Optimization of perlite steels mechanical properties for car fasteners stamping

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Abstract. The car fasteners made of pearlitic steels by cold stamping method are to meet special requirements for their structural and mechanical characteristics.

The hardware is made of hot-rolled steel, which cannot be used straight after the delivery for fasteners manufacturing due to the poor quality of the structure and surface layer. Therefore, calibrated rolled stock gets heat treatment before drawing. In addition, hardware of strength class 8.8 and higher obtained from alloy steels using cold heading machines are subjected to temper hardening, which often leads to surface decarburization, cracking and distortion of finished products, that afflicts labor and energy efficiency, and, thus, the final cost of production.

The article suggests a method for 35X and 38XA pearlitic steels stock treatment excluding recrystallization annealing, rod-like items temper hardening, and including isothermal operation to prevent decarburization, risks and distortion. Passing through the die, hardening the surface due to volume strain and thread rolling impart to M8 bolts and studs the mechanical properties corresponding to strength grades 8.8 and 9.8.

This study also has practical application, it allows manufacturers to determine the appropriate mode for producing automotive fasteners.

Key words: pearlitic steels, drawing, structure, mechanical properties, cold stamping, automotive fasteners.

Introduction

Reliable operation of metal products to a great extent depends on metal characteristics [17,20], operating conditions [6,7] and its processing conditions [8,9] that form material structure [1,2,23] provided by the processing conditions refinement[ 3.21].

Special requirements are imposed on bar bolts manufactured from pearlitic steel [4,22] by cold stamping. The most common and productive method of manufacturing final products with metal parts of high quality is their metal-roll upset having uniformly distributed ductility, structure, manufacturability and no defects [11].

A huge stock of hardware products (bolts, studs and screws) that have no special requirements for strength properties is mainly made of State Standard 1050-2013, State Standard 4543-2016 and State Standard 380-2005 steel . These standards do not regulate metal structure and surface parameters when passing through the draw die and then being upset, that involves risks of such defects as strain cracks [5,14].

The chemical composition and mechanical parameters of metal for cold stamping on press equipment for cars, tractors and other vehicles are regulated by State Standard 10702-2016. The mechanical parameters of...
high-duty equipment are regulated by the active ISO 898-1: 1999 standard. The required strength class is ensured by the choice of steel grade [15,18] and the heat treatment of rolled products and final products [16].

Raw hot-rolled metal from pearlite-grade steels purchased from suppliers of metallurgical products has perlite-ferrite structure. Heat treatment and drawing of the main products before fitting are to form necessary surface and microstructure of rolled products [10,13], which guarantee high quality of metal products after cold upset [12,19].

By State Standard 1759.4-87, elongated products from cold upset alloy steels alloy steels with strength class 8.8 and higher must be subjected to temper hardening. However, this causes decarburization, cracking and deformation of the surface, afflicts labor and energy efficiency, and, thus, the final cost of production.

The purpose of the work carried out in NSTU named after R.E. Alekseev consists in developing an appropriate rolling preparation method, including isothermal mechanical treatment of pearlite steels 35X and 38XA, and excluding recrystallization annealing and temper hardening from the manufacturing process. This will reduce the risks of distortion of long-measuring automobile fasteners and decarburization of their surface. In this case, the surface and mechanical parameters of the stock must meet State Standard 10702-2016.

The object of this development is hot-rolled steels of pearlite class 35X and 38XA for cold headed automotive metalware.

Subject of study. The mode of technological processing of hot-rolled steels 35X and 38XA for cold headed automotive metalware.

Research Methodology. We studied samples of rolled steels 35X and 38XA, which are widely used for the engine, body, automotive and special equipment fasteners. The chemical composition of the metal studied is shown in table 1.

Table 1 - The chemical composition of the steels 35X and 38XA studied

| Steel grade | C    | Mn   | Si   | P    | S    | Cr   |
|-------------|------|------|------|------|------|------|
| 35X         | 0.34 | 0.52 | 0.19 | 0.009| 0.01 | 0.87 |
| 38XA        | 0.38 | 0.59 | 0.20 | 0.015| 0.009| 0.89 |

The scheme of rolling products isothermomechanical preparation was considered to obtain rod-shaped products with a low-shaped head and various studs of strength class 8.8 or more using cold-stamping automatic machines with hardening and tempering operations excluded. Such stock preparation includes heat treatment of the initial bundle; etching; drawing; isothermal treatment (470 °C); etching; drawing; compression.

The initial mechanical characteristics of rolled steels 35X and 38XA, supplied by metallurgical company, are presented in table 2.

The scheme of rolled steels 35X and 38XA isothermomechanical preparation is displayed in Fig. 3

The hot-rolled metal 35X and 38XA microstructures were studied and revealed to be “perlite + ferrite”. These microstructures can be seen in Fig. 1 and fig. 2

Table 2 - Mechanical properties of the initial stock 35X and 38XA

| Steel grade | Stock diameter, mm | Strength and ductility characteristics |
|-------------|--------------------|----------------------------------------|
|             |                   | δ  | Ψ   | σₜₚ  | σ₀.₂   |
|             |                   | %  | %   | MPa   | MPa    |
| 35X         | 10,1              | 21 | 59.6| 724   | 605    |
| 38XA        | 10,3              | 20,5| 59   | 750   | 610    |
The stock microstructure for metalware products with the diameter of 7.8 mm was formed by isothermomechanical treatment (annealing of the 2nd type). It is known that the transformation of austenite in the nitrate bath of these steels occurs in the range of sorbitol transformation of 650–470 °C. An austenitic eutectoid type is obtained. The considered method of thermal cooling at 470 °C after drawing is suggested for cold stamping when fitting short, medium and long studs and bolts with massive molded heads. When cooling the wire with the diameter of 8.2–8.6 mm at a temperature of 470 °C the completion of the austenitic stock transformation takes 3.9 minutes.

Metal samples were got by punching dies with the diameters of 8.1; 8.2; 8.3; 8.4; 8.5 and 8.6 mm, followed by treatment in a nitrate bath (470 °C). The final size was obtained with the diameter of 7.8 mm. The M8 bolts and studs produced were subjected to rupture in accordance with State Standard 1759.4-87.

The outcomes and their consideration
The chemical composition, strength and ductility properties of 35X and 38XA steels complied with State Standard 10702-16. The microstructure of the stock supplied consists of perlite with ferrite.

After isothermal treatment samples with the diameter of 8.1; 8.2; 8.3; 8.4; 8.5 and 8.6 mm in a salt bath at a temperature of 470 °C have the structure of perlite and sorbitol, it is shown in Fig. 4 and fig. 5.

The hardness of 35X steel samples after the above mentioned treatment is HB 249, and that of the 38XA steel samples is HB 254.

It has been found out that the strength characteristics of isothermally (470 °C) treated rolling steel increase monotonously with an increase in deformation when compressed from 4.9 to 17.7%. Thus, when rolling with the compression from 4.9 to 17.7% the tensile strength of 35X steel increases from 838 to 971 MPa, and that of the 38XA steel from 918 to 1067 MPa.

The conventional yield strength also increases after isothermomechanical preparation. It was revealed that the conventional yield strength of rolled 35X steel with compression deformation from 4.9 to 17.7% increases from 769 to 887 MPa, and that of 38XA steel from 797 to 948 MPa.

Rolled stock isothermomechanical treatment at a temperature of 470 °C followed by drawing with compression from 4.9 to 17.7% provides a monotonic decrease in the relative elongation for 35X steel from 16 to 12.2% and from 15.7 to 12.2% for 38XA steel.

The relative contraction of isothermomechanically treated rolled 35X steel with compression deformation from 4.9 to 17.7% decreases from 54 to 52%, and from 53.1 to 50.4% for 38XA steel.

According to State Standard 52643-2006, high-strength fasteners include products, whose tensile strength is greater than or equal to 800 MPa. Therefore, bolts and studs made of 35X and 38XA steels with the help of isothermomechanical method agree the strength class of high-strength fasteners. The results are presented in table 3.

Table 3 - Stud test results

| Diameter, mm | Steel grade | Quantity, items. | $\sigma_{\text{b}}$, MPa | $\psi$, % | $\delta$, % | HB |
|--------------|-------------|------------------|---------------------|--------|--------|-----|
| M8           | 38XA        | 25               | 925                  | 44.5   | 10.7   | 286 |
| M8           | 35X         | 25               | 820                  | 44.5   | 10.7   | 254 |

Hence, the test results analysis testifies that 35X steel can be used for bolts and studs with a strength class of 8.8. 38XA steel can be recommended for manufacturing hardware such as bolts and studs with the strength class 9.8g via cold die stamping after isothermal treatment of rolled stock.

Conclusion

Isothermomechanical treatment of rolled stock from structural steel of pearlite class 35X and 38XA with the diameter of 7.8 mm has been considered as a preparation stage for stamping studs and low-head bolts of strength class 8.8 and higher with hardening and tempering excluded from the process.
It has been proved that passing through thread rolling dies and surface hardening imparts such mechanical properties to M8 studs and bolts that they meet the requirements of strength classes 8.8 and 9.8 in compliance with State Standard 52643-2006.

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