LASER FORMING AND CREATIVE METALWORK

RESEARCHER: Dr Sarah Silve

INSTITUTION: Brunel University, UK

DATE OF AWARD: 2001

SUPERVISOR(S): Mr Brian Podschies, Dr Simon Thorne, Prof. Bill Steen

EXAMINER(S): Richard Hughes, Dr Graham Bennett

CREATIVE DISCIPLINE: Silversmithing and Jewellery

RESEARCH METHODS:
- Literature review
- Empirical research
- Scientific method (experimental design models)
- Metrology and numerical analysis

NUMBER OF DESIGN CASE STUDIES UNDERTAKEN BY THE RESEARCHER: 6

LENGTH OF THESIS: 76000 words

EXAMINATION FORMAT: Thesis and oral examination

DURATION OF STUDY: 4 years full-time

EXPERIENCE OF DESIGN PRACTICE BEFORE START OF PHD:
- BA Three Dimensional Design: Silver/Metal
- Jeweller and designer at an independent jewellery company (2 years)
- Model maker at a costume jewellery manufacturer (2 years)

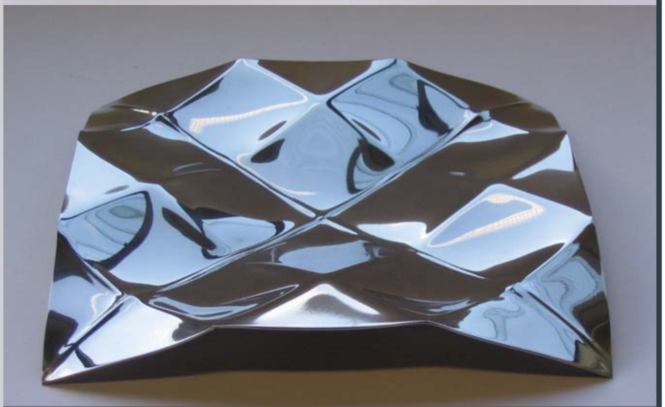
PERSONAL MOTIVATION FOR UNDERTAKING PRACTICE DURING PHD:
- The emergent technology had the potential to create forms not achievable with traditional silversmithing techniques and the investigation provided an opportunity for a sense of continuity and enquiry in personal design practice
- The process offered alternative possibilities for a commercially sustainable practice in a designer-maker context
- The communication of the above contributions seemed best manifested in finished objects so that they could be understood by other practitioners

AIM OF THE RESEARCH:
The aim of the project was to investigate the kinds of forms that could be made by laser forming and to explore the benefits of the process and potential integration within the practice of silversmithing.

RESEARCH QUESTIONS:
- To what extent are designer-makers using CAD/CAM, lasers and rapid prototyping?
- Does laser forming offer any benefits for making craft objects?
- What are the relationships between heating patterns and the resulting forms?
- What potential new forms and aesthetic identities for objects (in respect to metalwork practice) are made possible by this way of working?
- What opportunities are there for limited batch production, modular design, product scaling and product ranges using laser forming?
- How does working with the process change the nature of designing and physical practice? Is the integrity of the designed and made artefact maintained?

OBJECTIVES:
- To undertake a literature review in a number of mapped domains namely: the laser forming process; how lasers work; general laser processes and their use in industry; the use of lasers, CAD/CAM and RP in jewellery, silversmithing and the applied arts; and the wider contextual debate as to the opportunities for such methods to compliment or extend practice versus the diminishing of hand skills
- To investigate the relationship between heating strategies and resulting forms and to determine process capabilities for shaping sheet metal, tubes and spinnings
- To evaluate the contribution of laser forming to creative metalwork through comparisons between the forms achieved by laser and traditional methods.
- To investigate the integration of laser formed components with other metalworking processes, traditional or otherwise.
- To define the advantages and benefits of the process, such as forms not achievable by other means and the opportunities of non-contact processing
- To assess the repeatability of the process and the viability of producing limited batches or modular designs and the implications of CAD/CAM for producing laser formed product ranges, potentially by scaling
- To comment on how laser forming may be 'taken up' by other practitioners with particular regards to 'routes of access'

Dish made of two laser formed parts, Aluminium, 90 x 240 x 45mm



Variable Feed-rate Dish, Stainless steel, 150 x 150 x 22mm

X-Track Vase, Aluminium, 120 x 40 x 140 mm

SUMMARY:

Laser forming is a non-contact Rapid Prototyping (RP) technique that uses the heat of a laser to bend metal sheet and tubes. The work piece is typically moved underneath a laser beam by a Computer Numeric Controlled (CNC) workstation. The process has future applications in the aerospace and automotive industries for producing body panels, whilst on a micro scale it is currently used for aligning the laser diodes in the production of CD and DVD players. The intrigue of laser forming is that it bends without external forces and that there is a relationship between the 2D laser path and the 3D form. This research defined heating strategies and pattern typologies for shaping sheet, tubes and spinnings into forms suitable for silversmithing objects. Laser forming is complex; the study involved a technical and contextual underpinning through a literature review to inform the experimentation, which used empirical and numerical methods supported by metrology techniques and analysis. The research concluded with prospective routes as to the transfer of laser forming into creative metalwork practice.

RATIONALE FOR THE INCLUSION OF DESIGN PRACTICE UNDERTAKEN BY THE RESEARCHER:

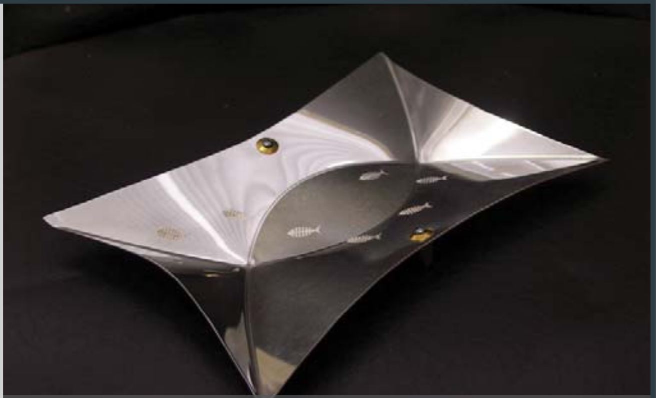
The origins of laser forming pertain to the flame straightening technique, such as is used in ship building. Laser forming as a more precise method emerged in the 1980s and by the mid -1990s the mechanisms for bending metal sheet and tubes were widely reported. Existing research had concentrated on establishing the effects of parameters and optimal rates of bending in alloys by experimentation with single line bending. Few products and applications had been developed, although there were some examples of net shape housings and simple spoons. These products raised interest in the process within engineering however; they could have been made by conventional means and more quickly albeit with tooling. This study demonstrated the wider potential of the process for producing forms that were more fluid and less archetypal than those emerging from engineering research and in doing so to further unpick the relationship between heating strategies and resulting forms. It sought to develop a range of samples that represented possibilities, the knowledge of which could be used by designers or engineers to enable a faster enquiry of a similar form. The motivation of crafts research is the utilisation of outcomes in objects. This holds value in visual terms and also in how it contributes to the evolution of practice. As samples, the value is muted. To make sense of the outcomes for crafts practice many samples were developed further, either combining them with workshop techniques or being made into objects. These were exhibited, and several conference presentations were given to disseminate the research and gain feedback from practitioners.

HOW THE PHD DESIGN PRACTICE DIFFERED FROM THAT OF COMMERCIAL PRACTICE:

Until there is an incredibly sophisticated piece of laser forming software that will process a 3D CAD model into a heating strategy, you are trying to control the laser path and subsequent 'through thickness compression' that is created by the heat of laser. This can be an almost open ended quest given the number of variables: laser power, velocity, beam size, material, path geometry, order and direction of lines, and rate of cooling. This has significant implications for the practice of designing with the process in mind:

- Unlike many conventional techniques, laser forming is a non-contact process, so it is not necessary to design tooling. Simple folded forms can often be produced quickly and as anticipated. Whilst the process is repeatable and may be used for a limited run, it can be a slow process and each component will take a similar amount of time, whereas commercially the investment in tooling generally reduces the manufacture time.
- Forms and objects may start with a sketch, but rather than realising the product in the workshop, the designs required consideration of the heating path and the writing of a CNC programme. Maquettes were sometimes made but they were used to gain insight as to the likely movement rather than being a static model of the final product. In most cases there was a period of research and learning from empirical investigation, using materials like paper, until the heating pattern and parameters yielded the desired result.
- In creating laser formed products a sense of satisfaction lies in the resolution of the heating strategy. The design can also be borne from experimental observations, and in this way design is not quite as at the fore as it is with commercial practice. Consequently, there can be a sense of ownership rather than authorship; and a slight detachment in the products not being made by hand, although this is alleviated when forms are developed into products using conventional techniques. Development of laser forming into a commercial reality with an appropriate interface would change this, making the experience comparable to other rapid prototyping processes.
- Laser forming causes you to think differently about how to move and shape material. The laser will compress or upset the metal but cannot stretch it. Forms can be achieved by the effects of folding or attempting to reduce the surface area. With the latter there are parallels with raising, however the laser is much more finite, calculated and less intuitive since it is acting very locally. When creating vessels you can also think of them as being distorted tubes or spinnings, rather than as fabricated or raised from sheet.

CONTACT DETAILS: ssilve925@googlemail.com



Sushi Dish, Aluminium, 180 x 270 x 25mm

Two Arc Dish, Stainless steel 150 x 100 x 25mm

Vase with rings of the upsetting mechanism (aluminium, 150 x 90mm)

DPR group

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