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ECOLOGYCAL ASPECTS OF HIGH STRENGTH LOW ALLOYED STEELS AT MECHANICAL CONSTRUCTIONS

Abstract: *Mechanical properties, resistance to atmospheric corrosion, the availability of joining methods, beneficial economic and ecologic effects conditioned that this steel grade become very important from the aspect of application at mechanical constructions. But, ecologic effects of application are not simple and have complex interactions. The most important aspects are considered in order to identify possibilities for minimizing total ecological impacts of mechanical constructions to environment.*
Keywords: *high strength low alloyed steels, ecology, mechanical construction*

1. INTRODUCTION

Present mechanical constructions can analyzed from very different aspects such as properties of used material, production engineering aspects, forming and joining, fatigue, wear, surface treatments, energy efficiency, environmental effects and so on. Those constructions have many diverse functions with simultaneous increase of demands and limitations. Used materials are selected and used on the basis of large number of very diverse factors (Figure 1).

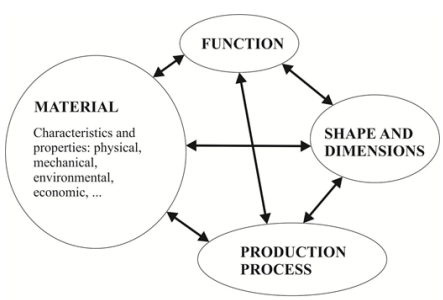

Figure 1. Selection of material at design of mechanical constructions

The used material is medium within all aspects of design, production and exploitation, so as load and environmental conditions simultaneous act. Present mechanical constructions are heterogeneous systems from the aspect of used materials. The specific needs for materials are heterogeneous, materials have be hard or soft, tough or brittle, thick or thin, or strong, easy to deform or with significant resistance to wear or fatigue, and also to have a combinations of the characteristics [1-3].

Every material has own specific environmental impacts. Those environmental impacts in relation to environmental impact of high strength low alloyed steel are in the focus of this paper. Also, those environmental impacts are put in correlations to advantages of specific material applications. The basic consideration in this paper is focused to characteristics and properties of high strength steel grades. Those characteristics and properties are analyzed from environmental aspects.

2. CHARACTERISTICS OF HIGH STRENGTH STEEL GRADES

The high strength steels are usually produced as sheets and plates with low carbon content (0.05% to 2%), while manganese content is not higher than 2.0%. Those steels also contain small amounts of nickel, molybdenum, copper, nitrogen, vanadium, niobium, titan, zirconium and boron.

The microstructure of low alloyed high strength steel is typically fine grained after the production processes and consisted of fine ferrite (α) grains with uniformity of shapes. In addition, the small amounts of cementite is present in microstructures of those steels, so as fine dispersed particles of carbon nitride (Figure 2) [4-5].

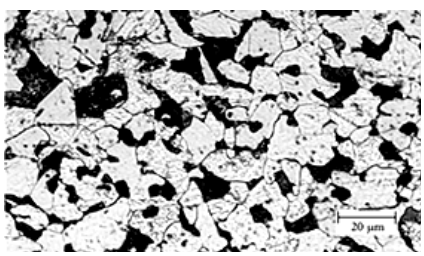

Figure 2. Typical microstructure of high strength steels [5]

During the final rolling process, the favorable conditions for forming of the large numbers of referent locations within the distinct formation of α metal grains. The locations, where energy level for formation of α metal grains, are dislocations, the grain binderies and sub-grains, duplicated grains, the deformation lines. The recrystallization process is consequence of the presence of alloying elements' atoms in solid soluble of steels and it is induced by continual rolling with short break periods, when the effects of niobium are dominant. In addition, recrystallization process is induced as the consequence of precipitation during reversible rolling with longer break periods, when the dominant process is separation of carbon nitride. The characteristics of high strength steels in exploitation are, on the other hand, the result of its microstructure and additional factors [6-7].

The considerations of this paper are linked to application of first generation of high strength steels (Figure 3). The microstructure of the second generation of high strength low-alloy steels is, basically, austenitic at room temperatures due to high content of manganese. The ultimate strength of those steels is higher than 1000 MPa with simultaneous deformation of 60%. The prices of those steels are very high due to high prices of alloying elements. The mechanical properties of second generation of high strength low-alloy steels overcome the requirements of general purpose mechanical constructions. The evolution of high strength low-alloy steels is continued by development of the third generation of high strength low-alloy steels. The intended microstructure of the third generation of high strength low-alloy steels have to be less complex then the microstructure of the second generation, which will improve the weldability with minimal compromises in mechanical characteristics [8].

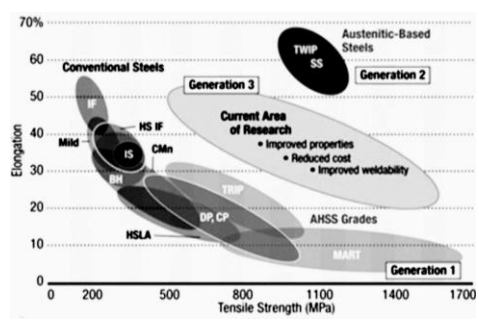

Figure 3. Generations of high strength low alloy steels [9]

3. ECOLOGICAL ASPECTS

The properties and characteristics of high strength low alloyed steels are determined by physical and chemical composition that is highly related to presents and quantities of alloying elements, production process and after-treatments. Most significant advantage of high strength low alloyed steel application at mechanical constructions is reduction of its masses with simultaneous increase of safety. As the result of those effects mechanical constructions have improved energy efficiency, and by that, emit less carbon dioxide in the environment. Due to application of high strength low alloyed steels at mechanical constructions its load increase, that also resulted to lower emission of carbon dioxide and reduced impact on climate. But those ecologic effects are not simple and have complex system of interactions. On the other side, steels are most important structural material because of its high strength in relation to its weight and price. Present machine industry is highly dependent on the availability of steel. High strength low alloyed steels are continually being developed and produced as high-tech and environmental friendly material.

The natural resources of planet Earth are finite. It is of the primary importance to conserve raw materials and to use them as efficiently as it is possible. The vital is to recycle materials, such as raw iron, that have already been used from natural resources. On the other side, steels are one of the materials that have greatest influences on usage of natural resources. Conservation of the natural resources demands energy efficient processes, and the most efficient and rational use of the finished steel product.

Steels are the most recycled material at present. Over lifetime, very high percent of all scrapped iron and steels are reused or recycled at specific phases of ecological cycle of steels, as it is presented at Figure 4. Present steels, also, present high strength low alloyed steel grades, can be considered as present part of lifecycle in which almost everything can be recovered. Nowadays, around one third of the steel production is based on scrap recycling.

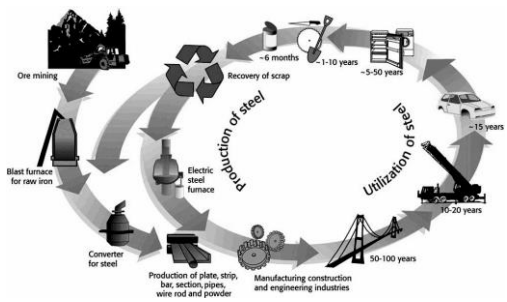

Figure 4. Ecological cycle of steels [10]

Production of steel and consumption of scrap by the steel industry for period of 1972 - 2005 is presented at Figure 5. according to International Iron and Steel Institute [9]. The same relation can be assumed for high strength low alloyed steels.

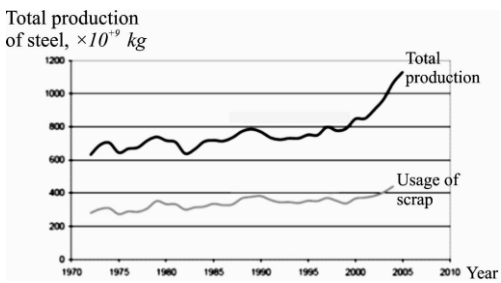

Figure 5. Production of steel and usage of scrap for recycling [10]

From the other aspect, steel production industry is among present most energy-intensive industries. Electrical energy and coal are mainly used in the steel making process, so as for production of high strength low alloyed steels. Responsible usage of coal, iron, gas and electricity can be represented as interaction between industry and the community and this interaction condition very high

efficiency of mechanical constructions.

4. CONCLUSION

High-strength low-alloy steels are the materials with currently fastest growing share of application at mechanical constructions. The shares of usage of those steels for production of cars in United States of America, as example, according to Ducker WorldWide and projections for those shares are presented at Figure 6 [11].

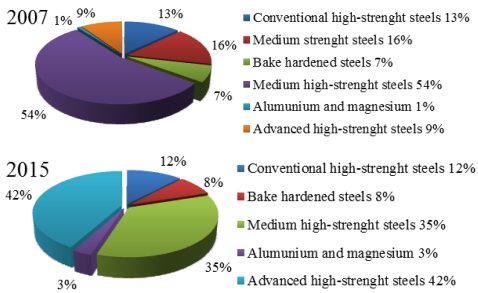

Figure 6. Tendencies for usage of steel grades for car production [9]

By the applications of high strength steels at mechanical constructions large number of significant advantages can be done. The optimization of design solutions of mechanical constructions made of this steel grade can be done only by adequate consideration of its specific nature and characteristic. Application of high strength steels at mechanical constructions put new significant perspectives for design of mechanical constructions, but, also brings some problems that must be solved in process of design.

The advantages of application of high strength steels at mechanical constructions must be put in correlations with its environmental effects. In correlation with applications of other materials high strength low alloyed steels can be considered as environmental friendly material.

ACKNOWLEDGMENT

Research presented in this paper was supported by Ministry of Science and Technological Development of Republic of Serbia, Grant TR 35033.

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