Received 10 August 2010
Accepted 14 April 2011

A small deflection model for yarn bending in a plain weave fabric

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Abstract

Purpose – The purpose of this paper is to establish a simple and practical elastica model for the deflection of weft (warp) in a plain wave fabric.

Design/methodology/approach – The weft yarn is considered as an elastic beam fixed supported at the ends and deflected in the middle by a vertical load. An analytical model, based on the elastic theory and small deflection case is adopted to study the factors affecting the deflection of the yarn. To investigate the model, yarns with different rigidities are used. A total of five different yarn counts are produced in the same ring spinning system and then used as weft yarn in a plain weave fabric. All other parameters of the yarns and the fabrics are kept identical. Fresh fabrics are analyzed and the maximum deflection of the weft is measured using the microscope. The actual curves of the deflected weft are then compared with the theoretical curves.

Findings – The experimental curves show to agree well with the theoretical model. The results also show that as yarn linear density decreases, the deflection increases.

Originality/value – The paper shows that while the large deformation "elastica" theory is typically used for woven fabric modeling, the small deflection theory can be useful for rapid computation.

Keywords Weft deflection, Elastic beam, Fixed-fixed beam, Small deflection, Fabric testing, Yarn testing

Paper type Research paper

1. Introduction

A major source of attention for many researchers has been thread deflection shape and geometry because it affects many of the fabrics' different characteristics. For instance, surface properties of the fabric such as yarn protrusion, friction, touch, etc. are affected by thread deflection in the fabric. Visual properties of the fabric surface such as light reflection and luster are also affected by thread bending. More importantly, mechanical performance of the fabric depends to a large extent on the geometry and shape of thread deflection in the fabric.

An early attempt in modeling thread deformation was made by Pierce (1937), who assumed a plain geometry for the deformation of threads in a plain weave fabric, neglecting yarn rigidity. This model was widely accepted and used. Kawabata proposed a three-dimensional model based on the assumption that weft and warp axes were on straight lines (Kawabata *et al.*, 1973). A saw tooth model was also proposed by Leaf and Kandil (1980), which yielded acceptable experimental results.

A number of studies were devoted to the analysis of the different factors affecting weft deflection in the fabric structure (Hosseini Ravandi and Ghane, 2000; Hosseini Ravandi and Ghane, 2004). The model used in these studies was based on a fixed-fixed

International Journal of Clothing Science and Technology
Vol. 23 No. 5, 2011
pp. 310-320

0955-6222
DOI 10.1108/09556221111166248

The authors would like to express their sincere thanks and gratitude to the Deputy for Research of Isfahan University of Technology for financial support.