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THERMOMECHANICAL ROLLING OF WIRE ROD WITH SUPERIOR PROPERTIES

Long products are one of the most important manufactured items of the global steel industry. Raising energy and commodity prices besides a tough legal regulation makes it necessary to increase the mechanical properties and reduce the energy consumption during the production. Thermomechanical rolling is a promising approach to satisfy the consumer demands for better mechanical properties and to reduce the energy consumption.

Длинномерная продукция является одним из наиболее важных изделий мировой сталелитейной промышленности. Растущие цены на энергоносители и сырье, а также жесткое правовое регулирование заставляют улучшать механические свойства и сокращать потребление энергии при производстве. Применение термомеханического проката является многообещающим подходом к удовлетворению потребительского спроса на улучшенные механические свойства и к сокращению энергопотребления.

Steel bars and wire are important products of rolled long products in all countries. Up to their designation they're used in the as-rolled condition but also further processed e.g. by cold heading in the automobile or construction industry. Due to the industrial progress the demand has moved to higher quality products with improved properties. Thus, also the rolling mill technology has changed. The objectives in the production of long products do not completely differ from the objectives in the production of flat products, but the rolling devices exhibit some strong differences in detail. They can be used to produce high quality products with a maximum efficiency and flexibility. For this purpose, thermomechanically produced products are an example. Because of tough legal regulation it is necessary to reduce the energy consumption during the rolling process and to produce at the same time products with a better strength to weight ratio. These products are requested especially by the car and the aircraft industry as these branches are also confronted with a steady tougher regulation to reduce greenhouse gases. Due to the wide range of mechanical properties and the unlimited recycle ability, the steel consumption all over the world as well as in Germany has grown steady over the past decades and the outlook is due to the emerging markets as China and Brazil even more promising. It is predicted that the steel production will grow at an annual rate of 5 to 6 %, which would imply that in the year 2010 the world steel production would excess 1400 Mio tons per year [1]. In absolute figures China is the fastest growing steel producer and consumer. In 2006 around 47 Mio tons of high quality steel grades has been produced in Germany.

As mentioned the steel industry, especially in Europe and North America, faces a tough competition. To defend its market share and even increase it, it is necessary to concentrate on high quality and niche products. The tough competition is not just limited to the consumer market; it is also tough on the commodity market. The world wide iron ore production as well as the market for alloying elements as molyb-

denum and chromium is highly concentrated. This situation makes it difficult for the consuming steel industry, which is also after the merger of Arcelor and Mittal, still strong fragmented. So it is necessary on the one hand to satisfy the rising demand for quality and on the other hand to increase the flexibly to substitute alloying elements by know how and technology to keep costs low.

The basic strategies to handle the situation are:

Shortening the process

Increase the flexibility of the process

Increase of quality

Increase of efficiency

Environmental-friendly production

An already introduced approach to shorten the process and to increase the quality at the same time is the thermomechanical processing of wire rod. Thermomechanical processing means the combination of several process steps e.g. of casting and rolling. The thermomechanical treatment is a controlled combination of hot rolling and accelerated respectively retarded cooling, which leads to good useful properties. It is adjusted to the chemical composition of steels, which exhibit a phase transformation, and can be applied in the austenite, austenite/ferrite and ferrite region [2].

Whereas the rolling/thermomechanical treatment in the austenite region aims at the grain refinement and the accumulation of the dislocation hardening, the thermomechanical treatment in the 2 phase region (austenite and ferrite) aims for an effect as subgrain formation to achieve effects which are similar to the grain refinement in the austenite region [3]. The accelerated cooling is necessary to control the transformation and the precipitation kinetics. By controlling these processes it is possible to obtain beneficial strength, toughness and deformability properties. Often these properties are connected to chemical properties as the corrosion resistance.

The application of the thermomechanical rolling in the production of wire rod leads to the following advantages:

Elimination of the subsequent respectively final heat-treatment

more homogeneous and improved mechanical properties

economization of the alloying element usage

The application of thermomechanical processing (rolling and cooling) of wire rod is not so widespread as it is in the production technology for flat products. Especially the thermomechanical rolling is just exercised in a few plants. This is rooted in the nature of wire rod. The rolling speed of wire rod is much higher (up to 150 m/s) than the rolling speed applied in flat rolling mills. Therefore it is just possible to employ an exact temperature control by installing additional cooling devices which work with water or extra extension between the stands of the rolling mill. A reduction of the rolling speed, which also results in decrease in temperature, is not possible due its bad impact on the economical efficiency. Often it is also not possible to apply deep temperature due to the increase of the deformation stress with decreasing temperatures. So often current rolling mills would be overloaded with the necessary rolling forces. Analogue problems occur in the cooling of the wire rod from the rolling heat. The process speed makes it necessary to apply very high cooling rates which are for some steel grades critical due to occurring temperature and property grades. Special methods of resolution as local heating of the wire surface of incremental cooling (water/air) are tested right now.

The most used programme is the combination of temperature controlled rolling and accelerated cooling. Many examples can be named here [4-6].

A lot of research about the thermomechanical processing has been done at the Institute for Metal Forming. Starting with an identical lean chemical composition, a reduction of the rolling temperature would lead to a refinement of the final microstructure. Fine microstructures increase strength and toughness. An additional accelerated cooling after the last rolling pass would lead to different microstructures (dependent on the cooling rate). The different microstructure exhibit different mechanical property profiles e.g. bainite is especially suitable for applications at very deep temperatures. If the achieved property level is still not high

enough, it is possible to retard the softening process in the microstructure during the rolling process by adding microalloying elements as Niobium, Titanium or Vanadium. The microalloying elements lead to even better mechanical properties. This goes along with increased costs due the usage of additional alloying elements, but compared to the former quantities of used alloying elements, the costs are relatively low.

The comments showed that it is possible to reduce costs and increase the quality simultaneously. The controlled rolling leads to a refinement of the final microstructure. By adjusting the rolling parameters, different microstructures as ferrite/perlite, bainite and martensite can be obtained. The most suitable microstructure depends on the application of the steel. It has to be outlined that the thermomechanical rolling provides a strength/toughness ratio which wasn't obtainable by conventional technologies, even not with an intensive usage of costly alloying elements.

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