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Editors:
Ljubiša Balanović
Dejan Tanikić

18-21 October 2023, Bor Lake, Serbia

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PREFACE

On behalf of the Organizing Committee, it is a great honor and pleasure to welcome all esteemed participants of the 54th International October Conference on Mining and Metallurgy (IOC 2023), scheduled to take place at the picturesque Bor Lake, Serbia, from October18th to 21st 2023.

The collaborative efforts of the University of Belgrade, the Technical Faculty in Bor, and the Mining and Metallurgy Institute Bor have meticulously organized this year's IOC. Our focus remains unwavering on showcasing the latest research findings and advancements in geology, mining, metallurgy, materials science, technology, environmental protection, and other engineering disciplines. Our primary objective is to foster a dynamic environment where academics, researchers, and industry professionals can come together to share their knowledge, experiences, and innovative ideas while exploring opportunities for collaborative research endeavors.

Our conference agenda is rich and diverse, encompassing plenary sessions, engaging invited lectures, technical presentations, enlightening oral and poster sessions, informative technical tours, a diverse exhibition, and memorable social gatherings. At the heart of this event lies our strong commitment to sustainable development within the mining and metallurgy sector. We are dedicated to exploring ecologically conscious methodologies, responsible resource extraction practices, and cutting-edge technologies that reduce the industry's environmental impact and enhance the well-being of local communities.

The conference proceedings comprise 129 papers authored by individuals from universities, research institutes, and industries in 22 countries. We are proud to welcome participants from Bosnia and Herzegovina, Bulgaria, Canada, China, Croatia, Germany, Greece, India, Iran, Kazakhstan, Libya, North Macedonia, Montenegro, Morocco, Romania, Russia, Slovakia, South Africa, Spain, Turkey, United States, and, of course, Serbia.

We are excited to host the 8th International Student Conference on Technical Sciences (ISC 2023) as part of IOC 2023. This event offers students from Serbia and the wider region a unique chance to showcase their research and discuss the future of their fields with experts.

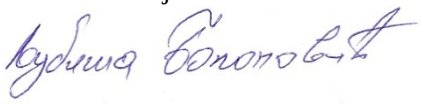
We sincerely thank the Ministry of Science, Technological Development, and Innovation of the Republic of Serbia for their generous financial support. In addition, we express our profound gratitude to all our sponsors, exhibitors, and friends of the Conference for their contributions and unwavering support for playing a pivotal role in ensuring the success of IOC 2023.

We would like to express our heartfelt thanks to all authors, committees, reviewers, speakers, and chairpersons for their invaluable contributions in shaping IOC 2023.

We look forward to welcoming you to the 55th International October Conference on Mining and Metallurgy (IOC 2024), which will be held in October 2024.

On behalf of the 54th IOC Organizing Committee,

Prof. dr Ljubiša Balanović



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ABOUT THE "RELATIVE PLASTICITY" BETWEEN STEEL MATRIX AND NON-METALLIC INCLUSIONS

Zoran Karastojković[1], Dragoslav Gusković[2], Ognjen Ristić[3], Zorica Kovačević[3]

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Abstract
It is clearly established in metallurgy, also in service of machine elements or components, that non-metallic inclusions are not desired into metals, either they are ferrous or nonferrous. One of the main factor for such conclusion is in markably decreasing the plasticity with increasing an amount of the non-metallic contenst. Non-metallic inclusions were classified according to its nature, shape and dimensions, as many national standards were defined those properties. Sometimes is not simple to make a fully definition of the plasticity, as a property important both for cold or hot deformation processes, because many factors must be involved at the same time. One attempt for judging the plasticity of a steel was made by using a "relatively plasticity".

***Keywords**: elasticity, plasticity, non-metallic inclusions, relatively plasticity of steel*

1. INTRODUCTION

Many efforts in mechanics and engineering, over a centuries, were made on defining what are elastic and/or plastic deformations. According to complex composition of many steels, it is not simple task for defining an unique value for plastic behaviour for every steel, and must be done for every steel particularly and for every method of deformation (forging, rolling, drawing, etc.). Such approach is, however, valuable and reliable, but require a huge (experimental) job.

In metallurgy, of course in materials science and engineering, the yield point is defined as the point on a stress-strain curve that indicates the limit of elastic behavior and the beginning of plastic behavior. So, below the yield point, a material will deforms elastically and behind this point the deformation is provided on irreverible manner, it means plastically. It looks like very simple, but in situations when different loads acting, it is not.

On many properties of a metal, including a plasticity, in real cirmumstances an important role play the contenst and shape of non-metallic inclusions. The origin of non-metallic inclusions in final metal product is in mineralogical nature of used ore(s) and materials. Great amount of non-metallic inclusions came from the ores, smaller part of them came from the refractory lining from metallurgical furnaces (blast furnace, converters, ladles, used fluxes, etc.),

These non-metallic inclusions practically are not soluble into the metal but show the great influence practically on every property [1-4]. The shape and dimensions of non-metallic inclusions were defined through many national standards [5,6] according to four main groups, and their influence on properties is analyzed and controled [7,8], but one interesting approach was made when plasticity is considered as a ration between of the true strain of the inclusion and true strain of the steel matrix, and this ratio is called the "relative plasticity" [10].

Here will be analized the usiness of such approach.

2. ORIGIN, DIMEIONS AND SHAPE OF NON-METALLIC INCLUSIONS IN STEELS

Great amount of non-metallic inclusions came from the ores, smaller part from the refractory lining at metallurgical furnaces (blast furnace, converters, ladles, used fluxes, etc.), used materials during treating of molten metal, as shown in Fig. 1.

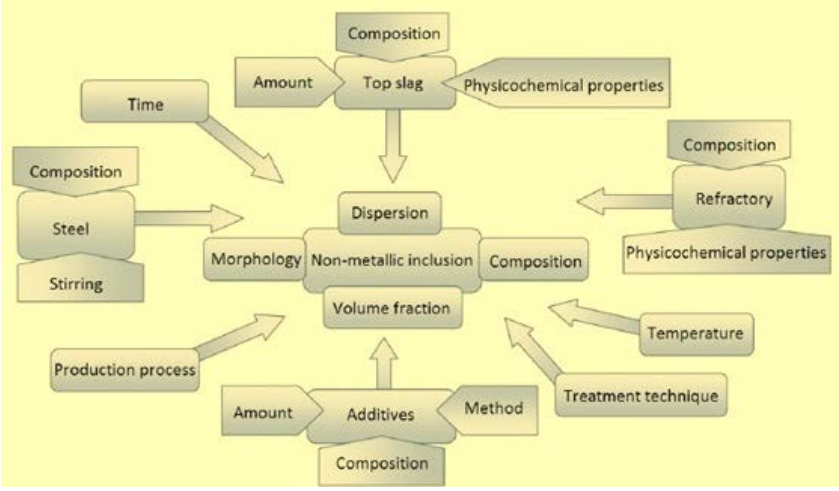
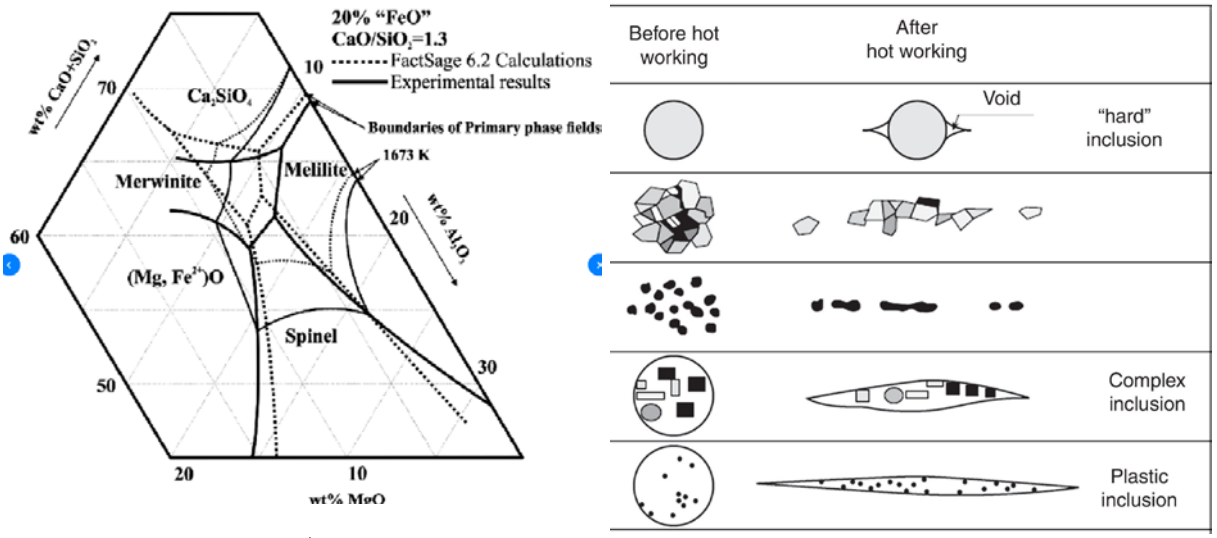


Figure 1 - Scheme of influences on formation of non-metallic inclusions

There is always an intention for removing the non-metllic inclusions from a melt.
In producing&controling the qualitative steels is well established and wide accepted, through many national standards, the scale for assesment the amount and shapes of non-metallic inclusions, according to four main types (sulphide, globular oxide, silicate and alumina). Non-metallic inclusions are deformed, however, at cold and hot processing. Chemical composition of non-metallic always is complex, one example of their many groups is given in Fig. 2a), as a part of ternery diagram with oxides.



a) b)

Figure 2 - a) Part of diagram MgO-CaO+SiO_2-Al_2O_3 and b) shapes of non-metallic inclusions before and after hot deformation [15]

In reality, the non-metallic inclusions. however, are not limited on oxide types, but on very complex compounds from groups of: silicates, suphates, sulfides, etc. Shapes of non-metallic inclusion before deformation almost are irregular, and after deformation is finished they became

broken, in Fig. 2b) is presented after hot rolling. Non-metallic inclusions also are crushing during cold deformation, no matter the kind of metal working process is applied.

3. CONCEPT OF „RELATIVELY PLASTICITY“ IN STEELS

Property of plasticity is pretty complex, depends far away from the circumstances during casting, solidification (dendrite grow) and farther the regime of metal working process. Plasticity [10] „describes the state of stress and strain or strain rate in these bodies under the influence of a given load or deformation”, (underlined by Zoran Karastojković). Well, the load (force) actualy has the influence on metal flow/plasticity, but deformation (no mater elastic or plastic) is just the consequence of an acting the load, so the deformation could not be the reason for the appearance the plasticity. The force creates the deformation, i.e. the deformation is self induced it is always from internal stresses or weight of a body.
It is well known that the plasticity of any metal strongly depends from a temperature, but there are other numerous important factors as: composition of an alloy, deformation degree shedule, stress state, strengthening or softening mechanisms, speed of tool moving (in some deformation processes), strain rate, strength of matrix and non-metallic inclusions, and others.

Concept of “relatively plasticity” [10] is established on rather simple manner, eq. 1, and with an improved version as like by eq. 2.

$$\nu = \varepsilon_i / \varepsilon_m \tag{1}$$

where: ε_i is the true strain of the inclusion and ε_m is the true strain of the steel matrix

$$\nu = \frac{\varepsilon_i}{\varepsilon_m} = \frac{(\ln\lambda - \ln\lambda_0)/2}{\ln\frac{h_0}{h}} \tag{2}$$

where: λ_0 and λ are the aspect ratio of an elliptic inclusion before and after rolling.

If inclusions are cylindrical and in the case of plane strain rolling of the steel plate, than the expression from eq. 2. may be used [10]. For applying both equations for cases from crushed non-metallic inclusions given in Fig. 2b), is needed an excese time, always with pretty limited results. At those equations never are included data about strength and/or plasticity of non-metallic inclusions. So, the plasticity, here in steel plate, could not be explained only by geometrical factors about the presence of non-metallic inclusions [16].

The serious analyse in proposed approach needs the constantation that during rolling of (steel) plate exists plane strain, because according, to the rolling theory, in the rolling zone rather exists three stress state.

It should be underlined that temperature dependance of plasticity od any non-metallic inclusions always represents a serious problem. On fatigue strength, also [17]

4. CONCLUSIONS

It is clear that the plasticity of metal/alloy is complex in their nature, and in great deal is determined by the presence of non-metallic inclusions in the structure, no matter on the way of applied metal working process, i.e. plastic deformation. The “relative plasticity” here is mentioned in rolling, but the problem of plasticity, however, exists at all methods of deformation.

The plasticity during rolling of steel plate could not be reduced only on the ratio between geometrical dimensions of non-metallic inslusions, as proposed by [10], even the logarithmic deformations are included into account. Crushing of non-metallic inclusions, as like in Fig. 2b), made a proposed manner for calculation the plasticity more problematic and less usable. For all main groups of non-metallic inclusions (sulphide, globular oxide, silicate and/or alumina) such

approach is just unavailable. The main attention must be paid on the metallurgical treatment during refining of molten metal, further for crystallization effects, obtained structure during casting, and related metallurgical factors.

The effects of microalloying were not included in this analize. so this fact does not represents an advantage, just contrary.

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