

ESTIMATION METHOD OF SPOT CONNECTORS MECHANICAL PROPERTIES

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1. Introduction

Clinch joining technique can be successfully used in many industries for joining of thin-walled profiles. This solution brings multiple benefits to the producers. The most important are: elimination of metal surface preparation, reduction of the energy consumption and negative influence of the heat zone. Furthermore, joining process does not cause bore dust, and does not require gas shroud, generating noise at a low level of intensity [1].

The advantages of the clinch connections tends leading European tools manufacturers like Attexor Equipments, BTM, Eckold, TOX, or Trumpf to use them more and more frequent. At the same time instensification of studies concerning their mechanical properties can be observed. The authors of papers [2, 3] focused on the issue of clinches suitability for joining steel parts. They analyzed carefully the advantages and disadvantages of this technique and the process itself. One of the most interesting paper focused on this subject is [4], in which a comparison of cliche, bolt and rivet connections in terms of their strength and usability in steel constructions was made. Another interesting paper is [5]. It is focused on the impact of SPJ (square press joints) tensile force direction on connection shear strength. Paper [6] is focused on degradation of the press joints mechanical properties under the influence of time. You can also meet with the papers of the author [7], which examines the impact of spot connections quantity on the thin-walled elements mass-production costs. There is a lack of comprehensive studies concerning clinch joints mechanical properties, especially about their minimum load-carrying ability, which ensure correct deformation process for stroke-loaded elements.

2. Material tests

Material tests were made for currently used in automotive industry, typical, higher-strength steels, such as: DP600, DP800, DP1000, DP1200 and deep-drawing steel. For specified grades of

steel static and dynamic material tests were made. Next step was definition of the material constitutive equations according to the Cowper-Symonds model:

$$\sigma_n = \sigma_y \left[1 + \left(\frac{\dot{\epsilon}}{D} \right)^{\frac{1}{p}} \right]$$

where:

- σ_n - stress level due to the material strain rate hardening
- σ_y - static stress level
- ϵ - strain
- $\dot{\epsilon}$ - strain rate
- $\epsilon_y, \epsilon_u, A, B, p, D, D_u, D_y$ - other parameters to calculate

best correlation between the model and obtained results D and p coefficients were determined by means of the statistical analysis tools. The figure below depicts correlation between the Cowper-Symonds model and one of the material analysis results - i.e. DP600 higher-strength steel.

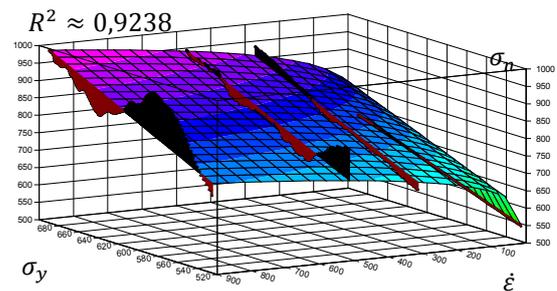


Fig. 1: The correlation of the Cowper-Symonds strain rate hardening model and DP600 steel grade

3. Connection properties

Obtained D and p factors were used in the material numerical models definition. In order to conduct numerical experiments, geometric models of car longitudinal were made. Top-hat and double-hat profiles were connected by means of separable joints with the following failure criterion:

$$\left(\frac{F_N}{F_{Nmax}}\right)^{a_1} + \left(\frac{F_S}{F_{Smax}}\right)^{a_2} \leq 1$$

where:

- F_N - normal force value,
- F_{Nmax} - normal force maximum value,
- F_S - shear force value,
- F_{Smax} - shear force maximum value.

Used connection stays integral as long as above relation is a true. It should be noticed that, depending on the different values of a_1 and a_2 coefficients, connection is characterized by different load-carrying ability:

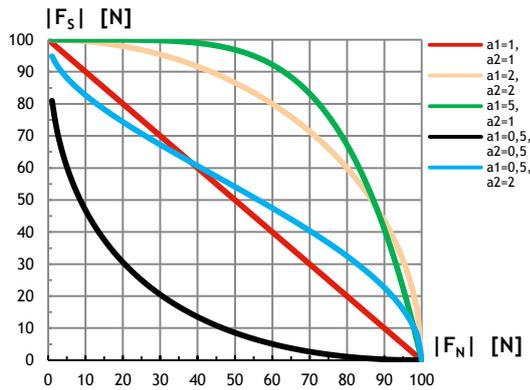


Fig. 4: Influence of a_1 and a_2 coefficients on connection load-carrying ability

For further test, the coefficients a_1 and a_2 were set to 1, and the values of maximum forces F_{Nmax} , F_{Smax} were set to 50kN. Implementation of joints with higher strength properties will therefore ensure that the joined profiles will not be disconnected during dynamic deformation. The fact that the described methodology may find application in the estimation of minimum mechanical properties of other types of spot connectors, such as welds, is noteworthy.

4. Conclusion

Analysis of joint normal and shear forces allows to determine their maximum value during deformation of the sample. Analysis of these data

allow to draw a conclusion, that the developed research methodology enable to determine spot connection minimum load-carrying ability with ensure correct crush parameters such as shortening of the sample and amount of absorbed energy.

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