HODNOCEŇÍ MECHANICKÝCH VLASTNOSTÍ TWIP PLECHŮ

EVALUATION OF MECHANICAL PROPERTIES OF TWIP SHEETS

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Abstrakt
The paper deals with the evaluation of plastic properties for new high-strength materials. In this case is described quite huge and new type of materials marked like TWIP materials and to be specific high-strength TWIP sheets. In experimental part were measured results of mechanical properties from the static tensile test and was also used approximation of static tensile test to compute C, n and φ0. Results predestinate these materials for wider using in the future for engineering industry. This submission was written within solution research design MŠM 4674788501.

Key words:
High-strength materials, TWIP sheets, Ductility

1. INTRODUCTION
Sheets producers are still under quite large pressure from automotive industry. Because there is requirement for safety of passengers on the one hand and on the other hand quite large requirement for light weight material. Everything is basically oriented on economical and ecological requirements. There are considerable reductions in weight, in fuel consumption and in the emission of exhaust gases. Another important aspect is the increase of the specific efficiency (engine power per mass unit). And that is why during last years were developed wide spectrum of materials suitable for automotive industry (Dee-drawing, IF, BH, DP, CP, TRIP steels etc). This paper gives a very short overview about one of the newest materials called TWIP steels (Twining Induced Plasticity). Such type of steels is suitable for the development and design of the types of high strength lightweight steels. TWIP are high manganese steels where the phase transformation is suppressed and heavy twinning formation is sustained (TWIP effect) – due to high stacking fault energy. So basic of these steels is mechanical twinning formation instead of phase transformation. Mechanical properties of these steels and mentioned trends in automotive industry have led to great interest in these high strength and tough steels. On the other this kind of material is still in the development stage and it is really necessary to describe their behaviour at first.

2. TWIP SHEETS
TWIP steels (twinning induced plasticity) are group of materials where the increasing elongation with decreasing temperature is attributed to strain-induced twinning: the TWIP effect. These sheets belong to so-called high-strength steels and are still mainly in the development process. On the other hand processors in automotive industry already have some experiences which revealed advantages and also disadvantages of this kind of material. Such kind of materials contains austenite stabilising elements, e.g. Mn or Ni. The developed light weight high manganese steels exhibit an extremely large elongation in combination with quite large yield strength. It is due to reality that with increasing manganese content up to about 20 wt-% Mn the stacking fault energy will be decreased and extensive mechanical twinning occurs and these steels exhibit extraordinary high plasticity.
3. EXPERIMENTAL PART
The experimental part of this paper was carried out on device for static tensile test (testing device TIRAtest 2300 – see figure 1). Measured were samples with the rolling direction 45° and were evaluated the main mechanical properties (R_p0.2, R_m, A_50, C, n).

Fig. 1. Testing device TIRAtest 2300
Obr. 1. Testovací zařízení TIRAtest 2300

First of all specimens were cut by water jet. It is both due to their high strength and because of non-heat influenced area by water jet. The results are shown in the table 1. Were measured 3 samples (because of material quantity) and in the table you can find yield point, tensile strength and ductility for l_0 = 50 mm.

Table 1. Mechanical results from static tensile test
Tabulka 1. Výsledky mechanických hodnot ze zkoušky tahem

<table>
<thead>
<tr>
<th>Mechanical properties</th>
<th>Rolling direction: 45°</th>
</tr>
</thead>
<tbody>
<tr>
<td>R_p0.2 [MPa]</td>
<td>587,05</td>
</tr>
<tr>
<td></td>
<td>610,96</td>
</tr>
<tr>
<td></td>
<td>613,52</td>
</tr>
<tr>
<td>R_m [MPa]</td>
<td>1159,17</td>
</tr>
<tr>
<td></td>
<td>1155,3</td>
</tr>
<tr>
<td></td>
<td>1165,22</td>
</tr>
<tr>
<td>A_50 [%]</td>
<td>53,22</td>
</tr>
<tr>
<td></td>
<td>54,14</td>
</tr>
<tr>
<td></td>
<td>57,46</td>
</tr>
</tbody>
</table>
Measured values were used by the help of software OriginPro 7.5. Computing of C and n were carried out according the norm ASTM E 646 – 78 [1]. C, n and $\phi_0$ were computed according the Swift-Krupkovsky approximation in the interval $R_{p0.2} - R_m$. In the following graphs are shown graphical records of tensile tests and results for coefficients C, n and $\phi_0$.

Graph 1. Graphic results of static tensile test for 1st sample
Graf 1. Poměrné a skutečné hodnoty napětí a deformace pro 1. vzorek

Graph 2. Graphic results of static tensile test for 2nd sample
Graf 2. Poměrné a skutečné hodnoty napětí a deformace pro 2. vzorek
Graph 3. Graphic results of static tensile test for 3rd sample
Graf 3. Poměrné a skutečné hodnoty napětí a deformace pro 3. vzorek

Graph 4. Graphic results of approximation of static tensile test for 1st sample
Graf 4. Aproximace skutečných hodnot napětí a deformace zkoušky tahem pro 1. vzorek
Graph 5. Graphic results of approximation of static tensile test for 2\textsuperscript{nd} sample
Graf 5. Aproximace skutečných hodnot napětí a deformace zkoušky tahem pro 2. vzorek

Graph 6. Graphic results of approximation of static tensile test for 3\textsuperscript{rd} sample
Graf 6. Aproximace skutečných hodnot napětí a deformace zkoušky tahem pro 3. vzorek
Table 2. Results from static tensile test – C, n and φ₀
Tabulka 2. Výsledky ze zkoušky tahem – C, n a φ₀

<table>
<thead>
<tr>
<th>Mechanical properties</th>
<th>Rolling direction: 45°</th>
</tr>
</thead>
<tbody>
<tr>
<td>C [MPa]</td>
<td>2674,42779</td>
</tr>
<tr>
<td>n [-]</td>
<td>0,61474</td>
</tr>
<tr>
<td>φ₀ [-]</td>
<td>0,07747</td>
</tr>
</tbody>
</table>

4. CONCLUSION
TWIP steels are very new materials suitable for application in automotive industry. There belong to high-strength materials category, but their properties and quite very wide scale of producing TWIP steels predestinate such kind of steels combined properties both from deep-drawing steels and high-strength materials.
The main advantages of TWIP steels are evident from graphic results of tensile tests. There is a huge measure of the energy absorbed before and during the fracture process. The area under the tensile stress-strain curve provides an excellent value of toughness. There is deep-drawing material (e.g. DX56) with excellent elongation and on the other hand quite lower mechanical values (yield and ultimate strength). High-strength materials (e.g. MSW1200) have very good mechanical properties but are not too suitable for forming processes.
At first sight it is evident that TWIP steels represent a material group with extraordinary values which have led to a great interest in these steels. The excellent mechanical properties are due to massive twinning in the austenitic matrix during deformation. A gradual formation of deformation twins is necessary.
According to results of coefficients C and n is evident that these values are extraordinary high. There is still increase in coordinates R-ε which means that there is not almost at all necking part for testing samples.
The high ductility together with the high strength of these newly developed lightweight TWIP steels could improve the crash resistance of structural body parts. The excellent formability enables deep and stretch forming of parts with complex shape at room temperature. The reduced specific weight leads to an overall weight reduction of the car body. The potential applications of these steels are to be considered as deep drawing sheets, reinforcing bars and beams in automotive vehicles.
On the other hand there are of course also disadvantages for processors of these materials. The main of them is probably tendency to fracture after deformation and welding.

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REFERENCES