1.0 Introduction

Study of handle characteristics of fabric in an organized manner, in other word evaluation of quality of fabric in terms of tactile, aesthetic, comfort, etc, is always a matter of interest since so many decades. In fact this subject probably simultaneously evolved since the inception of textile technology. Traditionally it used to be envisaging that these are subjective parameters of the fabric and can be judged only subjectively. Many developments have taken place over the past century and still counting.

Way back in 1930 Pierce [1] suggested that fabric handle if a measureable quantity objectively. In recent past it has been pointed out by many researchers that it is quantifiable and can be objectively judged. It has been established that many mechanical properties of fabric particularly low stress mechanical properties influence the aesthetic and comfort properties related to human tactile sensation and are referred as handle of fabric or feel of fabric. Over a period of time many researcher tried to establish relationship among these variables. At the same time, many new dimensions of quantifications of those mechanical properties of fabric are explored. One of such technique and the most talked technique in recent past is nozzle extraction technique.

The concept of nozzle extraction is pulling a fabric through a narrow space in the form of ring or a hollow right circular cylinder or hollow frustum of cone as the case may be. It is obvious that the force required to pull the fabric as mentioned varies according to fabric properties as well nozzle properties. These parameters provide a measure of handle of fabric, as reported many researchers viz. Hearle et. al.[2] , Pan et al.[3-5], Kawabata et. al.[6,7], *Postle* et al [8], Behera et. al.[9], Gong et.al.[10], Sultan et. al.[11] and Grover et. al.[12].

During nozzle extraction testing procedure, the fabric is subjected to folding/bending, compression and rubbing. Therefore, the forces involved in the nozzle extraction testing procedure are related to the low stress mechanical properties like

bending and shear of the fabric. Pan et. al.[6] investigated correlation of the mechanical and physical properties and the general shape of the curve of nozzle extraction test. They found that the curve was strongly influenced by bending stiffness, compression properties, surface roughness, tensile energy, thickness, weight and shear hysteresis of the fabrics. Correlations between different physical properties of fabric and nozzle extraction parameters are also recommended by Kawabata [7] and stressed that more investigation in this regard are needed.

1.1 Objective of the present study

The main objective of the present study is to develop an instrument based on much acclaimed nozzle extraction principle to study the handle characteristics of fabric keeping in mind the followings:

1) The instrument must be a simple one for its application and interpretations of results.
2) The instrument should be low cost so that any small to medium sector of manufacturer can afford to have it and use it.
3) A major concern in textile material and its testing is low degree of reproducibility due to its inherent nature of variability. Therefore, major focus has been given to design and adjust the machine variables in such a way that provides reproducibility of the test results and establish the validity of the instrument.
4) To carry out a representative study of handle characteristics of fabric in the newly developed instrument to demonstrate the usefulness of the instrument and provide a quick guidelines for its uses and areas of applications.

Therefore, in the present study main focus was given to develop a simple, cost effective, easy to use instrument based on nozzle extraction principle on the basis of experience of the previous researchers to study the handle characteristics of fabric objectively. The focus of the said development is to minimise external influencing factors in the process of measurement. Also efforts have been made to study the reproducibility of testing, which is a major concern in textile material due to its inherent nature of variability and hence low degree of reproducibility.

Attempts have been made to overcome the limitations of complicated measurement and to develop a simple, inexpensive and reliable objective method to measure the fabric hand value. In this method, the force generated while withdrawing a fabric specimen through a nozzle was measured. The extraction force generated due to the combined deformation of the fabric sample related to the bending, shear, tensile, compression, and friction. The earlier studies on fabric hand by extraction method concentrated on correlating either the withdrawal force with Kawabata evaluation system for fabric measurements or the extraction force with hand related surface and physical properties. The fabric surface and physical properties are not only the parameters on which the extraction force depends. The variables during testing, like speed of extraction, repetition of extraction, shape of the sample, may also have some effect on extraction force.

It is hereby reported that an instrument namely fabric feel tester has been successfully developed to evaluate the handle characteristics of fabric objectively using nozzle extraction principle. The measurement technique of the instrument comprises of number of load cells attached to the measuring head to measure the forces exerted by the fabric while drawing out of the nozzle. The force required to draw the fabric through the nozzle in the direction of pulling or in other word axial direction is referred as extraction force. The force exerted by the fabric on the wall of the nozzle through which it is being pulled or in other word the radial direction of pulling is referred as radial force.

The nozzle through which the fabric is pulled is split nozzle. The nozzle is slit through the centre in vertical axis. Therefore, the radial force recorded in the instrument in both the parts of the nozzle separately and are referred as right radial force and left radial force with respect to the relative position of the same.

The said instrument is having many modern features like it is a user friendly, automatic, low cost, low maintenance, fully computerized instrument. Instrument doesn't demand special attention and the ambient condition required for the instrument is same as in normal testing laboratory. No other extra attachment like compressor, balance, etc are required. The instrument does not demand high skill operator to run it and store the test results, only a basic understanding of computer is sufficient.

The nozzle extraction forces depends upon many attributes of fabric since its inception to special finish applications. These attributes particularly like materials, yarn, fabric particulars i.e. ends and picks per inch, finish application etc. determines the handle characteristics of fabric. On the other hand, the above mentioned fabric attributes also directly or indirectly determines the extraction force.

Therefore firstly an attempt has been made to find out the dependence of the forces of extraction and various fabric attributes mentioned above. Therefore, firstly from the preliminary study outline of suitable variables related to fabric parameters, nozzle parameters, fabric sample parameters have been identified. Thereafter, efforts have been made to identify some of the important mechanical parameters of the fabric relevant to fabric handle. Efforts have also been made to establish relationship among fabric parameters and the nozzle extraction parameters. It has also been tried to establish a general guideline to evaluate the fabric parameters with nozzle extraction parameters.