International Journal of Mechanical Engineering and Robotics Research

ISSN 2278 – 0149 www.ijmerr.com
Vol. 3, No. 3, July, 2014

Review Article

MECHANISM OF LASER ASSISTED BENDING FIXTURE- AN OVER VIEW

B N Nagendra Kumar[1], Shailesh P S[2]*, Ramesh Babu K[2] and Arvind Rao M Yadwad[1]

**Corresponding Author: Shailesh P S* ✉ *shylesh_mysore@yahoo.com*

Laser beam forming is a novel technique developed for the joining of metallic components. In this study, an overview of the laser beam forming process,the basic mechanisms of the laser beam forming process, some recent researchstudies and the need to focus more research effort on designing a manually operated fixture for laser forming process is presented.

Keywords: Laser forming, Mechanisms, Bending angle, 3D model of Solid Works software

INTRODUCTION

LASER Beam Forming (LBF) is a non-contact forming process and is based on the flame bending process which was traditionally used for ship construction. Laser Beam Forming can be regarded as a flexible manufacturing process with great potential for sheet metal forming. It is considered as a novel manufacturing method for forming and shaping of metallic components. It is a thermo-mechanically forming process that enables component parts (sheet metals, rods and pipes) to be formed without external forces and does not require the use of dies as found in most traditional forming methods. The LBF process is achieved by irradiating the surface of the material with a defocused laser beam, there by inducing rapid localized heating followed by cooling as the laser energy is either moved to the adjacent area or switched off. The process can be considered as a green technology as no fumes are evolved during the process. The schematic of the process is presented in Figure 1. As a consequence of the thermal induced forming process, no spring back occurs in the material after the laser forming process. Three major process variables that are significant during the LBF process are the material parameters which include; the coefficient of thermal expansion, the thermal conductivity, the material density, latent heat, the mechanical elastic and plastic parameters (Young's modulus, Poisson's ratio, flow stress vs. strain curves) and the rate of laser absorption.

[1] Department of Mechanical Engineering, NIE, Mysore, Karnataka, India.
[2] Department of Tool Engineering, G.T & T.C, Mysore, Karnataka, India.

The parameters of the laser and this include; the laser power, the beam diameter, the feed rate and the beam wavelength which depend on the type of laser in use. And lastly the geometric parameters of the sample being formed which include the sheet thickness and width. The major advantage of the LBF process over flame bending is controllability. With LF, it is possible to accurately control the power and geometry of the heat source. LBF process also offers many of the advantages of process flexibility and automation associated with other manufacturing techniques, such as laser cutting, drilling, welding and marking. The major benefit of LF, from a metal forming perspective, is that spring back is completely eliminated. Materials such as steels and other light alloys such as Aluminium, Magnesium and Titanium have a high coefficient of thermal expansion. These materials significantly deform when heated with the laser beam. The temperature gradient developed during the process compels the material to expand non-uniformly, which in turn leads to non-uniform thermal stresses. Plastic deformation results when the thermal stresses.

THE MECHANISMS OF THE LASER BEAM FORMING PROCESS

The laser beam forming process is achieved by introducing thermal stresses into the surface of a workpiece with a high power laser beam. These internal stresses induce plastic strains that result in local elastic/plastic buckling. The process is principally used at the macro level to form metallic sheet material. The principle behind the process of forming sheet material uses a laser beam that is guided across the sheet surface. The path of the laser is dependent on the desired forming result. In the simplest case, it may be a point and in another case it may be a straight line, rotating and wavering beam across the whole part. The degree of deformation is often dependent on the forming mechanisms being employed. During the laser beam forming process, photons travel to form a beam of light. The beam, which may not be visible, comes out from the laser cavity and is directed towards the material process station. Based on the laser wavelength, the beam travels either via optical fibers or directly through optics to the workpiece. There are five different types of mechanisms identified in LBF process and are hereby discussed.

The Temperature Gradient Mechanism (TGM)

This mechanism is widely used to form sheet material out of plane towards the source of the laser beam. The temperature gradient mechanism develops from processing conditions, one of which is rapid heating of the work piece surface in order to generate high temperature gradients in the workpiece. The thermal expansion of the heated surface brings about the initial bending of the sheet away from the heat source or towards the cold side of the workpiece during the heating process.

The Buckling Mechanisms (BM)

The buckling mechanism occurs in relatively thin sheets where the ratio of the beam diameter of the heated area to the sheet thickness is relatively high that is, it could be in the order of 10 or above. This is when the laser beam diameter is large compared to the sheet thickness and the processing speed is low resulting in a small temperature gradient across the sheet thickness.

The Point Mechanism

The point mechanism is the dividing line between the two previously discussed mechanisms, that is, the TGM and BM. The point source mechanism creates a heated zone in the World Academy of Science, Engineering and Technology 71 2012. Using short pulses of the laser to introduce a thermal gradient, yet the mechanism remains a point source since the beam is stationary when heating the component. Longer pulses enables heating through thicker materials, and may be mistaken for another type of mechanism for instance buckling, however the beam and workpiece are also stationary when in contact. Micro components may be formed with the Point source Mechanism.

The Upsetting Mechanism

The upsetting mechanism develops when uniform heating of a localized zone is achieved through the thickness of the sheet metal. The process parameters may be similar to the buckling mechanism, except that the diameter of the heat source is the same as the plate thickness or larger than it. As a result of the near homogenous heating of the sheet in the localized zone, and prevention of thermal expansion by the surrounding material, the sheet is subjected to near uniform compressive strain through the thickness of the material. At cooling, the region contracts, and deformation occurs in the sheet. This mechanism finds applications in spatial sheet metal forming and profile forming.

Coupling Mechanism

Coupling Mechanism (CM) is the combination of the Temperature Gradient mechanism (TGM) and Upsetting Mechanism (UM). The process parameter for the CM lies between that of TGM and UM. From a TGM analysis, the plastic compressive deformation does not occur at the bottom surface and for UM, plastic compressive deformation at the top surface of the materials is nearly same as the plastic compressive deformation at the bottom surface of the material. On the other hand with Coupling Mechanism, plastic deformation occurs at both the top and the bottom surface of the material but greater at the top surface.

CURRENT RESEARCH WORK

Recent research attempts conducted on laser beam forming of thin metal sheets reviewed in this section. First of such attempts is the research work conducted by designing 3D model with the help of solid works software. To design a fixture that lifts the worktable upwards after laser beam scan pass to bend thin metal sheets up to 90° with the help of external forces, following mechanisms are incorporated in the fixture. They are

1. Spring assisted bell crank lever mechanism
2. Peauciller mechanism

Bell Crank Lever Mechanism

A bell crank is a type of crank that changes motion through an angle. The angle can be any angle from 0 to 360 degrees, but 90 degrees and 180 degrees are most common. The name comes from its first use, changing the vertical pull on a rope to a horizontal pull on the striker of a bell, used for calling staff in large houses or commercial establishments.

A typical 90 degree bellcrank consists of an "L" shaped crank pivoted where the two arms of the L meet. Moving rods (or cables or ropes) are attached to the ends of the L arms. When one is pulled, the L rotates around the pivot point, pulling on the other arm.

A typical 180 degree bellcrank consists of a straight bar pivoted in the center. When one arm is pulled or pushed, the bar rotates around the pivot point, pulling or pushing on the other arm. Changing the length of the arms changes the mechanical advantage of the system. Many applications do not change the direction of motion, but instead to amplify a force "in line", which a bellcrank can do in a limited space. There is a tradeoff between range of motion, linearity of motion, and size.

Peauciller Mechanism

The Peaucellier-Lipkin linkage invented in 1864, was the first planar straight line mechanism the first planar linkage capable of transforming rotary motion into perfect straight-line motion, and vice versa. It is named after Charles-Nicolas Peaucellier (1832-1913), a French army officer, and Yom Tov Lipman Lipkin (1846-1876), a Lithuanian Jew and son of the famed Rabbi Israel Salanter. Until this invention, no planar method existed of producing straight motion without reference guide ways, making the linkage especially important as a machine component and for manufacturing. In particular, a piston head needs to keep a good seal with the shaft in order to retain the driving (or driven) medium. The Peaucellier linkage was important in the development of the steam engine.

With the help of this mechanism we have designed a manually operated fixture to bend thin metal sheets. For this purpose, the fixture is designed in solid works software 2013 to generate 3D model. Three types of 3D model and calculations are demonstrated in this article.

Figure 1: Schematic of the Laser Beam Forming Process

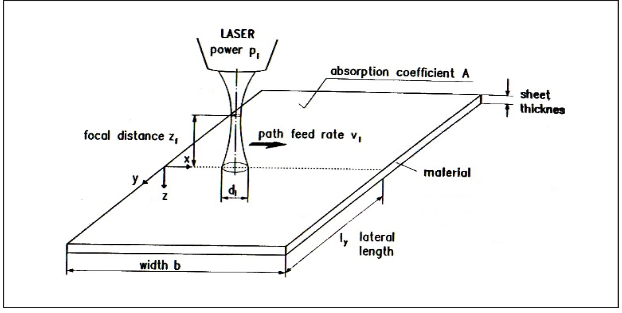


Figure 2: Shows Top View of the Fixture Spring Assisted Bell Crank Lever

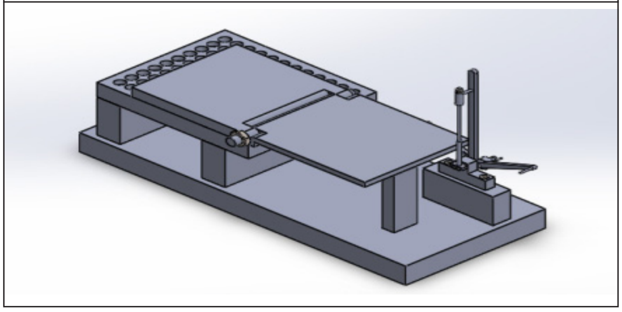


Figure 3: Shows Front View of the Fixture of Spring Help of Assisted Bell Crank Mechanism

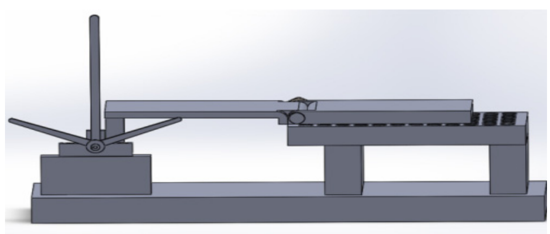
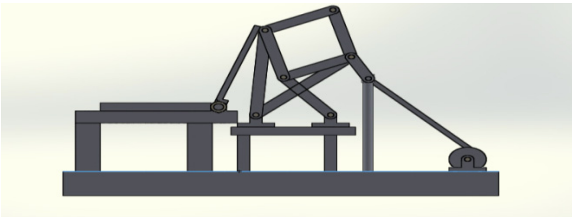


Figure 4: Shows Work Table Lift with the Peauciller Mechanism



CONCLUSION

Laser beam forming alternatively is a flexible manufacturing process that forms metal sheets by means of thermal stresses induced by external heat instead of external force common in mechanical forming process. Empirical evidences from the reviewed literature suggests laser beam forming as a viable process for the production of sheet metal prototypes, spring back free and non-contact process. Further more, the process has demonstrated potential uses in many different engineering applications. An overview of the Laser Beam Forming process a has been presented in this study as it is been applied in the industry, with special attention to the LBF of titanium and its alloys.

REFERENCES

Journals

1. Amir H Rochi and M Hoseinpour (2012), "External Force Assisted Laser Forming Process for Gaining High Bending Angles". *Journal of Manufacturing Process, Gollo Tarbiat Modares University, Tehran, Iran*, Vol. 14, pp. 269-276.

2. Ferdinand Bammer, Thomas Schumi, Andreas Otto and Dieter Schuöcker (2011), "Laser Assisted Bending for Efficient Light-weight-production", *ISSN* pp. 1330-3651.

3. Gigliola Iubiano and Jorge A Ramos (xxxx), "Department of Mechanical & Metarllurgical Engineering", *Portificia University, Chile. Laser bending of thin metal sheets by means of a low power CO2 laser*.

Book

1. Design of machine elements, third edition by V B Bhndari. ISBN-13: 978-0-07-068179-8.