ASSESSMENT ON QUALITY OF THE METALLIC REINFORCEMENTS USED FOR SUPPORT AND SECURITY OF THE UNDERGROUND EXCAVATIONS

Eng. PLESEA VALERIU, PhD, S.C. ICPM SA Petrosani, ROMANIA, vplesea@yahoo.com
Eng. & ec. VLAICU POPA MARIUS EREMIA, PhD, SNLO Tg. Jiu, ROMANIA, m.vlaicu@yahoo.com
Eng. TOMESCU CRISTIAN, INCD INSEMEX Petrosani, ROMANIA, critom05@yahoo.com

Abstract: On the account of the advantages benefited regarding the correlation of the sliding work regime with the specific characteristics of the predominant rocks from the lithostratigraphical structure of the Jiu Valley’s underground, the support of metallic elements continues to represent the most advantageous version from the technical and economical point of view.

Besides a series of advantages, including the ensuring of bearing capacity expected per meter of work by applying the correct adopted support fields, the metallic support presents deficiencies generated by the irrational usage of steel for machining rolled profiles, with repercussions on imperfections recorded on element’s cold cutting and bending, including over the underground operation period of the armouring.

The target of presented paper is to analyze those deficiencies with their evaluation through analytical calculation and the presentation of counter measures.

KEY WORDS: Molded profiles, manganese steel, hardness, impact resistance, tenacity, elongation, heat-treating, normalization, hardening and tempering.

1. INTRODUCTION

The maintaining of the optimal functionality of the underground excavation, in full security conditions for deploying service processes for which this are destined, continues to represent a major interest problem regarding that no matter what the reference domain is the success of an adequate exploitation with few interventions in the maintenance expenses chapter makes possible the framing of the economical agent in the anticipated profitability.

This is not possible yet in the case of the mining units afferent to CNH Petrosani where, although the system of metallic support for execution of the mine galleries is introduced over 45 years and the efforts to its improvement were significant regarding the increasing of performing quality and underground efficient exploitation in underground, the metallic reinforcements continues to represent a problem with no universal solution, being influenced, besides the excavation geo-mining conditions and the support constructive technical requirements, by the quality of the machining/rolling of the molded profiles for the execution of the component elements (the beam and the pillars).

Next will be presented some aspects regarding the quality of steels used for the machining of molding profiles, by comparing the situation regulated by normative with the one that existing in mining practice.
2. QUALITY CONDITION OF STEEL FOR PERFORMING THE MOLDED PROFILES

The general requirement for the used steel are:
- to ensure high resistance values also the material rupture to occur at high loads;
- to ensure higher values of the flow limit to imprint to the support elements a higher bearing capacity in the elastic domain;
- to record high values of tenacity, elongation and necking so the molding elements to support high distortion without the appearance of the rupture phenomena;
- to ensure the possibility of reusing the support elements by cold straightening, without applying some eventual previous or subsequent heat treatments.

By economic considerations, in the last period, for machining the molded profiles are used non-alloy steel, respectively charcoal steel type 31 Mn 4 (tip carbon – charcoal steel type) which, in the absence of vanadium, aluminum, niobium or titanium as alloy elements, the existing normative in force foresee the use of charcoal in proportion of up to 1.2 – 1.6 %, and as technical principles of molding of the one scheduled by the German standard DIN 21544 – 85, according with the delivery of the molded profiles is made in a improved status (normalized).

The steel with high carbon content, respectively the charcoal steel, namely until 0.4 %, can be characterized with resistance at stretch and superior flow limit on the account of reduction of the deformation capacity, meaning of the tenacity, elongation and necking with negative consequences in the mining practice.

As a result, the modern steel manufacturing is based on the using of a moderate content of carbon (under 0.3 %), measure which leads on the obtaining of a acceptable deformability. The trend in this case, of decreasing the flow limit, on the reduction of carbon content, can be diminished by the presence of the alloying elements (V, Al, Ti, Ni) in the chemical composition, and in the lack of those (the case of charcoal steel), upper values of the flow limit can be obtained by a later appliance, after molding, of thermal treatment processes, meaning normalization and improvement (hardening + recovery).

Application to the supplier of the thermal normalizing treatment which consists of heating the profiles after molding at temperatures of 850 – 900°C, followed by a slow cooling in air, leads to removal of the ferito-perlite rows structure arrangement, respectively steel finishing and mixing, resulting high values for rupture resistance and flow limit, including elongation.

In the case of applying the improving thermal treatment, it is recommended to be applied after cutting and bending the support elements, of which process consists in tempering the elements by heating at 850 – 900°C and sudden cooling in water, emulsion or oil, followed by a high recurrence of the material, by heating at 500°C and slow cooling in air, producing an important increase of the rupture resistance and flow limit, in the account of reducing the elongation due to the profile’s molded status. Also, by applying the improvement treatment is produced the elimination of internal tensions, recrystallization and homogenization of the harden structure which results from the cold bending process.
3. THE QUALITY OF THE STEEL USED FOR MOLDING THE METALIC SUPPORT PROFILES

Currently, from the wide range of molded profiles produced in the country for manufacturing the SG support (18, 23, 29), is produced the SG 23 molded profile, which shape is one of gutter, produced by the e-company „Siderurgica” SA Hunedoara, made of steel type 31 Mn 4 which, in lack of alloying elements, suppose an moderate addition of carbon in the chemical content, up to 0,3 %, in accordance with DIN 21544 – 85 standard.

In reality, the molding of SG 23 profile is made by using charcoal steel with a carbon content way over the maximum admitted limit by the type 31 Mn 4, imprinting to the internal structure of the material an gross aspect, with an uneven arrangement and in layers of the crystalline grains, resulting increasing of hardens and fragility on rupture, on the account of reduction of deformation characteristics, respectively over the plasticity and resilience.

As the carbon, the charcoal content is also high, fitting in the interval of 0,81 – 1,36 %, from 0,8 – 1,1 % Mn admitted by the standards.

In contrast, the aluminum, as the only alloying element from the chemical composition of type 31 Mn 4 steel, records low value contents, contained in the interval of 0,006 – 0,01 %, due to the imposed minimum of 0,02 % Al.

In those situations, the checking of steel’s mechanical characteristics highlight sizes of rupture resistance (Rm) placed over the scheduled limit, of up to 850 N/mm² (fig. 1), than Rm = min. 550 N/mm², which is explained by the excess of C and Mn, which favors the self hardening of the profiles during the molding process, with subsequent negative repercussions regarding cracking and breaking of the profiles when cutting and bending, especially on cold weather.

In contrast, but negative, the flow resistance values (Rp 0,2 = min 350 N/mm²) and resilience (KCU = min. 70 J/cm²) predicted by the standards for the type 31 Mn 4 charcoal steel, are situated at a higher level than the one resulted by testing (figures 2 and 3), with repercussions on the accentuated reduction of steel’s plasticity and tenacity.

![Fig. 1. Framing mode of the steel’s rupture resistance measure depending of Carbon content and different profile delivery statuses](image-url)
As a result of quality inconvenient of the used steel chemical content, was tried, in the case of charcoal steel, in the lack of imposed standard thermal treatments, the reduction of carbon content, which generated a superior resistance to flow and resilience but due to reduction of resistance at rupture of the molded profiles, under the minimum stipulated limits, with repercussions on the reduction of support bearing up to 20%.

4. CONCLUSIONS

The SG.23 molding profile used for execution of the metallic support elements, besides the inconvenient of manifestation at joints of the un-calibration phenomena, by pole splitting and beam compression, as a consequence of joining with gaps between the shoulders, presents the disadvantage of self-hardening during the machining process, as a result of the used charcoal steel (31 Mn 4 type) and the lack of subsequent thermal treatment for quality ensure, with all the adverse consequences regarding the appearance of the highly deformation degree imprinted actually with the existent curving installations.

In order to increase the quality of machining the molded profiles become necessary the reuse of the alloy steel (OPM type) or applying by the supplier of the normalizing heat treatment after rolling and of the increasing one (hardening and high recovery, by beneficiary, after curving the elements).

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