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Art aiding development of technology and science

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Abstract

Multidisciplinary approach changes the traditional way of working in engineering sciences because co-operation requires open attitude and willingness to consider to stop guarding the boundaries of professional skills and know-how. In this study, four case examples are presented to demonstrate how artist-engineer co-operation helped develop laser material processing research during a year. The cases were: laser forming of steel foil, bending of thick steel sheet, laser cutting of silver, and making of technical drawings with organic, complex shapes. The research was conducted in a laser-art-residence by creating an open atmosphere by testing different materials, ideas, and possibilities instead of pre-set research questions. It was concluded in this study that creative work challenges the limits of technology and thus forces it to develop. These limits expose bottlenecks in manufacturing, and further development in these areas typically bring great benefits. The technical solutions found can also be applied and scaled to engineering more generally.

Keywords: Type your keywords here, separated by semicolons ;

1. Introduction

Before times of modern science artists were seen as the innovators for technology. Nowadays innovations are rarely made without technical education. (Malina, 1974) However, solutions to technological applications and problems can still be found in art. A study was conducted in The University of Michigan where Japanese kirigami art was utilized in creating solar panels that incorporate solar tracking. (Lamoureux et al., 2015)

The differences between work cultures of creative fields and engineering present their own challenges and benefits to the co-operation. In creative fields, especially art, the goal is to find ways to stimulate and satisfy human emotions; the truth and facts respected in science are not the driving force. (Candy and Edmonds, 2002) One example of this would be a 3D model where an engineer wants as accurate as possible representation of a real life object. The goal of an artist might be a 3D model that only distantly resembles the original object. In an artist's work the starting point is imagination and toying with ideas, from which point the artist approaches the final goal by narrowing the scope little by little. Working in this manner provides ample empirical ground for engineering work, which in turn serves as basis for new technological innovation. (Malina, 1974; Maijanen, 2015)

This study was conducted as part of the Lares research project. This project was funded by Tekes (Finnish funding agency for innovation) and it was carried out by Lappeenranta University of Technology (LUT) and Saimaa University of Applied Sciences (Saimia) in 2014-2015. Project involved also industrial partners. The project aimed at new know-how and lateral thinking by establishing a laser art residence at the laser processing laboratory at LUT. Similar ideas were explored in Costart project during 1998-2003 in the UK, but it concentrated more on computer-aided visualization of art. (Edmonds et al., 2005)

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2. Case analysis and results

2.1. Laser forming of thin steel sheet

It is not surprising that the engineering industry has not fully embraced the idea of laser forming yet as there are several challenges in process control and accuracy in end product. However, artists have begun exploring laser forming as an additional tool in the making of decorative and artistic pieces that have previously been difficult to realize. (Silve, 2009)

A 200 W continuous wave fiber laser was used for the forming experiments, and additionally a 120 W CO_2 laser was used for cutting the steel foil. The fiber laser was fitted with scan head optics with a focal length of 810 mm. The focused laser beam spot diameter was about 150 µm. The steel foil was placed on the working table with weights pressing it flat against the table. Focused laser beam was moved along the lines of a vectorized drawing, made by an artist. The purpose of these experiments were to produce folds that would both look aesthetically pleasing, and also strengthen the sheet.

Set of experiments can be seen in Fig. 1. It was quickly found out that if the outer edge of the shape was cut prior to laser bending, the multiple bends would quickly distort the shape and thus misalign the laser beam path. This problem was mostly solved by cutting the steel foil only partially prior to laser bending, leaving small bridges in the material that kept the part attached to the steel sheet (see Fig. 1A). Thermal energy imparted to the work piece still induced bending, but it was not problematic anymore.

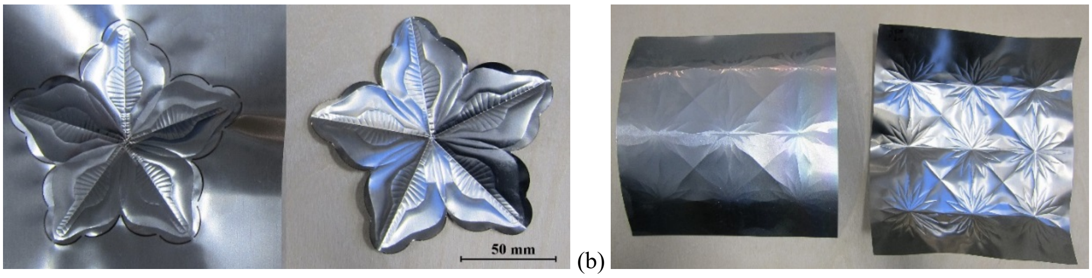
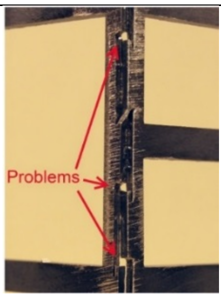
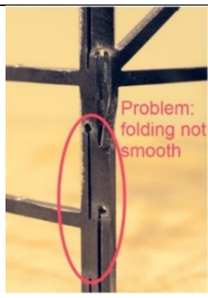
(a) (b)


Fig. 1. (a) Partially cut and laser formed art piece. (b) Laser formed larger area art piece, sheet size 450x450 mm.

2.2. Bending of thick steel sheet

In this case the goal was to find out if a 5 mm thick steel sheet could be partially cut with a dotted cut line by a laser beam. The idea was to produce such a cut that it could then be easily bent by hand, leaving an aesthetically pleasing bend (see Table 1). The idea came from an artist who needed to bend a steel sheet for an art work in a way that was impossible for an edge press machine. A 5 mm thick Ruukki AR 400 Raex wear resistant steel was used for these experiments. The steel plate was cut with a 2.5 kW CO_2 laser.

Table 1. Three examples of bending the steel sheet after laser cutting. Lines are 20 mm long.

		
Vertical distance: 14 mm	Vertical distance: 14 mm	Vertical distance: 14 mm
Horizontal distance: 1.5 mm	Horizontal distance: 2.5 mm	Horizontal distance: 2.5 mm

The idea to modify the bend lines is not new: it is extensively used in e.g. packaging where creases and scoring is used with non-metallic materials (toilet paper, stamps, tearable parts in liquid packages etc.). However, these experiments prove that not only is this method effective in metals, it can also be applied to thicker materials. Even thicker than 5 mm steel plates could be used if needed. Each thickness would require its own set of parameters since the optimal parameters depend on the thickness of the material. Finding out these parameters can be time consuming. However, this technique could easily be developed further. If more than two dotted lines were used, it would enable a smoother, much larger bend radius. This might be useful in applications where rounder shapes are required.

2.3. Laser cutting of silver

A 925 silver sheet with a thickness of 1 mm was cut with a pulsed Nd:YAG laser in these cutting experiments. It is well-known that silver is a difficult material for laser cutting due to its high reflectivity and thermal conductivity, and possibly also due to low surface tension in liquid form. (Nogi et al., 1986) For these reasons lasers with high energy pulses that can quickly punch through the material are typically used in cutting of silver. The artist wanted to try silver cutting at the laboratory because companies that offer laser cutting services are generally hesitant to cut silver with their industrial metal sheet cutting lasers, due to the possibility of back reflections to the laser resonator that might lead to severe damage to the laser equipment.

A pulse length of 0.3 ms, pulse peak power of 2 kW, pulse repetition rate of 100 Hz and cutting speed of 100 mm/min were used to conduct these experiments. In the set-up the silver sheet was stationary and the laser beam was moved along the cut lines. The cut shape can be seen in Fig. 2.

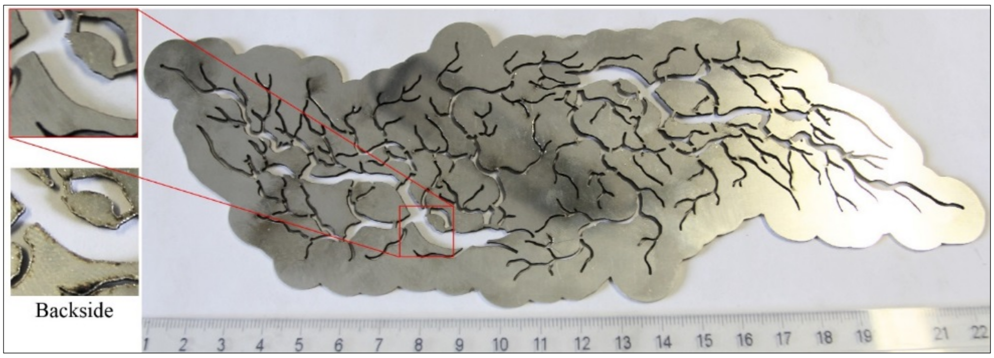


Fig. 2. Bracelet which is laser cut from 925 silver. Shown also are the front and back sides of a small area marked with a red boundary.

2.4. Creation of technical drawings with organic shapes

Making of technical drawings was chosen as the fourth case because as the manufacturing is increasingly digitalized, easy and fast ways of drawing or otherwise producing the technical drawings on a computer is becoming more important. Technical drawing is often challenging but it is especially difficult to draw organic, complex shapes. A common solution is to use either 2D or 3D scanning to scan a real life object and then produce either a 2D drawing (after line tracing the scanned image) from 2D scanning or a 3D model from 3D scanners.

A hand-held 3D scanner was available and the artist in the residence wanted to scan himself and create a 3D model of himself. However, as the artist was going through the process he noticed that the triangulated mesh that was created from the point cloud data received from the scanner could easily be used to create 2D drawings as well. 2D projections from front and back sides of the triangulated mesh were taken and those used as 2D drawings in laser cutting, see Fig. 2.

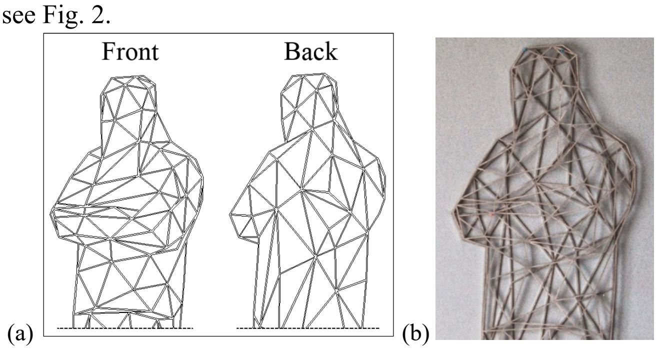


Fig. 2. (a) Top parts of the drawings created from the triangular mesh produced by 3D scanning. (b) Laser cut parts stacked on top of each other.

Varying the number of triangles changes the accuracy of the representation. Overall, while modern equipment was used in the creation of the drawings, the process itself was very quick and relatively easy compared to drawing from or on top of an image. An illusion of a fully 3D object was created by placing these laser cut sheets slightly apart from each other and observing it from a distance.

3. Conclusions

Four case examples of artists working and co-operating with engineers and scientists in an art residence at a laser laboratory were presented and discussed in this study. The cases were selected based on the significance and interest of their contribution to research work. Laser cutting of silver for jewelry was found to be possible, but at the same time a slow process that results in rather rough cut quality. Quality could possibly be improved with parameter optimization. Dotted line laser cutting was used in order to manually bend a 5 mm thick laser cut steel plate. It was found that by cutting two dotted lines parallel to each other and optimizing the horizontal and vertical distances between the cut lines, an easily bendable fold could be created. Ideas for further development of the method includes using more than two lines to create round, smooth bends; creation of bends that will mechanically lock in place once a certain bend angle has been reached; and use of welding to finalize and strengthen the bend.

Laser forming was used to create decorative pieces that could have commercial use. Only thin steel sheets were used in these experiments and few basic guidelines for laser forming of thin steel sheets were formulated. It was demonstrated that laser forming can be used to create decorative, aesthetically pleasing parts. 3D scanning was used in order to quickly produce 2D drawings from existing organic shapes.

Overall, the role of an artist seem to be an initiator of new ideas. These new ideas might initially only be applicable to the particular piece of art that the artist wants to realize but they also open up new possibilities and applications that are useful more generally. The contributions made by the artists and gained benefits are compiled in Table 2.

Table 2. Artist contributions and their benefits in research cases.

Case	Artist contributions	Benefit
Forming of thin steel sheet	• Invent applications for laser forming (decorative) • Thinner steel sheets than have been previously tested • Idea to keep the laser formed part attached to the parent steel sheet during laser forming to help maintain flat shape • Idea to use a thermal camera to control the process • Basic rules for successfully applying laser forming	• New applications for laser forming • New knowledge about a poorly know laser process
Bending of thick steel sheet	• Creation of the art piece for bending experiments and the initial idea for it • Initial tests for finding out optimal parameters for the folds • Ideas for further research	• Proof that there is use for creating laser cut dotted lines to help manual bending • Further research has a lot of potential
Silver cutting	• Material choice • Created a complex drawing for a bracelet for cutting	• New basic knowledge about silver laser cutting • Commercial viability of silver laser cutting
Technical drawings with organic shapes	• Idea to 3D scan and then 3D print the most challenging parts of the design • Idea to use the triangulated models instead of the final 3D models in further manufacturing • Idea to test making 2D drawings for laser cutting from slicing the 3D scanned 3D model • Principle of drawing ideas from every stage of designing process	• Ideas how to creatively use modern technology in manufacturing • Knowledge about compatibility between common 3D scanning and 3D printing technology

As it can be seen from the Table 2, the artists wanted to try laser processes and ideas that were not already widely used because the artists were eager to produce unique art in a unique way. This behaviour seems to suggest that creativity is useful in recognizing new potential in existing technology by using the technology in an unusual manner. Since artists often want to create complicated artworks, their demands also bring out weaknesses of the technologies used. The weaknesses can serve as the basis for future development.

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