List of Publications

Journals

B. K.Samui, M.P.Prakasan, D.Chakrabarty and R.Mukhopadhyay, "Hysteresis characteristics of High modulus low shrinkage (HMLS) polyester tyre yarn and cord", *Rubber Chem. Technol.*, **84**, 565 (2011).

B.K.Samui, M.P.Prakasan, C.Ramesh, D.Chakrabarty and R.Mukhopadhyay, "Structure-property relationship of different types of polyester industrial yarns", J*r. of the Text. Instt*., **104**, 35 (2013).

Conferences

B K Samui, Amardip Kumar and Ramani Subramaniam, "A new laboratory test method for determination of cured cord strength of tyre cord", presented in the International rubber conference and exhibition, Mumbai, India, November, (2010).

B.K.Samui. M.P.Prakasan, Amardip Kumar, D.Chakrabarty and R.Mukhopadhyay "Structure-property relationship of dimensionally stable polyester yarn", presented in the India rubber expo and tyre show, Mumbai, India, January, (2013).

HYSTERESIS CHARACTERISTICS OF HIGH MODULUS LOW SHRINKAGE POLYESTER TIRE YARN AND CORD

BARUN KUMAR SAMUI, MANIKANDA PRIYA PRAKASAN

RESEARCH AND DEVELOPMENT TECHNICAL TEXTILE BUSINESS, SRF LIMITED, MANALI, CHENNAI 600 068, INDIA

D. CHAKRABARTY

DEPARTMENT OF POLYMER SCIENCE AND TECHNOLOGY, UNIVERSITY COLLEGE OF SCIENCE AND TECHNOLOGY, KOLKATA 700 009, INDIA

R. MUKHOPADHYAY*

HARISHANKAR SINGHANIA ELASTOMER AND TIRE RESEARCH INSTITUTE KANKROLI, RAJASTHAN 313 342, INDIA

RUBBER CHEMISTRY AND TECHNOLOGY, Vol. 84, No. 4, pp. 565–579 (2011)

ABSTRACT

Hysteresis characteristics of high modulus low shrinkage (HMLS) polyester tire yarn and cord were evaluated to determine "specific work loss," which indicate its heat generation characteristics. Test parameters were selectively chosen, considering the service conditions of high-speed passenger radial tires in which HMLS polyester tire cords are predominantly used. Specific work loss was found to increase exponentially with the increase in extent of stress relief. Dynamic property of this yarn and cord was also studied to determine "loss tangent (tan δ)," which influences rolling resistance of tires in service. A good correlation has been found between specific work loss of hysteresis test (a slow speed test) and tan δ of dynamic test (a high-speed test). Dynamic property of polyester dipped cord was investigated for a wide range of temperatures (100–180 °C) and frequencies (5–25 Hz). Tan δ at 100 °C was found to be relatively low and its magnitude remained at the same level for a wide range of frequencies. This is a favorable condition for the high-speed passenger radial tires, made out of HMLS polyester tire yarn. Microstructure of HMLS polyester yarn was analyzed. Crystallinity is around 43% (measured by Wide angle x-ray scattering); crystal width and long period are 61 and 142 Å, respectively. [doi:10.5254/1.3614532]

INTRODUCTION

Polyester industrial yarns are used for wide range of applications, viz., passenger radial tires, conveyor belts, v-belts, coated fabrics, etc. Among the polymeric fibers, polyester offers maximum varieties of yarns, which are quite different from each other in terms of properties. Modern spin draw technology produces different types of polyester industrial yarns from the same polymer (Intrinsic viscosity around 0.95[1,2]). Major types of polyester industrial yarns are as follows.

- High modulus low shrinkage (HMLS) yarn—for carcass of high-speed passenger radial tires.
- High tenacity (HT) yarns—for warp in belting fabric of heavy duty conveyor belts.
- Low shrinkage (LS) and super low shrinkage (SLS) yarns—for various coated fabric applications, viz., tarpaulin, tent covers, signage fabrics, etc.

Properties of one particular type of yarn differ significantly from the others and hence the morphology of these yarns is expected to be different from each other to achieve the set of target properties. Properties of the reinforcing textile significantly influence the characteristic and the field performance of the products such as tires, conveyor belts, etc.

"Relationship matrix" between tire performance and tire yarn properties, as has been observed from literature survey[3,4] and appeared to be relevant for our work, is depicted in Table I. It is quite evident that "modulus" of the tire yarn/cord significantly influences most of the characteristics

*Corresponding author. Ph: + 919414156197; email: rm@ktp.jkmail.com

The Journal of The Textile Institute, 2013
Vol. 104, No. 1, 35–45, http://dx.doi.org/10.1080/00405000.2012.693277

Taylor & Francis
Taylor & Francis Group

Structure–property relationship of different types of polyester industrial yarns

Barun Kumar Samui[a], Manikanda Priya Prakasan[a], C. Ramesh[b], Debabrata Chakrabarty[c]* and R. Mukhopadhyay[d]

[a]R&D Centre, Technical Textile Business, SRF Limited, Chennai 600 068, India; [b]National Chemical Laboratory, Pune 411008, India; [c]Department of Polymer Science and Technology, University College of Science and Technology, Calcutta University, 92 A.P.C. Road, Kolkata 700 009, India; [d]Harishankar Singhania Elastomer and Tire Research Institute, Kankroli 313 342, India

(*Received 13 December 2011; final version received 09 May 2012*)

Four major types of polyester industrial yarns (1000 Denier) which are used commercially were studied for their key structural parameters. An attempt has been made to establish a relationship between morphology and properties of these yarns. High tenacity (HT) polyester yarn has the highest birefringence, amorphous orientation, and long period but is relatively less crystalline. High shrinkage characteristic of HT polyester yarn can be accounted for its higher amorphous orientation. High modulus low shrinkage (HMLS) polyester yarn has higher crystallinity and crystal size compared to HT yarn. Fraction of tie molecules of these yarns has been calculated and found that low shrinkage (LS) and super low shrinkage (SLS) yarns have lesser tie molecules. These LS and SLS yarns are tailor-made to achieve lower shrinkage and at the same time maintaining a good level of tenacity. This is achieved with lower amorphous orientation in the final drawn yarn structure. Amorphous orientation was found to have stronger influence than any other structural parameter on the key yarn properties like modulus, tenacity, elongation, and shrinkage.

Keywords: polyester; structure; orientation; modulus; shrinkage

Introduction

Polyester industrial yarns are commercially available for wide range of applications viz. textile reinforcement in passenger radial tires, conveyor belts, v-belts, mechanical rubber goods, seat belts, coated fabrics, geo-textiles, etc. (Table 1). For each of these applications, yarns are converted into cords/fabrics and processed further as per the requirements. The properties/performances of the fabrics are governed by the yarns which are tailor-made for the target applications. Modern spin draw technology produces different types of polyester industrial yarns from the same basic polymer quality i.e. intrinsic viscosity of polyester chip (around 0.95) (Buyalos, Millure, Neal, & Rowan, 1991).

Physical properties of one type of yarn differ significantly from the other and hence the morphology of these yarns is expected to be different so as to achieve the target properties. Numerous research works have been carried out in the past in the area of polyester yarn morphology which may be categorized as follows:

(a) Characterization of polyester yarn through various analytical techniques to study and understand its semicrystalline structure and morphology (Desai & Abhiraman, 1985; Dumbleton & Bowles, 1966; Goschel, Deutscher, & Abetz, 1996; Heuvel, Heuvel, Faasen, Veurink, & Lucas, 1993; Lemanska & Narebska, 1980; Lindner, 1973; Smole & Zipper, 2000; Sotton, Arniaud, & Rabourdin, 1978; Valk, Iellinek, & Schroder, 1980; Wong, Chan, Yeung, & Lau, 2003).
(b) Studies on influence of spinning process parameters on yarn morphology and its relationship with key yarn properties (Huisman & Heuvel, 1989; Keum, Jeon, Song, Choi, & Son, 2008, Lin, Tucker, & Cuculo, 1992; Wu et al., 1995; Wu, Jiang, Tucker, & Cuculo, 1996; Zhou, Wu, Tucker, & Cuculo, 1995).
(c) Thermal/chemical treatment on polyester yarn and its influence on yarn morphology (Cho, Yu, Youk, & Yoo, 2007; Gupta & Kumar, 1981a, 1981b; Gupta, Ramesh, & Gupta, 1984; Karacan, 2006; Keum & Song, 2005; Wang, Tian, Zhang, & Wang, 2011).

*Corresponding author. Email: chakrabarty_deb@yahoo.com

A New Laboratory Test Method for Determination of Cured Cord Strength of Tyre Cord

Barun Kumar Samui, Amardip Kumar and Ramani Subramaniam

Research and Development Centre
Technical Textile Business, SRF Limited;, Manali, Chennai-600 068; INDIA
Tel.: 91- 44- 25946303; E. Mail: bksamui@srf.com

Tensile strength of the tyre cords drops during tyre manufacturing process (primarily in fabric dipping and tyre curing) due to various thermal and chemical treatments and during service due to fatigue. No standard laboratory test method (ASTM / BISFA etc) is available for determination of cured cord strength of tyre cords.

An attempt has been made to develop a test method for determination of cured cord strength of tyre cord by using a specially designed mould (Refer Fig1)

Empty Mould

Mould with Rubber – cord layers

Fig 1.Mould for making rubber-cord composite

Different layers of rubber compounds and tyre cords as placed in the rubber cord composite is depicted in Fig.2.

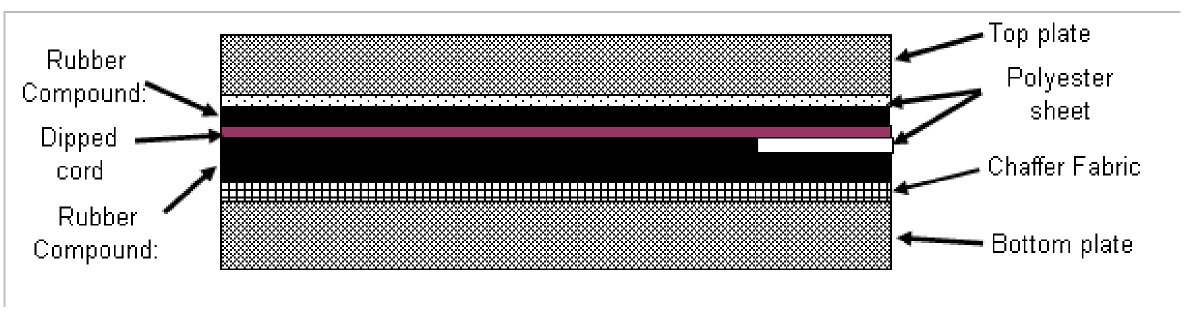

Fig 2. Layers of rubber compound and tyre cord

Individual cords during curing in a tyre curing press are subjected to tension. Such tensions whilst curing is simulated in this experimental set up, by using dead weights during curing in a single daylight press. (Refer Fig3). This feature has been incorporated in the test so that the curing conditions followed in the laboratory test are closer to the actual tyre curing process. Cured cords are then peeled from the

STRUCTURE-PROPERTY RELATIONSHIP OF DIMENSIONALLY STABLE POLYESTER YARN

BARUN KUMAR SAMUI, MANIKANDA PRIYA PRAKASAN, AMARDIP KUMAR AND RAMANI SUBRAMANIAM
RESEARCH AND DEVELOPMENT
TECHNICAL TEXTILE BUSINESS, SRF LIMITED, MANALI, CHENNAI-600 068; INDIA

D. CHAKRABARTY
DEPT. OF POLYMER SCIENCE AND TECHNOLOGY; UNIVERSITY COLLEGE OF SCIENCE AND TECHNOLOGY; KOLKATA – 700 009; INDIA

R. MUKHOPADHYAY (*)
HARISHANKAR SINGHANIA ELASTOMER AND TYRE RESEARCH INSTITUTE
KANKROLI; RAJASTHAN -313 342; INDIA

ABSTRACT

Dimensionally stable polyester yarn and more specifically high modulus low shrinkage (HMLS) polyester yarn is the preferred reinforcing material for carcass / body ply of high speed passenger radial tyres. One of the key requirements of high speed passenger radial tyre is “uniformity”. “Dimensional stability” of the tyre at high speed is the utmost important factor which influences “uniformity” of the tyre. Properties of HMLS polyester yarn is tailor made to meet the requirements of high speed passenger radial tyres.

A detailed study on “hysteresis” and “dynamic properties” of HMLS PET yarn (1000 denier) and cord (1000/2 denier) indicates that a good co-relation exists between “specific work loss” of hysteresis test (a slow speed test) and “tanδ” of dynamic test (a high speed test). Dynamic property (tanδ) of HMLS polyester dipped cord (1000/2 denier) was fund to be relatively low up to temperature 100^{o}C (maximum service temperature of a passenger radial tyre) and found to be remained constant for a wide range of frequencies. This is a favourable condition for the high speed passenger radial tyres which satisfies the requirements of the tyre designer towards achieving lower rolling resistance and improved fuel efficiency.

Properties of HMLS PET yarn are quite different than that of other types of polyester industrial yarns viz. high tenacity (HT), low shrinkage (LS), super low shrinkage (SLS) etc. This is achieved through creation of specific yarn structure / morphology. An elaborate study on “structure-property relationship” indicates that HMLS PET yarn has higher crystallinity and crystal size than that of the HT PET yarn. “Amorphous orientation” has influence on most of the important yarn properties. Amorphous orientation of HMLS PET yarn is lower than HT PET yarn which has resulted lower shrinkage. At the same time HMLS PET yarn has higher fraction of tie molecules. This unique combination makes the HMLS PET yarn a dimensionally stable yarn, which is the preferred material for reinforcement of high speed passenger radial tyre.