USE OF WATERJET IN MANUFACTURING TEST BARS OF HIGH-STRENGTH STEELS

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Abstract

This article introduces a procedure which has been used for developing and optimizing a process of making tensile test specimens of ultra-high-strength sheet metal samples. Thermomechanically-processed materials of this kind are characterized by high hardness, strength, and toughness. Making specimens of these materials by classical chip cutting is therefore difficult, time-consuming, and costly. For the sake of comparison, various methods are listed here which are potential candidates for making such specimens. In this case, an alternative process was chosen: waterjet cutting. From the production viewpoint, the design of the workholding fixture for this process is of major importance. The fixture has an indirect but very significant impact on the manufacturing process and, ultimately, on the quality of the test specimens produced. In this experimental programme, the suitability of the workholding fixture, the process chosen, and the cutting conditions were examined

Keywords: Abrasive waterjet cutting; Machining; AWJ; Workholding fixture; AHSS; Unconventional technologies; Test bars.

1. Introduction

In order to produce high-quality test specimens from high-strength metal sheets, a new procedure that could deliver the desired quality and effectiveness had to be developed and put in place. Thermomechanically-processed materials of this kind are characterized by high hardness, strength, and toughness [10],[11]. For this reason, making specimens of these materials by classical chip cutting is difficult and costly. Cutting plate is a difficult and time consuming task, especially when the job calls for a tight tolerance or an unusual shape. In those cases, can choose abrasive waterjet cutting [9],[4]. Abrasive waterjet cutting is an attractive process with many advantages. The process is suitable for cutting steel of small thickness where it provides a smooth and very precise cut. In terms of precision, waterjet cutting can even outperform laser cutting, as the resulting edges are smoother and free from melting, burning and thermal distortion [1]. Waterjet is now the most cost effective method to cut steels [9]. Therefore, an alternative machining process of abrasive waterjet cutting was employed.

preparation, abrasive waterjet cutting was chosen. For this process, a workholding fixture for accurate and firm clamping of the specimens with respect to the tool had to be designed.

2.4 Process selection

The fixture is a very important item, as it has a major impact on the test bar quality. The main reason for using a fixture is the need for quality and dimensional, shape and geometric accuracy.

The requirements for the workholding fixture for waterjet cutting were as follows:

- secure positioning
- firm clamping of the part
- clamping the part in a defined position with respect to the tool

The design (3 and 4) was developed using the SolidEdge ST8 software.

Fig. 3: Visualized fixture with eight test specimens

Fig. 4 – Plan view from bottom

The design of the fixture allows up to 8 specimens to be cut out in a single series. This solution is motivated by the economy of and time savings in production. The test specimen is centred in the fixture with V-grooves. Mating cylindrical surfaces are guided accurately in the fixture. At the top, they are provided with threads for holding the specimens in place. The transverse plane of the fixture is provided with marks in the form of channels. These are used for centring the specimens before tightening.

To verify the design and function of the fixture (Fig. 5), it was manufactured of S235 steel. This material is not the optimal choice for this fixture because it lacks corrosion resistance but it is fully sufficient for verifying its function. Semi-finished products were also made by waterjet cutting. The fixture was designed to be producible from sheet metal.

3. Experimental

The process was tested in the WJ 2830-2Z-Cobra-PJ60 machine. The experiment compared the alignment of cutouts from the original, and the final shape. A total of 23 specimens were tested (Tab 1). The measurement was carried out using the CMM Carl Zeiss Prismo 7 Navigator 3D measuring machine. A total of four parameters were measured (Fig. 5): specimen width – dimension A, the distance between the right edge of the cutout from the initial contour – dimension B, the distance between the left edge of the cutout and the initial contour – dimension C, and the angle between the centreline of the initial specimen and the centreline of the newly-cut specimen.

Fig. 5 – Specimen dimensions of interest

Test arrangement:

- PTV JETS 3.8/60-COMPACT high pressure pump (max. operating pressure 415 MPa, max. flow 3.8 l/min)
- X-Y cutting table PTV WJ 2830-2Z (working space of 3000×2000 mm)
- Continuously variable cutting speed 0–20 m/min

Experimental conditions

- Operating pressure [MPa]: 400
- Abrasive type: GMA Australian garnet
- Abrasive particle size [MESH]: 200
- Mass flow of abrasive – [g/min]: 30
- Waterjet nozzle diameter [mm]: 0.10
- Abrasive nozzle diameter [mm]: 0.508
- Standoff distance [mm]: 4

Workpiece material

- Material – EN10131 DC01
- Thickness [mm] 1.5

As evidenced by statistical characteristics of the set of results, the fixture meets the requirements for clamping precision (Tab. 1). Since the cutting error is caused by random factors, the two sigma rule can be applied. According to this rule, an interval of two standard deviations around the mean value will contain 95.4 % of the actual measured values according to Gauss distribution. In this case, an accuracy of ± 0.03 mm from the mean value is achieved with 95.4 % confidence. As a consequence of inaccurate setting of kerf width compensation, the deviation of the mean width of the test specimen from the required value was 0.15 mm. In a subsequent run, this deviation was eliminated by precise measurement of the first piece and by resetting the kerf width compensation function. The difference of 0.4 mm between the B and C values was due to inaccurate movement to the zero reference point. This error was also eliminated by an improved fixture positioning procedure in the machine. In no case did the misalignment between the initial and the final contour exceed the critical limit of 1° .

Specimen number	Dimension A [mm]	Dimension B [mm]	Dimension C [mm]	Angle [°]
1	3.181	10.335	10.697	0.77
2	3.174	10.385	10.696	3.27
3	3.182	10.336	10.678	0.23
4	3.177	10.351	10.674	1.10
5	3.186	10.269	10.788	0.45
6	3.163	10.325	10.721	7.22
7	3.178	10.322	10.767	3.19
8	3.168	10.335	10.732	5.38
9	3.199	10.360	10.740	4.33
10	3.142	10.412	10.640	0.52
11	3.202	10.252	10.840	0.03
12	3.180	10.364	10.690	1.42
13	3.168	10.228	10.856	4.97
14	3.182	10.370	10.745	2.05
15	3.186	10.318	10.787	0.55
16	3.190	10.312	10.734	4.43
17	3.196	10.303	10.763	2.35
18	3.175	10.412	10.664	0.45
19	3.207	10.286	10.865	3.27
20	3.193	10.407	10.683	4.85
21	3.189	10.255	10.773	1.97
22	3.209	10.376	10.677	3.88
24	3.186	10.354	10.734	7.83
Mean value	3.183	10.333	10.737	2.805
Standard deviation	0.015	0.050	0.060	2.218

Tab 1. – Results of measurement

4. Conclusion

As many roads lead to the final destination, each product can be manufactured in various ways. When producing of the product, the goal was to produce the product for cutting tensile tests specimens in such way, which will fullfill not only all requirements of drawing documentation, but also will be produced in the cheapest way. Another aim was to demonstrate practical experience of making the product with the technology of waterjet cutting.

Waterjet cutting was used for making a fixture for preparing test specimens for tensile testing. As the materials in question were AHSS steels, the specimens were impossible to be prepared in required quality, quantity and at the required cost by classical machining routes. The fixture for making eight test specimens was tested. It was found that all requirements for the test specimen quality have been met.

In the future, we will focus on optimizing cutting conditions and their influence on surface integrity.

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