A SIMPLE SYSTEM FOR THE ONLINE DETECTION OF SKIP/LOOP STITCHES IN SINGLE NEEDLE LOCKSTITCH SEWING MACHINES

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Abstract:

In single needle lockstitch sewing machines, the needle thread consumption of 10 normal stitches for a fabric with a particular number of layers at a particular stitches per unit length is manually measured kept as a reference value. If the value of needle thread consumed per stitch is very small, the length of thread consumed per 10 stitches is used as a comparing value. The actual thread consumed for every 10 stitches is measured online by a rotary optical encoder sensor by converting the angular movement into the linear movement of the thread and continually compared with the reference value. If the online measured length is more or less a buzzer sounds to indicate the variation. The counting of every stitch formed is undertaken by a proximity sensor by sensing the protrusion in the hand wheel of the machine, which rotates once for every rotation.

Key words:
Skip/loop stitch, online, sewing, quality, thread consumption, rotary optical encoder

Introduction

Apparel manufacturing is traditionally labour intensive because of the extensive styles and fabric variations of the products. Most sewing machine manufacturers and some of the larger apparel companies have developed semi-automated sewing stations to perform constant operations across a large style range. These normally require an operator to load the machine, which then automatically sews and stacks the components. Although such stations improve production efficiency, they remove the almost unconscious operator inspection of the operation. The result is that only major seam faults are observed, for example, thread breaks. Other faults, such as mis-stitches or non-included seams for example, might not be detected until the garment is completed or perhaps not until after washing. At this point, the manufacturer’s cost is at a maximum. To reduce the number of defective garments it is necessary to develop complete seam monitoring systems that meet the apparel manufacturer’s requirements of flexibility, cost, and reliability. Thread breakage and skip/loop stitches are common aggravations on any sewing floor because they interrupt production, affect quality, and reduce the earnings and efficiency of production operators (Figure 1). In the case of a locked stitch on the bottom of the seam, if the bobbin thread has not been properly caught by the top thread and as the top needle has ascended, it pulls the top thread back out. When the top thread fails to catch on the underside of the seam, a “skipped stitch” is caused. Also, if the needle or bobbin threads have a lower tension than that the other one, it is likely to be pulled, thereby leading to loop stitch formation. If these failures are not immediately detected in the sewing process, but instead picked up later in the inspection process or, worse, further down the line after washing when the material cannot be salvaged for reuse, it will lead to greater financial loss. Furthermore, if the generation of these defects is detected online it can be corrected and the recurrence of the defects can be arrested. The damage caused by skip/loop stitches is much more severe in leather sewing than textiles because these seams are irreparable.

A study to predict sewing thread consumption has been reported using modelling methodologies to estimate thread cost [2]. An earlier study monitoring the sewing thread consumption of lock stitches and over lock machines using

<table>
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<th>Stitch top view</th>
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<td>Properly formed stitch</td>
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![Figure 1. Diagrams of normal and skip/loop stitches.](http://www.autexrj.org/No3-2010/0331.pdf)
an encoder showed that thread consumption is directly related to stitch balance [1]. Another study reported an online skip stitch detection system using a laser beam reflection method [4]. The latest commercial sewing machine [3] for sewing sensitive products such as automotive air bags has also been developed with sophisticated systems for measuring and comparing the stitch length stitch by stitch as well as the dynamic thread tension. In this work, the aim was to simplify the skip stitch detection setup so that it could be used in the industry as an extra attachment in existing machines and provide operator-friendly work processes at a lower cost.

Device setup

The following are the components that are used to set up a single needle lockstitch industrial sewing machine JUKI Model no: DDL9000 (Figure 2).

The needle thread from the thread package passes through a pretensioner and then moves 360º around the pulley inserted on the shaft of the rotary optical encoder to avoid any thread slippage (Figure 3). The thread passes next through the thread tension regulators, take-off lever, guides, and needle. As the stitch is formed the required amount of thread for one stitch will be pulled from the thread package in every stitch cycle. Therefore, for every stitch the encoder shaft will rotate a certain amount of degrees and the same amount will also be measured. The microcontroller program will then finally convert the angle signal into a length unit in millimetres using the following relationship:

- Circumference of the inner pulley - 20 mm,
- Thread length passed through in one full revolution of 360º - 20 mm,
- Thread length passed through in a 1º angular movement - 20 mm/360º = 1/18 mm.

The rotary optical encoder is fitted over the machine to measure the needle thread as shown in Figure 4. The proximity sensor is fitted behind the hand wheel as shown in Figure 5. The full setup of the control unit is shown in Figure 6.

- A rotary optical encoder/angle sensor - the sensor for measuring thread consumption (Bourns-EN rotary optical encoder);
- An emitter-receiver setup/proximity sensor - the sensor for detecting the number of revolutions (Inductive Proximity Sensor Reference 557-TFC-947-5-2); and a microcontroller (PIC16F870).

http://www.autexrj.org/No3-2010/0331.pdf
Methodology

The concept is mainly based on the fact that the amount of thread consumed per stitch is constant under the following conditions:
I. Uniform thread tension;
II. Constant stitches per inch (SPI) and
III. A constant number of layers of fabric.

Needle thread consumption per 10 normal stitches is measured for specific SPI and the number of layers of a particular fabric that will be stitched using the same thread (by unravelling after stitching) and the same thread consumption is kept as a constant reference value. The calculation for the current experiment is shown below.

The needle thread consumption of the normal stitch was measured for different numbers of layers of a fabric at two SPI and during this study the following values were kept constant:
- Thread-3 Ply, 37.5 Tex, Spun Poly and fabric type: 75 × 65, 180 GSM, plain cotton,
- Static Tension of needle 150 g and bobbin thread 50 g.

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Table 1. Average thread consumption in millimetres per 10 stitches for various SPI and fabric layers.

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<tr>
<th>SPI</th>
<th>No. of fabric layers</th>
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<tbody>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td>12</td>
<td>23</td>
</tr>
<tr>
<td>14</td>
<td>24.5</td>
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Average thread consumption in millimetres per 10 stitches for various SPI values (Table 1) with the tolerance of +0.5 mm are taken as a base value to compare the online thread consumption measurement. If the measured value is lower or higher than the tolerance limits of the respective reference value it is classified as a skip/loop stitch. Every time the fabric/thread changes the needle thread consumption for a normal stitch has to be calculated for the different numbers of layers of a specific fabric and the same number has to be input as a reference value.

Online thread consumption is measured by a rotary optical encoder sensor. To determine the initiation and conclusion of one single stitch, the revolution of the hand wheel in the sewing machine is counted by a proximity sensor. To compare the values by online determination and to synchronise the inputs from both the components a microprocessor/controller is used.

Working of the mechanism

When the system is switched on, the display will be as shown as in Figure 7.

Figure 7

To move into the setup mode, both switches 1 and 2 (Figure 6) should be pressed together. The display then changes to that shown in Figure 8.

Figure 8

The system will start measuring thread after receiving the first signal from the proximity sensor. The minimum value of the proximity sensor is zero and the maximum value is 10. For example, Figure 10 denotes that four revolutions have been completed and 13 mm of thread has been consumed during sewing. If the amount of thread consumed in 10 revolutions is within the specified limit, the system continues measuring for the next 10 revolutions and so on. If the amount of thread consumed in a particular 10 revolutions is not within the specified limit, the buzzer sounds and the error message is displayed as shown in Figure 11.

Figure 11

When the error message is displayed, the system automatically stops measuring. Simultaneously, the operator should stop the machine and take the necessary steps to rectify the cause of the fault (either skip stitch or loose stitch). Before restarting sewing the system should be reset by pressing both switches together.

Conclusion

This work has attempted to develop a cost effective, easy to use, and handy setup to detect one of the most common sewing defects, namely skip/loop stitches. The application of a skipped stitch detection system in the existing machine setup will greatly minimise the time and effort taken for a visual inspection, which is currently practiced in most garment industries in developing countries. By using low cost and easily available components this work has shown a simple and affordable way to detect skip/loop stitches and minimise the concentration of visual inspection after sewing, thereby improving the quality of sewing products and reducing rejections.

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