THE EFFECT OF MFI OF HIGH-DENSITY POLYETHYLENE ON THE
MATHEMATICAL MODELING OF TENSILE CHARACTERISTICS

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ABSTRACT

Several high density polyethylene grades produced in the State Company of Petrochemical Industries (SCPI) were fabricated to sheets and tested for tensile strength. The stress-strain curves were analyzed and the tensile data were estimated. Mathematical models were designed and correlations were developed to express the effect of melt flow index (MFI) as an additional independent variable of the models. The exponential form of the model for the grades with MFI values >1 seemed to represent the real tensile behaviour of the grades. Less positive effect on the developed models was observed for grades of MFI <1. The developed models are candidate to be used to determine tensile characteristics of all polyethylene grades produced in SCPI specially those of MFI>1 without the need carrying out destructive tensile tests.

INTRODUCTION

Polyethylene is a thermoplastic, chemically rather inert and electrically, a first –class insulator. It combines flexibility and toughness with insensitivity to moisture, low volume cost and ease of fabrication(1).

Commercially available polyethylenes have densities in the range 0.91-0.97 g/cm³ and are divided into two categories low density (density range 0.91-0.94 g/cm³) and high density(density range 0.94-0.97 g/cm³)(2).

In the State Company of Petrochemical Industries (SCPI), two main types of polyethylenes are produced; homopolyethylenes and 1-hexene/ethylene copolymers in which the ethylene is the major constituent; the latter may contain various amount of 1-hexene.

Both homopolymers and copolymers are obtained in various grades (3). The grades of the individual types have virtually approximate density, but they differ in melt viscosity. Some physical properties of polyethylenes produced in SCPI are given in table (1).

The properties of particular grade depend primarily on molecular weight and degree of crystallinity. Both factors are controlled during the polymerization process (4).

Because density is related to crystallinity, and is easier as well as more convenient to be measured, it is usual to quantify the density of a polyethylene rather than its crystallinity. However, density is not a complete index of the structural state of polyethylene.

In practice, the molecular weight is not determined, but melt viscosity is determined and expressed as the melt flow index (MFI) at 190°C and 2.16 kg(5). Thus, polyethylenes are classified in terms of density and MFI. One of the most important characteristics of polyethylene is its mechanical properties from which the end uses become apparent and limitations recognized (6). Among these characteristics are the tensile stress–strain properties, the test of which represents as plots of the force required to produce a given elongation for sample specimens of standard sizes.

Because of the fundamental viscoelastic nature of polymers, the stress-strain properties and other aspects of mechanical behavior often very strongly influenced by rate of application of stress and temperature (7,8,9).

In the present work, the tensile stress-strain characteristics for eight different grades of high density polyethylenes produced by SCPI were investigated experimentally, and the acquired tensile parameters were determined. The tested grade were divided into two categories; the first is of 0< MFI <1 and the second MFI >1. An optimization technique using Least-Square method was adopted to the mathematical analysis of the mechanical data. Two mathematical models (linear and exponential), describing the true stress-strain behaviour of high density polyethylenes, were estimated. The independent variables of the models were the elastic models and melt flow index. The coefficient of the models and the well-known adjacent factors(10,11) were determined. The designed models were