Analysis of laser cutting process of structural steel
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Introduction
The laser technology, due to its advantages like high precision and speed, is widely used for material processing such as cutting, welding, additive manufacturing, etc. [1]. Since the laser material processing is a multidisciplinary subject, analysing whole the process from laser itself to substrate material needs to have a wide knowledge of different fields of science and engineering as it is illustrated in Fig. 1.

In this study, thermomechanical analysis of mild structural steel S235 under laser cutting process is investigated.

Experimental setup
In order to have information on the actual LC process and on the effects on the material, thermographic monitoring of the specimen surfaces during the cutting process and chemical analysis on the HAZ were carried out. In this regard a set of two Optirp IR cameras including XI 400 with temperature range of 100 – 900 °C and PI 800 M with temperature range of 975 – 1900 °C were utilized (Fig.3).

Another way, which is reasonably cost effective, to measure the temperature is utilizing thermocouples in desired positions. In this regard, a datalogger RSPro1384 (4 channels) was used as measuring instrument with thermocouples type K (RS code: 621-3170) (Fig.6).

In order to see the kerf size and calibrate the model, also to see the heat affected zone (HAZ) and microconstituent changes, a light microscope was used as seen in Fig.4.

The position of the specimen and the measuring point with thermocouple is shown in Fig.5. Temperature distribution recorded by IR cameras are illustrated in Fig. 7 and Fig. 8. These data were used to as a reference point for calibrating the process and also a for the thermocouple.

The cutting parameters are also reported in the table below.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>Laser power</td>
<td>3.0 kW</td>
</tr>
<tr>
<td>Speed</td>
<td>20 mm/s</td>
</tr>
<tr>
<td>Focal length</td>
<td>100 mm</td>
</tr>
<tr>
<td>Gas pressure</td>
<td>0.7 bar</td>
</tr>
<tr>
<td>Gas type</td>
<td>Oxygen-iron</td>
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</tbody>
</table>

Result and discussion
Fig. 9, 10, and 11 depict the fitted model on corresponding experiments. As it can be observed from these figures, the shape of the kerf is matched very well. In the following, Figs 12 and 13 illustrate the temperature history in the measuring point during the time and transverse residual stress along the depth of the specimen.

All the experimental and numerical results for a certain set of parameters are shown in these two graphs.

Conclusion
The results showed a good agreement between numerical model and experiments that represent compressive stress at the cut-edge and stress variation in the HAZ which are because of martensitic phase transformation of Austenite and plastic deformation of heated material. Further investigations will be using machine learning to predict the behavior of the material and optimization of the process.

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References