Design for Six Sigma Using DMADV for Implementing Sewing Machine

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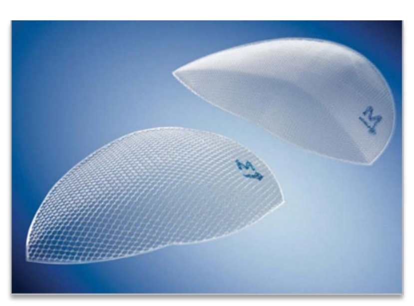
Abstract

This project focus on process design whose aim is to find credible bounding parameters for an industrial sewing machine to minimize production cost, speed up the process and assure an output of high-quality level. Design for Six Sigma (DFSS) was applied to structure a methodology that allows organizing and managing the process activities. This poster shows the implementation of a problem-solving method (DMADV) to improve the performance level of the sewing process. This exercise successfully identified significant factors which affect the product and suggested optimal settings related to the sewing process to produce optimal reliability.

Introduction

A variety of hernia repair products are manufactured at Becton Dickinson Interventional (BDI) Humacao through the use of sewing machines. These machines are used to sew two pieces together, create an orientation marker on the mesh, confine the memory ring, or make a pocket to ease placement and positioning, depending on the nature of the product.



Background

The sewing is one of the critical processes in the determination of compliance with productivity and quality of finished mesh products, and it is the most common way in BD Humacao to fabric the assembly in order to achieve the required seam during its manufacturing. The sewing thread is one of the crucial elements of the sewing process, and there is still no substitute for it. The problem associated with sewing output variations is a combination of the thread material and machine properties that cause breakage in the needle thread during the recurrent sewing operation.

Problem

Most of the machine components are obsolete on manufacturer's catalog. The company has the need to apply a lean project that can help reduce waste. With the replacement of obsolete sewing machines, the company expects to reduce manufacturing issues and meet product demand without incurring in Overtime hours.

Performance Measures		
Metrics	Baseline	Goal
Scrap	29,776 units	56%
Downtime	42 CM	80%

Methodology

- Substitute existing sewing machine processes in terms of machine parameters, conditions, user interface, methods and raw materials as applicable.
- Change of production volume per item
- DMADV approach, a Six Sigma tool for the design of further process characterization.
- DMAIC focuses on constant and continuous incremental improvements.

The DMADV roadmap steps for this project consists of the following:

Define
- Establish the problem, set the scope, identify metrics, and set project goals.
- Verify the performance level and map the main activities.
- Arrive at VOC/VOP

Measure
- Highlight the Critical to Customer features.
- Prepare Measurement System and gather data to understand the performance.

Analyze
- Analyze the process variability.
- Identify the relationship between factors.
- Determine significant factors.

Design
- Apply Design of Experiments optimization

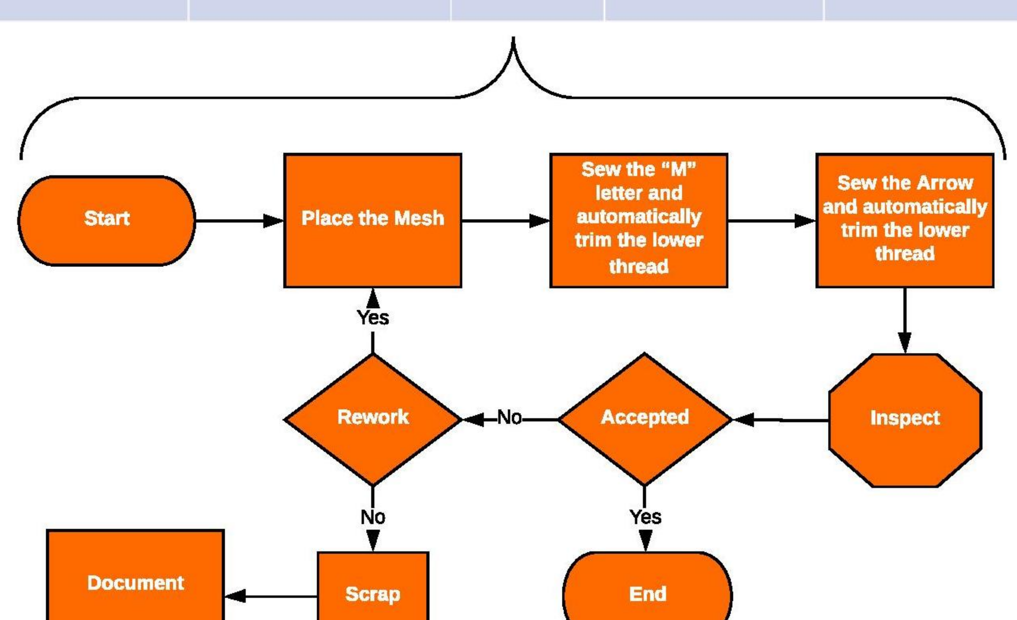
Verify
- Optimal design is validated
- Work Instruction

The key methodology concept is to design new processes and avoid defects with a high-performance level.

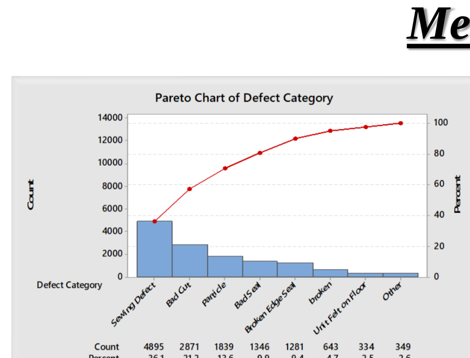
Results and Discussion

Define Phase

Suppliers	Inputs	Process	Output	Customers
➢Blue Polypropylene Monofilament ➢Regular Mesh Cut ➢Light Mesh Cut ➢220VAC ± 10% ➢Compressed Air ≥ 0.5 MPa	➢Sewing Speed ➢Lower Tension ➢Upper Primary Tension Controller ➢Upper Secondary Tension Controller ➢Threading	Sewing	➢Light Mesh with Medial Marker ➢Light Mesh with Medial Marker	➢Operator ➢Documentation



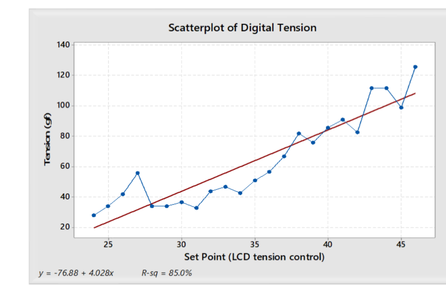
Measure Phase



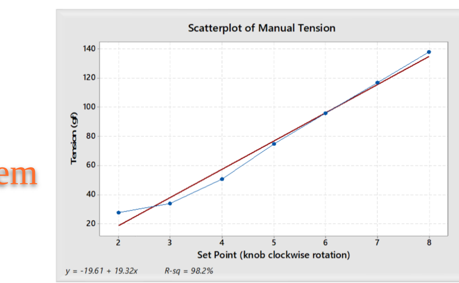
- Critical to Customer (CTCs) features were highlighted
- 1.1 million of meshes from January 2018 to March 2019

Results and Discussion (CONT)

Tension Behavior – Critical aspect of threading process

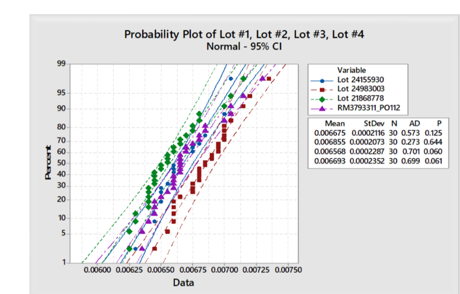


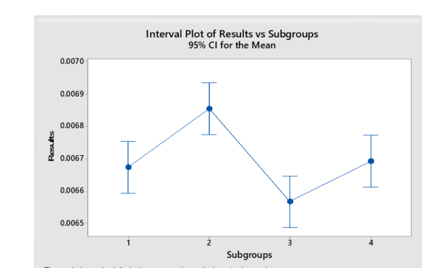
Digital vs Manual System



4 Thread Spools

Thread thickness specification: 0.0063" to 0.0080"

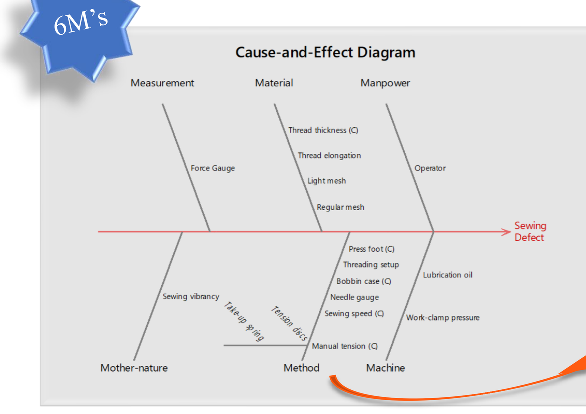




One-Way ANOVA: P-value 0.001

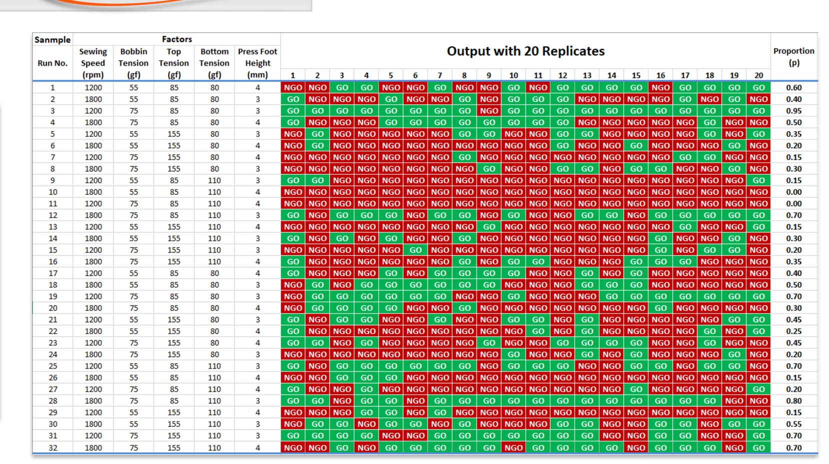
Analyze Phase

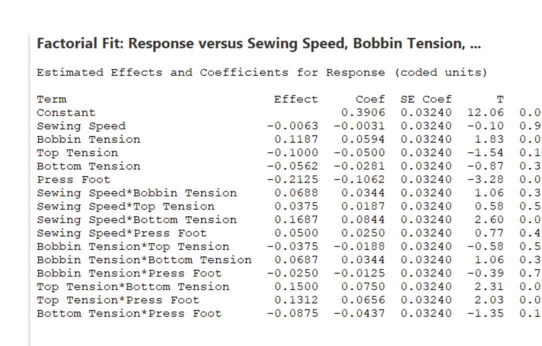
6M's

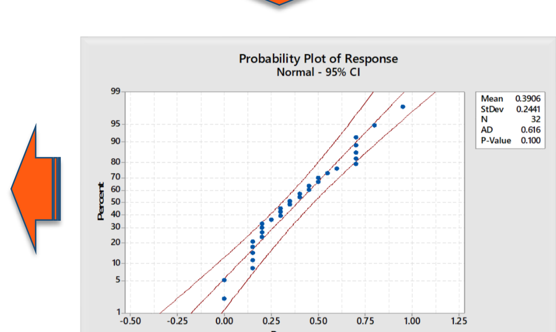


Potential Causes:
- Press Foot
- Bobbin Case
- Sewing Speed
- Take-up Spring
- Manual Tension

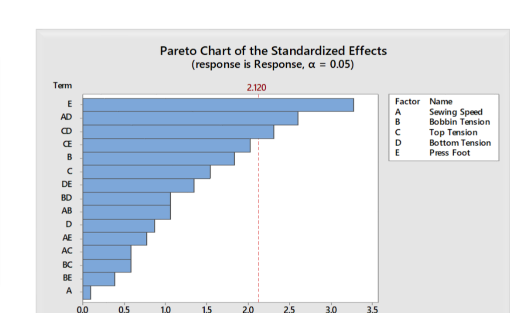
DOE Fractional Factor Design:
- 5 factors
- 32 runs
- 2 replicates
- ½ fraction
- Resolution V

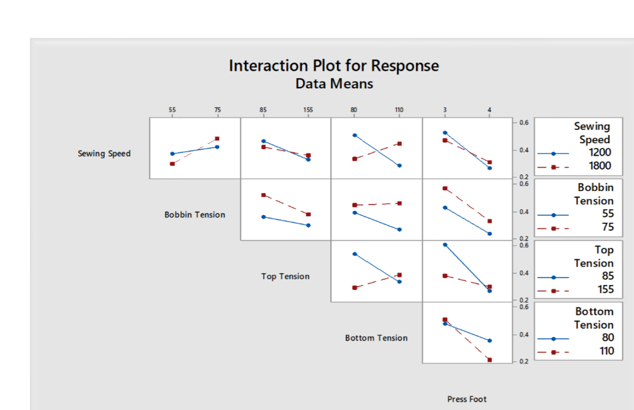


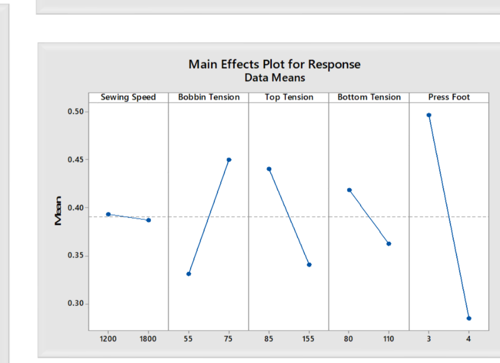




Statistically significant at 0.05 α-level:
- Press Foot
- Sewing Speed with Bottom Tension
- Top Tension with Bottom Tension







Results and Discussion (CONT)

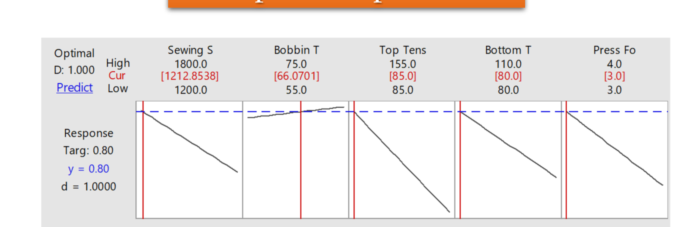
Design & Verify Phases

Factors	Low	High
Sewing Speed (rpm)	1200	1800
Bobbin Tension (gf)	54	68
Top Tension (gf)	85	120
Bottom Tension (gf)	80	110

Hold at Lower Setting

Light Mesh and Regular Mesh as blocks

Response Optimizer



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Full Factorial Design

Factors:   4   Base Design:        4, 16
Runs:     32   Replicates:             2
Blocks:    2   Center pts (total):     0

Block Generators:  replicates

All terms are free from aliasing.
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Conclusions

The Screening Design of Experiments was successfully conducted on the influence of five (5) independent variables on the sewing process and the design model was reduced to four. From the observations, it was determined that the highest yield of the Medial Marker acceptance is obtained near the lower settings.

- Press Foot fixed at 3mm height.
- Bobbin Tension shifted to 54 gf (low) and 68 gf (high).
- Top Tension optimized high level to 120 gf.

Future Work

The best optimal design will be validated to confirm the process parameters windows that were developed thru the process characterization of the Sewing Machine produce the expected output.

Acknowledgements

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