(#52) Development of A Durable Cutting Technology for Enhanced Efficiency in Textile Manufacturing

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Abstract

This study focuses on the development of durable cutting technology to improve efficiency in textile manufacturing, specifically for cutting thin fabric straps like shoulder straps for female undergarments. The research aims to design a cutting blade and mechanism actuated by a pneumatic actuator and controlled by an HMI-based system. It addresses the need for a durable cutting edge and proposes a method to model and design an effective cutting process. The study involves examining the mechanical properties of fabrics, frictional coefficients, and cutting mechanisms. It also explores the selection of actuation techniques and control systems, including the development of a ladder program to operate the mechanism. The methodology includes designing the blade using parametric curves, calculating cutting forces, and determining the wedge angle and blade thickness. Simulations ensure the blade's strength meets the requirements for cutting force. The research identifies factors affecting cutting tool effectiveness, such as wedge angle, curvature of the edge, and blade thickness, which influence the cutting force needed for different fabric piles. The study contributes a solution that can be applied in the textile industry for productive and cost-effective cutting strategies.

Keywords: *Fabric, blade, parametric, pneumatic*

Introduction

The research is based on developing technology for fabric cutting. The technology is based on cutting edge and a mechanism. The study is based on designing a cutting blade along with a cutting mechanism which the blade can be driven and actuating the mechanism using a pneumatic actuator and designing an HMI-based control system to control the cutting mechanism. The study mainly focuses on the cutting geometry and the cutting mechanism. Overall design concepts that are brought through this study can be applied in the textile industry to productive and cost-effective cutting strategies. This

study mainly focuses on cutting thin fabric straps mainly shoulder straps of female undergarments which are single-pile clothing. The force required for the shearing of these fabrics is much less.

The research gap identified in this study is developing a durable cutting-edge technology to minimize the drawbacks of existing cutting methods, proposing a suitable method to model the cutting edge using parametric curves, and designing the system to ensure an effective cutting process. This research provides a better solution for the industry.

The novelty of this research is that the design of the blade starts with mathematical curves called parametric curves. The cutting edge of the blade is modeled and designed using mathematical curves. The cutting mechanism is designed to drive the blade, and the controlling strategies are designed to suit the cutting mechanism. Providing overall cutting solutions to the industry.

Several fields should be studied before this study, Some of them are the mechanical properties of fabrics [1], [2], frictional coefficient of the fabrics[3], [4]. Fabric cutting mechanisms and important parameters. Selecting a proper actuation technique for the cutting mechanism and selecting a suitable HMI and a PLC for the control process. The study also focused on developing a ladder program to drive the mechanism.

Methodology

The first approach of this study is to study the parametric curves and model an effective curvature. Several parametric curves have been studied and factors affecting the cutting tool effectiveness have been studied. The major parametric curves that have been used are based on mathematical curves. The blade design is the first step of this study. As mentioned earlier parametric curves are used for modeling the curved edge. Then after that the cutting forces are calculated after the wedge angle and the blade thickness are calculated. Fabric is most likely considered as a soft solid. So, suitable wedge angle degrees are used for experimental designs [5]. After designing the blade, the next step is to design the cutting mechanism. The cutting mechanism is designed to drive the cutting blade smoothly and deliver the required shear force to make a clean cut in the fabric. The mechanism is actuated by a pneumatic actuator which is a spring returned single acting cylinder. The reason for using pneumatics in this aspect is it can deliver a higher force within a short period of time. After the CAD model the necessary simulations for the blade were done to ensure its strength characteristics were met to withstand

the cutting force [6], [7]. For this SolidWorks simulation tool is used along with Ansys software. The blade was modeled using its finite element model [8]then after that the simulations were carried out to make sure the blade met its strength requirement. After the simulation stage the next step is to design the pneumatic system [9], [10]. The pneumatic system is composed of a two-by-three directional valve which is solenoid-operated. And a spring-retuned pneumatic piston. The pneumatic system was designed using Festo fluid Sim software. The piston drives with a 10mm stroke. Control system development will be done [11], [12].

Results

There are number of parametric curves that can be used to model the cutting edge among then several parametric curves are used to design the blades and do the simulations. Some met the required strength characteristics, and some did not. The effect of the curvature and the nature of the sharp edge can be studied separately. The result of the overall system's performance is to be analyzed. Factors affecting the cutting tool are the wedge angle and the curvature of the edge. The blade thickness is also an important parameter thickness when it comes to the cutting force. When the thickness is higher the blade can undergo higher cutting forces. If the thickness is reduced, the cutting force it can withstand is lower. Another important factor in the cutting edge is the wedge angle. Higher wedge angles are used for large cloth piles while smaller wedge angles are used for small cloth piles. Ultrasonic cutting is an existing cutting technology that has several drawbacks of tool wear and cutting defects the blade is frequently replaced because of impacts and cracks of the horn. And the cutting performance is less because when the crack of the horn develops with time the fabric is more likely to get struck between that crack and less likely to be cut efficiently. Overall, 5 parametric curve designs are used for the study. The ecliptic-based parametric curve gives a good result of strength characteristics. Further tests and studies should be carried out to determine what is the best elliptic curve variation. Advanced technologies are required for further optimization of the design. The outcomes that come from this study is beneficial for many industries.

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