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Editorial

Researches and Simulations in Steel Rolling

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1. Introduction and Scope

Steel is one of the world's most popular metallic alloys. We can easily predict that this material will remain the most common metal alloy of the large-scale production in the 21st century. This is because steels are used in every part of the industry, beginning from low-carbon sheet steels for automotive applications, through structural steels for bridges, buildings, linepipes, ships, pressure vessels, etc., engineering steels, stainless steels, specialty steels, to tool steels. At the same time, most of the products are used as plates, sheets, bars, rods, wires, sections, and rails. All of them require rolling to form a semifinal product from a slab, billet, ingot, etc. Simultaneously to the dimention changes, a microstructure of the products is formed during subsequent casting, hot rolling and very often cold rolling. The advanced steels are usually produced in modern integrated technological lines to satisfy both high quality requirements and cost effectiveness. Physical and numerical simulations are effective tools, which enable to easily go from an experimental part of the research to an industrial reality.

The Special Issue covers recent progress and new developments in researches and simulations in steel rolling including its various metallurgical and technological aspects. Research and simulations on microstructure-property relationships of hot-rolled, thermomechanically processed and cold-rolled steels, as well as selected technological aspects of modern rolling mills for flat and long products and researches on gauge, profile, flatness, and surface quality inspection are covered.

2. Contributions

The Special Issue includes ten research articles from internationally recognized researchers showing original results and recent advances in steel rolling. The subjects of this Special Issue can be divided into three categories: thermomechanically processed products [1,2], hot-rolled products [3–8] and cold-rolled products [9,10]. Some of the works are focused on experimental research; however, a majority of them concerns both experimental and simulation issues related to steel rolling. It should be noted that the experimental parts are validated on modern structural steels, including high-strength low-alloy (HSLA) steels [1–3], ultrafine-grained (UFG) steels [7], dual phase (DP) steels [8], and other multiphase steels [3].

The first two papers show the importance of thermomechanical processing control for ensuring required mechanical and technological properties of HSLA plate and sheet steels. Opiela and Grajcar [1] presented the impact of hot-rolled shear bands on microstructure, mechanical properties, and anisotropy of plastic properties of HSLA steel plates. They found that a lack of conditions ensuring the near complete static recrystallization between successive roll passes led to localization of plastic deformation and formation of shear bands in dynamically-recrystallized austenite. The bands were the cause of low impact resistance of rolled plates. Górka [2] investigated the weldability of S700MC steel subjected to the thermomechanical control process (TMCP). He reported that the welding process considerably differs from the TMCP conditions leading to the significant reduction of ductility both in the heat-affected zone (HAZ) and in the weld area compared to the thermomechanically processed samples.

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The majority of the Special Issue is devoted to different aspects of hot rolling like microstructure evolution, microstructure homogeneity, hot strip rolling design, control and inspection systems, strip flatness control, etc. Rauch et al. [3] presented the computer-integrated platform for automatic, flexible, and optimal multivariable design of a hot strip rolling technology. They demonstrated a software system involving the flexible integration of virtual models of various devices used in the process: furnace, descalers, rolling stands, accelerated cooling systems, and coiler. Besides the computer science part, they included the material models describing the rolling parameters, microstructure evolution, phase transformations, and product properties. Physical simulations of rolling cycles were performed to supply data for the verification and validation of the models. Finally, they presented some case studies of modern industrial processes for multiphase steels. Hanoglu and Sarler [4] elaborated a rolling system for simulating hot rolling of slabs and blooms, as well as round or square billets, in different symmetric or asymmetric forms in continuous, reversing, or combined rolling. The related large-deformation thermomechanical problem was solved by the novel meshless Local Radial Basis Function Collocation Method. A compression test was used to compare the simulation results with the finite element method.

A useful algorithm for surface defect identification of steel plates based on genetic algorithm and Extreme Learning Machine (ELM) was presented by Tian and Xu [5]. The output matrix of the ELM's hidden layers was treated as a chromosome, and some novel iteration rules were added. The algorithm was tested with 1675 samples of hot rolled steel plates, including pockmarks, chaps, scars, longitudinal cracks, longitudinal scratches, scales, transverse cracks, transverse scratches, and roll marks. Another interesting measurement method was shown by Cantu et al. [6]. They designed two robust mutlivariable controllers, H∞ and a decentralized quantitative feedback theory (QFT), in the frequency domain for the 2×2 looper system in a steel hot rolling mill to keep stability in the presence of parametric uncertainties. The H∞ controller was designed by using the mixed sensitivity approach, while the multivariable decentralized QFT was designed by the extension of the sequential loop closing method. Inoue et al. [7] examined the hot rolling conditions for fabricating a low-carbon Nb-microalloyed steel sheet with an ultrafine-grained (UFG) structure. The fabrication of a 2 mm UFG steel sheet by three-pass rolling for an initial thickness of 14.5 mm was attempted by the proposed large-diameter rolling process. The embedded pin method was employed to understand through-thickness deformation. The submission of Li et al. [8] concerned the improvement of longitudinal performance uniformity of hot-rolled coils used for further cold rolling processing of DP980 automotive sheet steel. The authors used the temperature field of hot-rolled coil (using ABAQUS software) to survey the cause of the longitudinal performance fluctuations of hot-rolled coils. The results illustrated that the average cooling rate of the head and tail parts are higher than that of the body part during coil cooling, which caused the longitudinal performance fluctuation of hot-rolled coils.

The next two works addressed the cold rolling processing. Jin et al. [9] performed a numerical study on contact conditions and roller wear in cold rolling. They utilized finite element analysis to quantify the local contact pressure and local sliding over the rolling bite in a plate cold rolling process. The numerical results indicated that the local contact pressure over the rolling bite demonstrates a hill profile, and the peak coincides with the neutral plane. They proposed a novel concept of wear intensity to examine the wear of the roller based on the local contact pressure and local sliding distance. The work of Li et al. [10] was focused on a strip flatness control, which is one of the most important quality indexes of the cold rolling strip. They analyzed the influence of fluid–structure interaction on the strip amplitude distribution and the flatness calculation deviations. The effects of different aerodynamic loads and tensions on the strip midpoint amplitude and the flatness calculation deviation were analyzed.

3. Conclusions and Outlook

The contributions gathered in this Special Issue show that steel rolling is still a hot topic both from a scientific point of view and an industrial practice. A lot of works can be useful as a platform of the science to industry transfer. The contributions showed that a continuous development of rolling equipment and cold rolling/hot rolling mills requires an adequate scientific update on processing-microstructure-properties, especially for advanced structural steels including multiphase and ultrafine-grained sheet and plate grades. Recent advances in numerical and modelling tools made it possible to present some interesting studies on advanced simulation approaches in steel rolling. The complex simulation platforms for hot strip rolling were presented and some tailored solutions in different aspects of defect identification, strip flatness control, etc. Hence, this special issue will be useful for students and researchers in both academia and industry.

As Guest Editor, I would like to thank all the authors for their excellent contributions to this Special Issue. I would also like to give special thanks to the reviewers for making useful comments, and to the Metals editorial staff for fruitful collaboration.

Conflicts of Interest: The author declares no conflict of interest.

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