THE OPTIMIZATION OF THE WELDING PROCESS PARAMETERS OF THE DX52D STEEL TUBES

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Abstract
The more and more larger demand for the seemed tubes on the market is occurred. On account of the economic aspects and the very high usable parameters the seamed tubes on the very wide scale in the motor industry are being applied. In the very difficult and competitive times the most important thing for the every company which want to keep its position on the market is keeping the condition of production in the good, optimal state. It affects the level of the production costs at all. The technological production process of the tubes of the 40 mm diameter and 1,5 mm thickness made of DX52D steel in the paper has been analyzed. The chemical depot of the DX52D steel was carried out (it was the batch material of the production process). In the work the mechanical properties of described steel were examined. The optimum area of the welding parameters (velocity and temperature) of the DX52D steel tubes was appointed. This was the main factor of process improving and lowering the costs of production - reduction the very important company problem. The results show on the possibility of the adjusting of welding temperature in the limits: $1130^\circ{\text{C}} - 1200^\circ{\text{C}}$ and $1230^\circ{\text{C}} - 1260^\circ{\text{C}}$, and welding velocity in the limits: $43,35 \text{ m/min} - 43,78 \text{ m/min}$.

1. INTRODUCTION
The demands for tubes still rises for the sake of their high functionality and together with it also raise requirements as to the tubes quality. This caused introduction of product control during technological process. Production quality control is inseparably connected with production process [1, 2, 3].

Currently tubes are treated as finished element which is characterised by: high tolerance and also clean and smooth surface. They find application in many different industry branches. Besides continuously rising demand for precise metallurgical products also can be noticed continuous rise of recipients’ requirements as to quality of these products, which are met by production technology development in directions leading to formulation of products with designed and required by clients features [4, 5, 3].

Majority of structural elements applied to building, among others: industrial structures, bridges, ships, to concrete reinforcement, to tubes for pipelines are connected by welding or pressure welding. Steel weldability is called its susceptibility to forming weld joints with properties close to parental metal properties. This steel property is important because currently individual elements in steel structures are connected mainly by welding or pressure welding [6, 14]. Chemical construction of weldable steel is thus subject of limitations and is chosen with consideration of carbon equivalent value calculated according to formula [6, 7, 8].

\[ C_E = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15} \]  \hspace{1cm} (1)
where, accordingly: C, Mn, Cr, Mo, V, Ni, Cu – meet mass concentration of these elements in steel.

In case when \( C_E \leq 0.45\% \), steels are weldable without any limitations. Steels with higher carbon equivalent require preheating before welding, regulated by cooling or annealing after welding [6].

Steels for tubes delivered by metallurgy in form of varied moulders, sheets, strips, bars and wires should have good weldability, high \( R_m \) strength values, \( R_y \) yield point and low temperature of ductile to brittle transition. Required properties of these steels assure suitable choice of chemical construction and also of steel melting technology, plastic forming and heat treatment [6, 9, 10, 11, 12].

Very important role in technological production process of seamed tubes describe among others such tubes pressure welding parameters as: pressure welding speed and temperature. These parameters in significant degree influence the properties of these pressure welded tubes and their optimisation has the key importance for stabilisation of the whole pressure welded tubes production process. In further part of the article is carried out pressure welding parameters optimisation for tubes with 40 mm diameter and 1,5 mm wall thickness made from DX52D steel.

2. TESTED MATERIAL

Tubes for which was carried out analysis of pressure welding parameters were made from DX52D steel. This steel is weldable and low-carbon, letter D at the beginning means flat product (tape) and at the end for metallization. DX52D steel is the type of steel which does not require X type rolling. On the surface of this steel was spread layer of aluminium with the addition of silicon, however, this layer was spread on fire way. Before spreading the aluminium layer the surface was degreased and chemically passivated. DX52D steel composition is showed in table 1.

Table 1. DX52D steel chemical construction [13]

<table>
<thead>
<tr>
<th>Content of elements in DX52D steel [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>0,02</td>
</tr>
</tbody>
</table>

Fig. 1. Mother material of the tube made from DX52D steel, with area 250x, nital etched [13]
Analysis of the structure of DX52D steel mother material was carried out on NEOPHOT 32 metallographic microscope. The structure of parental material of testes steel has purely ferrite structure with small excess cementite released inside ferrite seeds, what can be seen on fig. 1. According to shape and directivity of some seeds can be stated the presence of the texture, which remains after the rolling process. Individual seeds of the structure are quite regular but diversified as to their size.

The outcomes of the DX52D steel mechanical testing are showed in table 2.

**Table 2. Mechanical properties of tested DX52D steel [13]**

<table>
<thead>
<tr>
<th>Type of steel</th>
<th>$R_{ct}, \text{MPa}$</th>
<th>$R_{m}, \text{MPa}$</th>
<th>Extension, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>DX52D</td>
<td>276</td>
<td>339</td>
<td>$A_{80} = 31$</td>
</tr>
</tbody>
</table>

3. ANALYSIS OF PRESSURE WELDING PARAMETERS OF THE TUBES MADE FROM DX52D STEEL

Aluminium tubes made from DX52D steel with 40 mm diameter and 1.5 mm wall thickness were pressure welded in the following scope of parameters: power 52 – 55 kW and frequency 400 kHz. The length of cut tubes was 6 m, performance standard PN-H-74241.

After pressure welding selectively were carried our attempts of tube expanding and on the basis of these attempts were marked visible on fig. 2 areas of tested parameters.

![Fig. 2. Dependence of pressure welding temperature and shift speed of the tube made from DX52 steel, with size 40x1.5 mm [13]](image-url)
In four appointed areas were noticed following outcomes:
I – as the result of the tube expanding attempt occurred fractures in the heat influence zone.
II – as the result of the tube expanding attempt occurred 3 fractures in the heat influence zone and three tube expanding attempts were good.
III – as the result of the tube expanding attempt occurred fracture in the weld.
IV – in 100% the tube expanding attempt was positive.

On the fig. 2 we can notice that area IV, in which all conducted tube expanding attempts were good, is included in the following scopes:

- temperature:
  - from about 1130 °C till about 1200 °C,
  - from about 1230 °C till about 1260 °C,

- pressure welding speed from about 43.35 m/min till about 43.78 m/min.

On the fig. 3 were described examples of selected tubes after technological attempt of tube expanding, good pressure welded joint without fractures (fig 3a) and with presence of fracture (fig. 3b). This attempt was conducted on the suitable machine used in order to change the diameter of the pressure welded tubes. During the technological tube expanding attempt the increase of the tube’s diameter occurred at about 25%.

The measurements of individual pressure welding parameters were conducted in the industrial conditions, directly on the pressure welding process line. The pressure welding temperature of individual pressure welded joints was read directly from fixed on the line pyrometer and other parameters from suitable devices also fixed directly on the process line. The basic verification of pressure welded joints quality was the tube expanding attempt performed on machine used in order to change the diameter of the pressure welded tubes. This attempt was conducted at random but it had to be conducted minimum one time for the parcel of pressure welded tubes.

4. SUMMARY

As a result of conducted metallographic analysis of parental material of DX52D steel applied to pressure welded tubes production it was found that this structure is purely ferrite with small excess cementite released inside ferrite seeds. Furthermore, it was found the presence of the texture, which remains after rolling process.

On the basis of the measurement of the selected pressure welding parameters, such as pressure welding temperature and speed and also the conduction of the tubes tube expanding technological attempt were described scopes of parameters for tested steel, in which each...
received joint met the reception requirements conditions. In the work was considered the choice of temperature and speed for the pressure welded tubes made from DX52D steel with the size of 40x1,5 mm. As a result of experience and also after conduction of controlling tests it was established that optimal parameters for tested type of steel are the pressure welding speed from about 43,35 m/min till about 43,78 m/min and temperature scopes $1130^\circ C \div 1200^\circ C$ and $1230^\circ C \div 1260^\circ C$.

As a result of conducted tests it was found that tubes pressure welding temperature (picture number 2) is inversely proportional to pressure welding speed and decreases together with its increase. This happens because with higher pressure welding speeds we deal with higher strip’s edges clamp force and speed, and with higher clamp force it will be needed lower temperature during pressure welding. When speed is too low, in the tube will appear lack of strip’s edge weld, what would cause receiving tubes inconsistent with requirements. However, in case of too high pressure welding temperature, present in heat influence zone material would be overheated. This would cause the increase of susceptibility to tube’s fractures in overheated zone, resulting from too high grain growth and clamp force would cause the formulation of excessively high flash. Pressure welding parameters depend in high degree on technical possibilities of pressure welding technological process line and first and foremost occur limitation of the weld shift speed with higher diameters and tubes thickness with consideration on saw’s cut possibilities.

Conducted optimisation allowed to avoid unnecessary wastes’ costs connected with incidental selection of pressure welding parameters. As a result of such optimisation process company should increase its productivity in tested process through saving time on its normalisation through process parameters changes. Besides, the company should receive better economic effect in the process for the sake of energy savings through from the beginning arrangement of process parameters from specific scope. Recapitulating, it can be stated that adequate production and technological operations management leads to the raise of finished product quality, in this case it is pressure welded tube and to minimisation of production costs.

The above tests confirm unquestionable direction of the highest management staff on the processes which guarantee adequate quality, in this case suitable joint’s strength.

**BIBLIOGRAPHY**


