

**RESEARCH ARTICLE**

# Experimental Investigation of Edge Formation During Fiber Laser Cutting Of 8 Mm Thick Sheet Steel on An LF3015 Machine

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## Abstract

The article presents the results of an experimental investigation of edge formation during fiber laser cutting of 8 mm thick sheet steel on an industrial LF3015 laser cutting machine system. The relevance of this study is associated with the need to improve the cut surface quality and reduce edge defects during the processing of metallic materials.

During the study, an analysis of the cut surface morphology of the experimental samples was carried out. Characteristic edge defects were examined, including the formation of burrs, the structure of grooves (striations), and changes in surface geometry. It was established that the quality of the formed edge is determined by the stability of the metal melting processes and the efficiency of molten material removal by the flow of the assist gas.

The obtained results indicate that morphological analysis of the cut surface can be used to evaluate the quality of laser processing and to optimize the technological parameters of the cutting process.

## KEY WORDS

Laser cutting, fiber laser, edge formation, sheet steel, cut quality, surface morphology, thermal processes, gas-dynamic processes, melt ejection, assist gas pressure, cutting speed, laser power, specific cutting energy, heat input, edge defects, burr formation, surface roughness, striation structure, process parameter optimization, LF3015 laser machine.

## INTRODUCTION

Laser cutting is one of the most efficient technologies for the thermal processing of metallic materials and is widely used in mechanical engineering, instrument manufacturing, and other industrial sectors. The main advantages of this technology

include high processing accuracy, a narrow kerf width, and a high cutting speed [2].

In recent years, fiber laser systems have become widely

adopted, providing high radiation power density and stable processing conditions. This makes it possible to significantly improve cutting quality and increase the productivity of metal material processing.

The quality of the edge formed during laser cutting is determined by the interaction of thermal and gas-dynamic processes occurring in the laser beam interaction zone. Under the action of laser radiation, the metal undergoes melting, and the removal of the molten material is carried out by the flow of an assist gas. Instability in these processes may lead to the formation of cut surface defects such as burr formation and increased surface roughness [2,3].

In this regard, the study of edge formation during laser cutting of sheet materials represents an important scientific and practical task.

The aim of this work is to experimentally investigate the formation of the cut edge during fiber laser cutting of 8 mm thick sheet steel using an LF3015 laser cutting machine.

## **METHODS**

The experimental study of edge formation during laser cutting was carried out on an industrial fiber laser cutting machine LF3015 laser cutting machine, designed for processing sheet metal materials. This equipment provides high positioning accuracy and ensures the stability of the technological processing process.

Sheet carbon steel with a thickness of 8 mm was used as the material for investigation. The samples were obtained by fiber laser cutting under various processing conditions [4,5].

The laser cutting process is based on the effect of focused laser radiation on the metal surface. The laser power density can be determined using the following expression:

$$q = \frac{P}{A}$$

where:

q — laser power density, W/mm<sup>2</sup>;

P — laser source power, W;

A — area of the laser spot on the material surface, mm<sup>2</sup>.

One of the important parameters of the process is the specific cutting energy, which is determined by the ratio of the laser power to the beam scanning speed:

$$E = \frac{P}{v}$$

where:

E — specific cutting energy, J/mm;

P — laser power, W;

v — cutting speed, mm/s [5].

During the experiment, an analysis of the edge surface morphology of the obtained samples was carried out. The cut quality was evaluated based on visual and macroscopic inspection of the cut surface. Particular attention was paid to the following parameters:

The structure of cut grooves (striations);

The presence and size of burrs;

The uniformity of the edge surface;

The geometry of the cut surface.

The obtained samples were documented using photography for subsequent analysis of the morphological features of the cut surface. The conducted macrostructural analysis made it possible to identify characteristic features of edge formation under different laser processing conditions. A comparative assessment of the cut surface morphology was used to determine the influence of thermal and gas-dynamic factors on the cutting quality [6,7].



Figure 1. Macrostructure of the edge surface after laser cutting.



Figure 2. Cut surface structure under a different processing condition.

## RESULTS

During the experimental study, samples of 8 mm thick sheet steel were obtained by fiber laser cutting on an industrial LF3015 laser cutting machine. The quality of the formed edge was analyzed based on the morphology of the cut surface and the characteristic signs of thermal effects of laser radiation on the material.

During laser cutting, the metal is locally heated to its melting temperature, followed by the removal of the molten material by the flow of assist gas. The efficiency of this process is determined by the ratio of laser power to the scanning speed of the cutting head. The specific thermal input into the cutting zone can be determined using the following expression:

$$H = \frac{P}{v}$$

where:

H — specific thermal input, J/mm;

P — laser power, W;

v — laser cutting speed, mm/s.

An increase in cutting speed reduces the specific thermal input, which may lead to a decrease in the material's melting depth. Conversely, excessive thermal input causes the accumulation of molten metal at the bottom of the cut and the formation of burrs.

An important factor in edge formation is the efficiency of molten material removal by the assist gas flow. The gas pressure creates an additional force that ensures the ejection of molten metal from the cutting zone. This effect can be described by the following expression:

$$F = P_g * A$$

where:

F — force exerted by the gas flow, N;

P<sub>g</sub> — assist gas pressure, Pa;

A — area of the gas-affected zone, m<sup>2</sup>.

The analysis of the cut surface morphology showed that under stable thermo-hydrodynamic conditions, a relatively uniform surface structure with regular vertical striations is formed. These striations are generated as a result of the sequential movement of the melting front along the cutting line.

When the stability of the process is disrupted, an increase in surface roughness is observed, along with the appearance of localized accumulations of molten metal and burr formation at the bottom of the edge. Such defects indicate insufficient efficiency in molten material removal or a mismatch between laser power and cutting speed.

Thus, the results of the study demonstrate that the quality of the formed edge during laser cutting of sheet steel is determined by the balance of thermal and gas-dynamic processes occurring in the laser interaction zone. An optimal combination of technological parameters ensures stable cut surface formation and minimizes defect formation.

## **DISCUSSION**

The results of the experimental study showed that edge formation during the laser cutting of 8 mm thick sheet steel depends on the stability of thermal and gas-dynamic processes occurring in the laser interaction zone. The processing was carried out on an industrial fiber laser cutting machine LF3015 laser cutting machine, with a laser source power ranging from 1500 to 3000 W, which ensures effective melting of the metallic material.

During laser cutting, the metal is locally heated to its melting temperature, after which the molten material is removed by an assist gas flow at a pressure of approximately 0.6–1.2 MPa. At a cutting speed of about 800–1200 mm/min, a stable cut surface structure is formed.

Analysis of the sample surfaces showed that edge quality is determined by the efficiency of molten metal removal from the cutting zone. Instability in the process can lead to surface defects such as burr formation, uneven striation structure, and increased edge roughness.

The obtained results indicate that an optimal combination of laser power, cutting speed, and assist gas pressure allows for a more uniform cut surface structure and reduces the number of defects when processing 8 mm thick sheet steel.

## **RECOMMENDATIONS**

Based on the results of the experimental study, the following recommendations can be formulated to improve the quality of laser cutting of 8 mm thick sheet steel:

1. During laser cutting, an optimal combination of laser power and cutting head scanning speed should be

maintained to ensure a stable metal melting process.

2. To effectively remove molten material from the cutting zone, it is recommended to use an assist gas at sufficient pressure to provide stable ejection of the melt.
3. When setting laser cutting parameters, the formation of striation structures on the cut surface should be monitored, as their uniformity indicates the stability of the technological process.
4. Macroscopic analysis of the cut surface is advisable for assessing edge quality, allowing timely detection of defects such as burrs and increased roughness.
5. Optimization of laser processing parameters enables improved cut surface quality and reduces the need for subsequent mechanical finishing of component edges.

## **CONCLUSION**

As a result of the experimental study, the features of edge formation during laser cutting of 8 mm thick sheet carbon steel on a fiber laser cutting machine LF3015 laser cutting machine were investigated. The morphology of the cut surfaces of the obtained samples was analyzed, and characteristic features of the edge structure were identified.

It was established that the quality of the cut surface is determined by the stability of the metal melting process and the efficiency of molten material removal from the processing zone. Under optimal laser cutting conditions, a more uniform edge surface structure is formed with minimal burr formation.

The study demonstrated that controlling the technological parameters of laser processing is a key factor in ensuring high-quality cutting of sheet metal materials.

The obtained results can be used to optimize laser cutting modes and improve the efficiency of steel processing on industrial equipment.

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