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Efficiency in Laser Etching Textiles: The Proportional Relationship of Power and Speed

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Introduction. Laser cutting is an automated cutting method used across a broad spectrum of industries (Yusoff, Osman, Othman, & Zin, 2010). Laser cutting, which originated in engineering is now a standard of practice within the apparel industry at "macro and micro levels" (Juciene, Urbelis, Juchneviciene, Cepukone, 2014, p. 662), used for cutting garment pattern pieces, as well as, cutting or engraving delicate internal shapes (De La Rosa, 2015). Balance of power and velocity is integral in cutting and engraving textiles to prevent fabric damage (Jackson, Preston & Tao, 1995). Therefore, for this experimental research the goal was to answer the following question: How does power and speed affect the cutting and etching of various textiles while frequency is maintained constant with a Trotec Speedy 400 CO_2? To answer this the researcher used mathematical principles, laser etching tests, and the apparel design process to determine appropriate power and speed parameters of etching and cutting various textiles.

Significance of the Concept. To understand the proportional relationship between power and speed can significantly increase efficiency in laser etching. This knowledge will allow for accurate predictions in manufacturing, such as estimation of design lead time and pricing for engraved products; ultimately increasing profits in their business.

Background on Laser Cutting and the Problem. Trotec Job Control is the software that communicates between a vector software and the Trotec Speedy 400 CO_2 laser machine (Trotec: "Operation Manual Trotec," 2015, p. 6). Once the vector design is uploaded, the Trotec printer driver allows the operator to manage laser cutting variables, power and speed. Documentation on laser cutting and textiles is minimal. Therefore the researcher laser cut and etched 127 textile samples (n=254) to determine the optimal guideline parameters. *Power* (Watts), *speed* (Velocity), and *frequency* (Pulses per Inch) were the variables, where power and speed were manipulated and frequency remained a constant. During the researcher's experimental garment design process, it was discovered that power and speed can be proportionally adjusted, while having no effect on aesthetics. However, efficiency (time) is altered and the overall job time is dependent on the vector textile design's *area*.

Methods. After the initial cutting and etching of the 254 samples, the researcher etching 127 different textiles. The researcher, who is also an apparel designer, created an experimental garment ensemble to further test the results. During the etching process, the researcher discovered that the relationship of *power* to *speed*, is proportional. For example, as the researcher was etching velvet at the determined optimal guideline parameters of *25% power* and *15% speed* the overall time to engrave one segment of a pattern piece the *area* of the laser cutting bed, took over 2 hours. When the parameters were increased from *65% power* and *15 % speed* to etch the same size *area*, the textile was not aesthetically affected and job time was reduced to an hour.

The relation of these variables it graphically represented in Figure 1. Interestingly, when the percentage of power and speed was increased on a vector design that covered a smaller surface area, the job time or efficiency was not affected, as it was with a larger design.

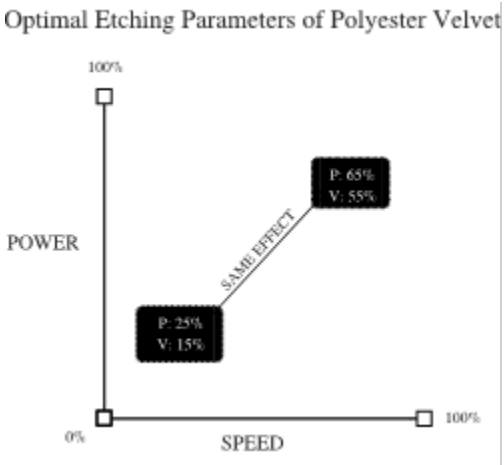

Figure 1. Proposed proportional relationship for adjusting power and speed variables in laser etching.

Proposed Solution to the Problem. Although the researcher discovered that the proportional relationship between power and speed has a null effect on the aesthetics of etched textiles, what is yet to be understood is exactly how the surface "area" (the unit squares)" of the textile design contributes to efficiency in this relationship. Logically, the overall percentage of area that the textile design covers impacts the job time in etching. Strangely, for instance, increasing the power and speed when etching small 1.5" x 2" design may only reduce the job time by a few seconds, while the same proportional adjustment for a 24" x 39" design may reduce the job time by half. The variable of "area" impacts efficiency, hence there is a need for an equation which allows designers to calculate efficiency based on the variables of power, speed, and area when frequency is held constant.

Future Research. The research provides a foundation for determining the optimal parameters for laser etching a variety of textiles based on adjusting power and speed. During the research it was confirmed that the surface area of a vector design is an independent variable in laser etching and power and speed have a proportional relationship. However, to efficiently laser etch an area additional research is needed to create an equation useful in predicting job time.

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