STRUCTURAL STEEL

LASERTUBE: STANDING INNOVATION

The laser cutting technologies employed to manufacture tubular structures are gaining wider use the construction field.

Some recent studies and tests, conducted at respected universities, give a great impetus to the use of laser cutting for buildings by excluding a direct correlation between surface hardness (that is induced by laser cutting) and the fatigue of the material.

Steel has always played a major role in the construction industry, owing to its excellent mechanical properties and its versatile use: these features are essential to build imposing structures that are often characterized by complex shapes. The tubular structures featuring round-section (CHS) elements, which have been manufactured during the past few years by combining stunning appearance with structural efficiency, provide a clear example of this. The difficult execution of the joints between CHS elements, mainly due to the 3D cutting of the element ends, has been one of the main reasons that have, in the past years, caused such elements to be used only for special applications, e.g. the off-shore structures, where the advantages given by the elements would compensate for the difficult execution of the same. Such difficulty can now be overcome by means of the 3D laser cutting technology, which allows you to quickly make items featuring complex shapes while ensuring very high quality and accuracy of the cut edge, which is an essential requirement for the attractive glass and metal structure covering the Mart square in Rovereto, TN, Italy.

Moreover, a change in the regulatory requirements for structural metal fabrication, through the implementation of two technical standards (firstly, the NTC2008 regulations, then the EN 1090 Standard), which have changed the ways and methods of designing and manufacturing the steel structures. The main innovations implemented by the EN 1090 Standard, which was implemented in July 2014, include the introduction of a concept relative to the steel structure manufacture class and the basic requirements applicable to the machined structural components by using the ordinary processing methods: all of the above aims at obtaining the EC mark for the structural elements, in accordance with the NTC 2008 regulations.

The optimum quality of the cutting surface that can be obtained by means of the laser cutting technology makes it possible to meet the requirements applicable to the strictest manufacture class (i.e. EXC4),

garantendo quindi in automatico la rispondenza a tutti i requisiti di thus guaranteeing laser cutting's compliance with all of the tolerance requirements established for every single type of structure.

The EN 1090 Standard suggests, in regards only the structures exposed to fatigue loads and subjected to a high number of cycles (especially bridges), a direct connection between the local hardness (HV10) of the cut surface that does not have to be reworked (e.g.

holes, slotted holes or sections not to be welded) and the fatigue response.
The aforesaid connection is, however, not matched by the experimental evidence of the studies and surveys made, over the past few years, as a result of the collaboration between the Department of Civil, Environment and Mechanical Engineering (DICAM) of the University of Trento (Italy) and ADIGE-SYS company, such a collaboration aiming at examining the effects of the laser cutting technology and the use of the same with structural steel elements machined in accordance with the EN 1090 Standard.
The results of the research made on construction steel by the work team led by Professors O.S. Bursi and P. Scardi have pointed out the following, as regards the materials machined by means of laser cutting systems:

- the slight effects on the material's mechanical properties (**the heat affected zone features a very small thickness, i.e. approximately 0.15 mm**)
- the material's provide very good fatigue response, with values nearly the same as the ones for the identical material when machined by mechanical means (milling machine), despite hardness values (HV10) nearing the limit or higher than the ones suggested by the EN 1090 Standard.

This study, the first one of its kind, carries great significance for laser applications and, in particular, for structural use. Experimental evidence has for the first time been given – and a scientific analysis of these facts is being made – **that no direct connection exists between the surface hardness and the fatigue response (brittleness). The laser cutting specimens feature a greater fatigue strength than the ones cut by making use of a mechanical tool (milling machine)**.
Therefore, new opportunities arise for applying the laser cutting, holes, slotted holes and sections to a number of materials (even the special ones), contrary to the prescriptions in force until today.

Those who are not familiar enough with the terms used and the standards and regulations in force may find it useful to refer to the summarizing explanatory steps below:
The EN 1090-1 and 2 Standards (UNI-harmonized) have been in force since July 2014 and essentially establish that each piece of work shall be provided with an EC certificate. Therefore, all components (starting from raw materials) shall have their own traceable certificates, and so shall all manufactured items that make up the same; likewise, the companies that supply them shall have their own manufacture process certified, as detailed in the standard.
The designer will be responsible for defining the works specifications and the standards to be complied with, including the EN 1090 Standard. By defining the EX execution class depending on the type of work, the relevant class, the execution class and the manufacture class, the prescriptions will be increasingly reduced, down to the strictest EX4 class which fully encompasses the laser cutting performance. The other types of thermal cutting processes (such as plasma cutting and torch cutting) fall into EXC2 and EXC3, respectively.
Law-makers have established, in regards to all execution classes (EX1-EX4), that "hardness shall, if specified so, conform to Table 10 of the EN 1090-2 Standard". This clause aims at laying down stricter limits in case of works and items exposed to significant fatigue (e.g. bridges and off-shore installations), while entrusting the designer with the task of specifying this, which means that anyone may impose strictest constraints even when the latter are actually not needed.
With reference to Table 10, as regards the types of steel featuring a grade equal to or smaller than 355, the permitted maximum HV hardness grade is 380°, a value that has not been reached by the specimens tested when we made the survey, and yet nearing the real value to a large extent. As regards steel grades 460 and above, a maximum HV 10 value of 450° has been obtained (this value was reached and slightly exceeded by the specimens at issue).

The conclusions that can be reached are described above, i.e. no connection exists, as far as laser cutting is concerned, between the hardness and the fatigue strength; despite higher values than the established ones have been found in some cases, the specimens are able to withstand the test better than the specimens cut by using a milling machine.

Based on these significant results, which have already been presented at industry meetings and workshops, first in 2014 and then in 2015, also thanks to the support by the Foundation for Steel Promotion (represented by its technical manager, Dr. Monica Antinori, a member of the National and European Standard review committees), we managed to have Table 10 removed from the next revision of the standard, which should be implemented this year.