Response to Reviewer 2 Comments

Point 1: The introduction part, even if the authors make an extensive literature survey, for the reviewer, it is not clear enough what is the novel for the work, the authors need to clarify this.

Response 1: According to the Reviewer 2 suggestion the last paragraph of the manuscript introduction was modified: “In the available technical literature, there are few papers on the rolling process of wire rod which describe the possibilities of shaping and improving the mechanical and technological properties of the finished product using numerical methods and physical modelling taking into account the limitations of the available testing apparatus and the verification of such studies in industrial conditions. Therefore, the research issues undertaken at work are current. An important achievement of the work is solution of the numerical and physical modeling problems of the analyzed rolling process using commercially available software and test equipment, taking into account its limitations in terms of the applied total strain, strain rate and break times between successive deformations. The proposed methodology for modelling the rolling process of the wire rod reflects with high accuracy the actual technological process and changes occurring in the microstructure of the deformed material. The proposed parameters of thermo-plastic processing of wire rod from 20MnB4 steel grade with diameter of 5.5 mm ensure that a finished product with a microstructure and properties comparable with the products offered by leading world producers is obtained. The obtained results and their analysis should be helpful in developing changes in the currently used methods of wire rod production, or in the design of new technological lines for rolling wire rod.”

Point 2: For the Figure 5 of fraction the microstructure, what can be the error bar range for each?

Response 2: The QTSteel software calculates the ratio of the various microstructural constituents and mechanical properties of steels after heat treatment (quenching, tempering). Beginning with the chemical composition and the austenitizing conditions of time and temperature the software calculates corresponding CCT diagram which describes the decomposition of the undercooled austenite to ferrite, pearlite, bainite and martensite. Predicted or user defined CCT diagrams can be used for computer simulation of isothermal or anisothermal transformation of specified steel for predefined cooling curve. The software divides the cooling curve into the sequences with uniform cooling rate and calculates the percentage of the various microstructural constituents (ferrite, pearlite, bainite or martensite) for each sequence. Detailed studies aimed at determining phase transition temperatures, methodology and elaboration of TTT and DTTT diagrams for 20MnB4 steel grade are presented and described in details in the paper no. [55]. Laber K.; Koczurkiewicz B. Determination of optimum conditions for the process of controlled cooling of rolled products with diameter 16.5 mm made of 20MnB4 steel. 24th International Conference on Metallurgy and Materials - METAL 2015, Brno, Czech Republic, June 3rd÷5th 2015, pp. 364÷370. The accuracy of determining the percentage share of microstructure components depends on the DTTT diagram implementation accuracy into the QTSteel program database, among other things. It is difficult to say what can be the error bar range for each microstructure component because the share of microstructure components in the real material (wire rod) has
not been investigated in the paper unfortunately. So, it is impossible to compare results in this field. But based on others results (mechanical and technological properties compared between real wire rod and material after numerical and physical simulation) it can be stated that the results are very consistent. So, in our opinion the maximum error bar range for each microstructure component can be less than about 10%.

**Point 3:** Equations (12) and (13) express the empirical equations to calculate YS and UTS, an open question is how the accuracy compare with the state of the art models, e.g. statistical models, etc., this is not an mandatory comment.

**Response 3:** These equations are taken from technical literature ([60]. Hodgson P.D.; Gibbs R.K. A mathematical model to predict the mechanical properties of hot rolled C-Mn and microalloyed steels. ISIJ International. 1992, vol. 32, 12, pp. 1329-1338; https://doi.org/10.2355/isijinternational.32.1329). They are dedicated for C-Mn steels. Results obtained by using these equations were compared also with others empirical equations (Sawada Y., Foley R.P., Thompson S.W., Krauss G.: Proc. 35th MWSP Conf. Proc. ISS-AIME, Pittsburgh 1994, p. 263):

\[
YS = \frac{HV}{0.378} - 123 \quad (1) \quad UTS = \frac{HV}{0.352} + 70 \quad (2)
\]

where: HV – Vickers hardness

and with compression test results (for YS) of samples after physical modeling. Results obtained by all these methods are comparable (average differences about 7%). Unfortunately, the others art models, e.g. statistical models, etc, were not used.

**Point 4:** The conclusions can be much shorter and clearer for stating a few points.

**Response 4:** According to the Reviewer 2 suggestions, chapter no.4 was modified:

"The speed of implementing the results of theoretical calculations and tests on a laboratory scale in industrial conditions determines the development and dissemination of new technologies. Industrial research is the last but usually very expensive element of the implementation process. The costs of implementing new technologies can be significantly reduced by using modern numerical and physical modelling methods. Using the above-mentioned methods, the conditions for the thermoplastic processing of 20MnB4 steel wire rods were determined, guaranteeing the receipt of a finished product with properties far exceeding the minimum requirements of currently applicable standards, which are similar to the properties of products offered by leading global manufacturers [38]. Based on the research carried out, the following conclusions were formulated:

- the best cooling variant is the W1-5 variant, in which the cooling rate was 10°C/s, such parameters of thermoplastic processing ensure a final product with a favourable complex of mechanical and technological properties as well as a fine-grained, even microstructure, lacking clear banding is obtained,
- the wire rod produced in this way has a high yield strength of 0.74 and can be cold deformed with a relative plastic strain of 75%, without compromising the consistency of the material,
- cooling of the examined steel grade after rolling in the RSM block at the temperature of 850°C and subsequent controlled cooling in the range of 0.6÷15°C/s ensures a ferritic-pearlitic microstructure in the wire rod is obtained,"
- in the examined range, an increase in the cooling rate causes an increase in the analysed mechanical and technological properties of wire rod from 20MnB4 steel,
- in the studied cooling rate range, an increase in the cooling rate caused a simultaneous increase in the yield strength, tensile strength and yield strength of the investigated steel,
- the results obtained during the industrial verification correspond with high accuracy to the results obtained from the numerical and physical modelling of the analysed rolling mill process. This confirms the correct definition of the initial and boundary conditions during numerical modelling, especially the rheological properties of the tested steel, friction conditions and heat transfer coefficients.”

Additionally:

References was formatted according to the „Materials” Journal requirements and „DOI” identifier were added in some places also. We added also translations in works other than in English language. All manuscript was verified in grammar by professional translator.