



INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title: Enhancement of Efficiency and Accuracy of Laser Based Bending and Straightening Processes

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SHORT ABSTRACT

Laser based bending process is an advanced process in sheet metal forming in which laser heat source is used to shape a metal sheet. The process has many advantages over conventional forming processes. It is a contact free forming process and is suitable to carry out bending and straightening at areas unachievable by conventional forming. The process is convenient to generate very small and accurate bend angles. The laser bending process can also bend brittle materials in some cases. It is also possible to generate complex shapes by employing a suitable scanning strategy. Basically it is a thermo-mechanical process. Literature contains effects of different laser process parameters, material and workpiece geometry on laser bending. The recent interest in laser bending research and development reflects the industrial potential of the process. Several research groups are currently investigating the fundamentals and applications of laser bending. Several analytical and numerical models have been developed. The forming mechanism of complex sheet geometries has been analyzed using software based on finite element method (FEM). Many studies involved moving laser sources with straight and curve laser beam paths. However, scant attention has been given to the reverse process i.e., laser based straightening. Limited research outputs are available in the literature about straightening. The focus of this thesis is on enhancement of accuracy and efficiency of the laser based bending as well as straightening.

First, in this work the deformation of a sheet, subjected to irradiation, has been studied through a series of experiments where the metal surface was coated with black enamel paint for enhancing the absorptivity of laser and thereby acquiring a higher bend angle. Use of black enamel paint on laser bending resulted in a large increase of bend angle in a mild steel sheet. Later on, a strategy is proposed for choosing the parameters of multi-pass laser line heating for obtaining the accurate bend angle for a prescribed accuracy of prediction. The strategy was verified with experiments for three different materials.

A technique to straighten bent metallic strips with magnetic-force-assisted laser irradiation is also developed. Experiments were conducted for three different types of mechanically-bent mild strips. The first type was bent strips without any heat treatment. The second type was stress-relieved and third type was subcritical-annealed bent strips.

These strips were straightened following different schemes of laser irradiation sequence to understand the performance of straightening. A parametric study was conducted by varying laser power and scanning speed. Micro-hardness and microstructure after straightening were also studied. Different scanning schemes provided different microstructures and mechanical properties. Any serious deterioration in the quality of straightened strips was not noticed.

Later on, electromagnetic-force-assisted laser bending and straightening process is proposed, in which the external force is applied by a controlled force generated by an electromagnet. The process was found suitable for laser assisted bending and straightening. The experiments as well as simulations indicated that a large bend angle can be obtained by controlling the electric current and air gap between electromagnet and workpiece. A good agreement between simulation and experimental result was obtained. Edge effect was very less in case of strips that got attached with the magnet during laser bending. The spring-back effect was very less at high laser power, low scan speed and high current. The laser irradiated region had higher micro-hardness than that of base material. The micro-hardness of laser irradiated region depended on laser power, scan speed and magnetic force of attraction. Straightening of mechanically bent strip was also carried out. Results indicate that the use of an electromagnet with laser irradiation is an effective way to straighten bent strips.

Overall, the efficiency of the bending and straightening processes was improved by adopting the following measures: (1) use of paint for enhancing the absorption of laser irradiation, (2) use of magnet/electromagnet for assisting the laser bending/straightening. The accuracy of the laser bending process was improved by developing a suitable scheduling strategy for a multi-pass laser bending and bending using an electromagnet. The accuracy of laser straightening was improved by carrying out multi-pass laser straightening with the help of magnetic force and proper heat treatment. Future work should aim on the detailed optimization of the processes for different work materials.