycle gloves, since the method is the same), since it was requested by the client. Three individual test pieces of each seam and joins are tested and the mean value calculated. The test involves pulling a seam apart using a tensile testing machine and measuring the force for the break to occur. Tensile testing machine (CRE machine) having rate of traverse of 100mm/min. The jaws clamping distance is 30mm and the seam width 25mm. Tinius Olsen, L-series tensile testing machine was used for testing.

The fabric tensile strength was tested according EN ISO 13934-1 Determination of maximum force and elongation at maximum force using the strip method. Five samples from each fabric in both direction are cut in 20 cm length and 5 cm width. The fig. 3 shows the testing. The mass per unit area was determined using the standard test methods for Mass per unit area (weight) of fabric D 3776-96.

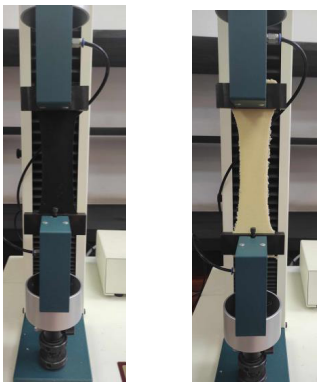


Fig. 3 Tensile testing motorcycle suit materials

Results and discussion

The fabric tensile properties were analysed in both principal directions. It is noticeable that Kevlar fabric show higher strength than Coolmax. Also. the Kevlar fabric obtains higher strength in transversal direction. Coolmax fabric shows greater anisotropy and its longitudinal strength is almost three times higher than transversal one. All the fabric during testing were broken in the jaws.

Table 1. Fabric strength and weight

Fabric Type	Coolmax		Kevlar	
Direction	MD	CD	MD	CD
Weight [g/m^2]	140		260	
Force [N]	564	221	607	653
Extension [%]	92.6	236	132	141

The results of seam strength testing are presented in Table 2.

Table 2. Seam strength of tested seam types

Seam type	**5.01.01**	**1.01.02**	
Stitch type	301	401	504
Force [N]	526.3	210.6	258.6
Elongation [%]	211.8	150.1	217.7
Extension [mm]	63.6	45.1	65.3
Seam strength [N/mm]	21.1	8.4	10.3

The values for seam strength are calculated by dividing the breaking force with the width of the tested seam. The seam type 5.01.01 remains undamaged during testing (thread did not break) and the maximum force represents breaking of the fabrics fig 4.

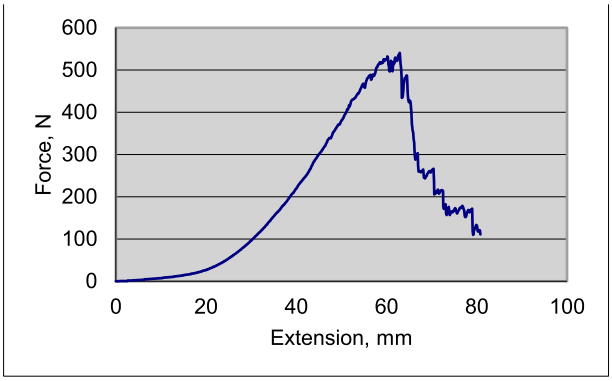


Fig. 4. Force extension curve of the seam type 5.01.01

The force extension curve of the seam type 1.01.02 testing shows quite different behaviour (fig. 5). There are two peaks in the force extension graph: the first peak is breaking of the stitch 401 i.e. the first part of the safety seam and the second peak is breaking the overlook stitch 504, which is second part of the seam. The results is solely attribute to mechanism of seam break, where the seam failure is just the result of sewing thread break. During testing, the thread starts to break and practically gets out of the fabric. The fabric in the seam remains undamaged.

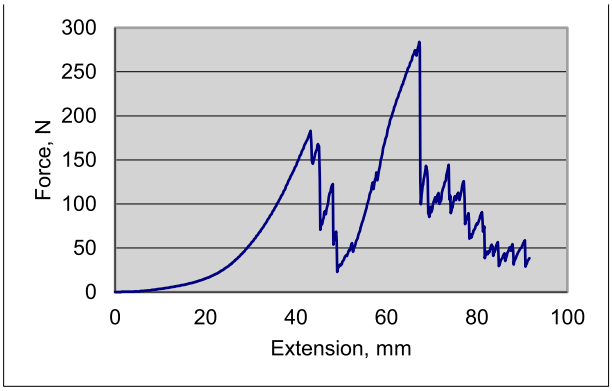


Fig. 5. Force extension curve of the seam type 1.01.02

The seam 5.01.01 type shows excellent performance in terms of safety, comparably to the highest range for AAA class in the first zone, according to the standard EN 17092. The strength of the seam 1.01.02 is within the limits of the standard for different zone and class. Because the performance of the seam 1.01.02 is a result only of sewing thread strength, the performance of this seam can be additionally improved by application of stronger sewing thread.

Conclusion

The basic element of garment quality are the stitches and seams, especially for the motorbike garments, which should protect the biker in case of traffic accident. Various types of garments have specific seam strength requirements, which are affected by factors, such as: fabric mechanical properties, sewing thread type and construction, sewing machine tension, sewing needle type, stitch and seam types and stitch density. When buying protective biker clothing, it is important to ensure that the product has been tested according recognized standards on tear, bursting, impact, and abrasion.

The results of seam testing of two different seam types has shown that seam construction greatly influences seam strength. The results of 1.01.02 seam strength testing shows composition of two peaks, which is result of seam failure mechanism directly due to thread break. The first peak depicts breaking of the 401 stitch and the second 504 stitch. The seam having stitch 504 has 23% higher strength than 401, because the different thread configuration in the stitch. Since the fabric in the seam is composed of very strong fibre, it remains undamaged during testing.

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