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Cotton Yarn Engineering Via Fuzzy Least Squares Regression

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Abstract: Modeling of yarn and fiber properties has been a popular topic in the field of textile engineering in recent decades. The common method for fitting models has been to use classical regression analysis, based on the assumptions of data crispness and deterministic relations among variables. However, in modeling practical systems such as cotton spinning, the above assumptions may not hold true. Prediction is influential and we should therefore attempt to analyze the behavior and structure of such systems more realistically. In the present research, we investigate a procedure to provide a soft regression method for modeling the relationships between fiber properties, roving properties, and yarn count as independent variables and yarn properties as dependent (response) variable. We first selected the effective variables by multivariate test (mtest) and then considered fuzzy least squares regression for evaluating relationship between cotton yarn properties such as tensile, hairiness, unevenness and fiber properties that were measured by HVI system. We also used mean of capability index (MCI) to evaluate the goodness of fit of the fuzzy regression models. The results showed that the equations were significant at very good MCI levels.

Keywords: Multivariate test, Fuzzy least squares regression, Mean of capability index (MCI), Cotton yarns, Ring spinning, Yarn quality properties

Introduction

The main purpose of many textile studies in the past century was to predict the yarn's important characteristic such as tensile, unevenness, and hairiness of yarn from fiber properties. Two main approaches used in these studies are statistical and mathematical approaches. One of the most common statistical approaches is the multiple regression method. Many researchers used linear multiple regression method for the estimation of yarn quality characteristics [1-5].

In spite of classical regression models in many fields, however, in practical studies the following problems arise in using statistical regression modeling: 1) low sample size, 2) imprecise observation, 3) vagueness in the relationships between variables (which do not follow the random error patterns). For instance, in quality studies of fine and expensive fabrics, the number of data available may be few. Also in Nano-fiber electro spinning, there are very low productions and complex conditions. Such situations, in which the data is few or relationships between variables are not precise (have been reported in literature [6,7]). We need, therefore, to investigate some alternative soft procedures to deal with the above situations. Fuzzy set theory provides appropriate alternative procedures for modeling the variables of interest when only few data are available and/or the data are reported as imprecise quantities and/or the relationship between variables is defined vaguely.

Over the past decades, several approaches to fuzzy regression have been developed by authors. From a general perspective, there are two main approaches to regression modeling using the fuzzy set theory. The first one, which is introduced by Tanaka *et al*. [8] is called possibilistic regression. In possibilistic approach, the coefficients of the model are assumed to be fuzzy numbers. This approach is essentially based on transforming the problem of fitting a fuzzy model to a linear (non-linear) programming problem. This approach has been developed by some authors [9-11].

Another approach to fuzzy regression is the fuzzy least squares approach which is an extension of the ordinary least squares regression and is proposed by Celmins and Diamond [12,13]. In fuzzy least squares approach, the optimal model is derived based on a distance between the observed (fuzzy) values and the estimated fuzzy values of the response variable. This approach is also investigated by some authors [13-16]. A review of the literature on the topic is provided in Taheri [17].

In spite of several works in theory and applications of the fuzzy regression models, as far as the authors know, there have been a few works in applications of fuzzy regression analysis in textile researches. In this regard, we could indicate to a work by Tavanai *et al.* [18]. They investigated and applied fuzzy possibilistic regression for modeling the colour yield in polyester high temperature dying as a function of disperse dyes concentration, temperature, and time.

In the present work, we investigate a fuzzy regression method for modeling the relationships between fiber properties as independent variables and yarn properties as dependent variables. In fact, after selecting effective variables by using the common statistical methods, a fuzzy least squares regression was used to predict the cotton yarn's important

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