RESEARCH AND EXPERIMENTS REGARDING THE MANUFACTURING OF METALLIC MATERIALS WITH A BETTER CUTTING CAPACITY

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VÝSKUM A EXPERIMENTÁLNY PROGRAM TÝKAJÚCI SA VÝROBY KOVOVÝCH MATERIÁLOV SO ZLEPŠENÝMI REZNÝMI VLASTNOSŤAMI

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Abstrakt

Uskutočnený bol výskum a experimentálny program s cieľom zlepšenia opracovateľnosti zameraný na určenie technológie prídavku síry, tak aby asimilačný stupeň nebol väčší ako 10% rozdiel medzi jednotlivými vsádzkami. Experimenty boli realizované v 50 tonovej elektrickej oblúkovej peci. Výsledky experimentov sú uvedené graficky i tabelárne.

Pretože tieto ocele sú určené pre súčiastky, ktoré pracujú v podmienkach rázového zaťaženia, opotrebenia a únavy, predpokladá sa u nich dodatočné obmedzenie v súvislosti s ich zlepšenou opracovateľnosťou. Častice, ktoré sú priaznivé v prípade procesu rezania sú prijateľné len v takom rozsahu aby ich množstvo, tvar a distribúcia významne neovplyvnili pružnosť, odolnosť proti únave, mechanické charakteristiky v priečnom reze, ich cementačnú schopnosť a prekaliteľnosť, atď.

Medzi prísadovými prvkami, ktoré sa používajú s cieľom zlepšenia opracovateľnosti tvorbou inklúzii (jednoduchých aj zložitých), absorpciou na povrchoch sulfidických a oxidických inklúzii, rovnako ako aj tvorbou izolovaných ostrovčekov v základnom materiáli (ich rozmery sa pohybujú v rozsahu 0,08 – 0,15μm) sa bude aj naďalej používať síra, fosfor, olovo, selén a telúr.

Abstract

The researches and experiments we have carried out on the improvement of the processing easiness aimed at determining a technology of sulphur addition, so that the assimilation degree should not be more that 10% different form one charge to another. The experiments have been conducted at an electric steel plant equipped with 50 tone furnaces. The results of the experiments are given both graphically and analytically.

As these steels are meant for parts that work in conditions of shock, wear and fatigue they imply supplementary restrictions as to the means to be used in order to improve their processing easiness. The inserts that are favorable in case of cut-processing are to be accepted only to the extent to which their quantity, shape and distribution does not significantly affect the resilience, resistance to fatigue, the cross sectional mechanic characteristics, their cementing capability and hardening capacity, etc.

Among the addition elements used in view of improving the processing easiness by inclusion forming (both simple and complex), by absorption on the sulphide and oxide inclusion

surface, as well as by the formation of isolated islands in the base mass (their dimensions ranging between 0.08 – 0.15μm) sulphur, phosphorous, lead, selenium and tellurium continue to be used.

Keywords: researches, experiments, steels, metal constructions, sulphur addition, technology, improvement of the processing easiness

1. Introduction

One of the most complex problems arisen by engineering machine-building industry to the metallurgy is the manufacturing of metallic materials with a better cutting capacity, a greater output and, in the same time, a surface condition suitable for the imposed aim, depending of the subsequent utilization of the respective product.

Due to the diversity of the steel utilization conditions, corroborating with the permanent need to increase the output, using the automatic machine tools with a heavy duty cutting regime, the range of the steel grades with a good workability is now extrapolated, in principal, on the following steel grades: soft steel, for small pieces with normal mechanical stresses, steel for engineering machine-building, for strong stressed pieces, stainless steel and high-speed steel.

The machine-building steel grades for heavy-duty pieces, working in shock, wear and fatigue conditions, need additional restrictions, regarding the means used for improving the cutting capacity. So, the presence of the favorable inclusions for the cutting processes will be accepted only if their amount, form and distribution don't appreciably affect the resilience, the fatigue strength, the mechanical proprieties in the cross section, the cementing and the hardness capacities, and so on.

Soft and extra-soft steels, characterized by high ductility, are processed unsatisfactorily through cutting, because the chip formation and its removal from the cutting area is proceeded by a considerable deformation and hardening of the ferrite base mass, with negative influence upon the wear of the tools. Having in view the cutting workability can be possible the resolving of this aspect. Introducing into the steel elements, which either form non-abrasive, non-metallic inclusions (interrupting the continuity of ferrite structure), or dissolve in the ferrite, thus hardening it, usually succeeds this.

Among the alloying elements used for improving the workability, susceptible of forming non-abrasive, non-metallic inclusions with lubricating properties in structure of the steel, are the sulphur, the lead, tellurium and selenium, in controlled quantities, which are, usually, smaller than the automatic soft steel alloying elements content. Normally, the sulphur is added to the automatic steels up to approximately 0.04%. Adding higher contents, up to 0.08% is not a practice, because the growth of workability is lower compared to the increased difficulties in the phases of elaboration and plastic deformation of such steels. Thus, the red brittleness is stressed at values of the Mn/S ratio below 1.7. In the case of steels destined for the making of screw nuts, where the cold upsetting is included as a technical procedure, the sulphur content is reduced to 0.08…0.12%. Fig. 1 presents the influence of sulphur content growth in the steel, upon the cutting workability.

Regarding the sulphur content of these steel grades (which had been inspected during the experiments), there were standardized steel grades with 0.08…0.15% or even 0.25%. Usually, it is considered that the 0.04…0.07% sulphur range has got the lowest influence on the

decreasing of the mechanical properties values. It was chosen a compromise range for the workability level and the mechanical properties.

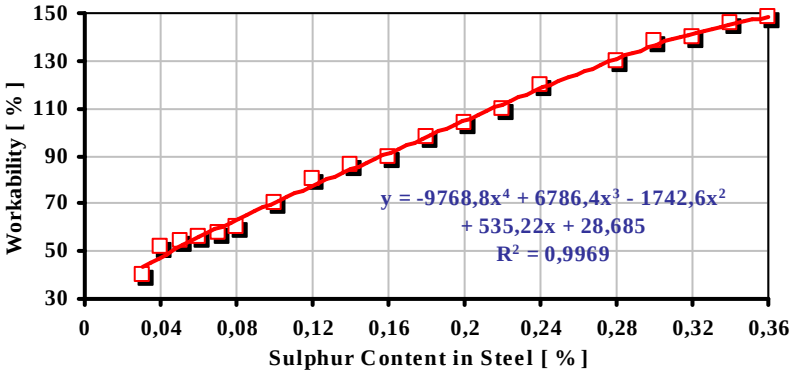

Fig.1 The Influence of Sulphur Content Growth upon the Cutting Workability

It is worth to be remembered that many required chemical compositions of steel grades guarantee the minimum limit of the sulphur content (approximately 0.02%) for the steel grades with normal sulphur content (maximum 0.045%). The using of these steel grades with controlled sulphur content (0.02…0.045%) helps the improving of steel products surfaces when the cutting speed is low. At the same sulphur content in the steel, the composition and especially the shape and distribution of sulphides (which depends an elaboration, dezoxidation and casting) shows a strong influence upon the cutting workability. It is generally admitted that the sulphide's inclusions of type I (globular) are preferred over those of type II, with intergranular or eutectic distribution.

The industrial and laboratory experiments regarding the determination of quantitative correlations between this steel's workability and the characteristics of the sulphide inclusions (KZ_{MnS}) which assure this property are presented in table 1. The middle value of the KZ_{MnS} is establish through a graduated standard with seven scores (score 0 for fine sulphide inclusions and respectively, score 6 for the rough inclusion), after the examination on microscope of the metallographic specimen surface, at an x 200 magnifying.

Table 1 The correlation between KZ_{MnS} and the workability of steel

KZ_{MnS}		Behaviour at the Machining
Limits	Middle Value	
3.0	2.75	Weak
3.0…3.5	3.25	Middle
3.5…4.0	3.75	Proper
4.0…4.5	4.25	Adequate
4.5	4.75	Exceptional

Adding sulphur or ferro-sulphur makes the sulphur alloying in steel ladle or in the furnace, together with the ferro-manganese and silico-manganese for dezoxidation. It is possible to add only sulphur, packed in paper bags, but in this case the sulphur assimilation is lower and the its spread is very high.

For sulphur alloying, it is also possible to use some of the sulphur chemical compounds (for example: iron sulphide, manganese sulphide or sodium sulphide), but in this cases appear the same problems as at the sulphur direct addition.

A modern solution for the sulphur addition is the using of the filled wire.

2. Experiments and Results

The experiments were made at an electric steel plant, equipped with electric-arc furnaces having a 50 tone capacity and the steel was cast in ingots having 3.5 tone capacities. All the working versions were experimented using the steel grade 33MoCr11 with the sulphur final content its 0.04%. We chose the following working versions:

I. The re-sulphuring using lumps of pure sulphur;
II. The re-sulphuring using iron sulphide;
III. The re-sulphuring using ferro-sulphur with 29.03% sulphur;
IV. The re-sulphuring using wire filled with pure sulphur.

2.1 Version I

The sulphur was added into the steel ladle, before tapping, bagged in paper bags. For experiments we used 8 (eight) heats with the sulphur assimilation degree varying within 12…58%. We consider that the great variation of the sulphur assimilation degree is due to the following causes:

- the relative low smelting point (112^0C) and ignition point (250^0C) make uncontrollable a sulphur amount which burns until the ladle bottom is covered with a steel layer having at least 150 mm depth;
- the non-uniform mixing of the small sulphur pieces with the steel bath, some of them remaining a much longer period of time on the bath surface and burning due to the atmospheric oxygen.

The great variation of the sulphur assimilation degree caused a great variation of the steel sulphur content and, many times, the values can not be within the imposed range.

2.2 Version II

We experimented here the addition of pyrite lumps proceeded from the Hunedoara county mine areas, having a medium sulphur content is 45% and a medium manganese content is 3.3%. The iron sulphide is floating on the bath surface, but, comparatively with the pure sulphur, is partly dipped into the steel bath and, thus, the assimilation degree would be within the 32…61% range, so more stables as compare to the first version.

2.3 Version III

In this case, the re-sulphuring was realized with ferro-sulphur produced at the Faculty of Engineering Hunedoara, inside an induction furnace (100 kg capacity), using as metal charge carbon steel scrap and pure sulphur (from the cocking plant), with the sulphur content within 99.2…99.6% and cast in ingots with 25 kg weight. As smaller is the ingot weight, the greater is the chemical homogeneity.

The sulphur content of ferro-sulphur varied within a small range (28.42…29.64%). It has been experimented 12 heats, the sulphur assimilation degree being within 64…86%.

Although the assimilation degree varied within a large range, the chemical composition of steel and the Mn/S ratio imposed for avoiding the friability were within the standardized range.

2.4 Version IV

The addition of the deoxidisation and alloying material filled wire is a modern solution for deoxidisation and alloying (of course, only if the respective materials can be brought to a suitable granulation for filling the wire). The filled wire having a 15 mm diameter was produced in Romania.

The machine for dipping the filled wire has two channels, for ϕ15 and ϕ13 mm. The dipping speed was 4 m/minute. For filling the wire, it had been used pure sulphur.

The assimilation degree for 15 heats was within 89…93%, which allowed the chemical composition of the steel to be within the standardized ranges. This assures a rigorous control of the chemical composition, with positive effects on the workability of the material, on the surface quality of the processed products and, of course, on the operation behavior and the working life of the cutting tool.

The variation of the sulphur assimilation degree, for the analyzed versions, can be seen in the Table 2, and graphically, in the fig. 2.

Table 2 The Sulphur assimilation degree according to the experiments versions

Number experiments of version	The sulphur assimilation degree [% / version]			
	Version I	Version II	Version III	Version IV
1	12.34	32.67	64.28	89.31
2	17.65	50.36	69.48	90.32
3	45.29	46.39	71.65	89.54
4	39.56	57.12	73.69	92.98
5	26.86	56.89	85.95	91.16
6	54.38	60.95	84.13	89.67
7	48.35	-	82.26	91.98
8	57.97	-	83.45	92.47
9	-	-	81.97	90.75
10	-	-	83.15	89.72
11	-	-	84.37	92.59
12	-	-	85.16	91.68
13	-	-	-	90.83
14	-	-	-	90.64
15	-	-	-	91.24

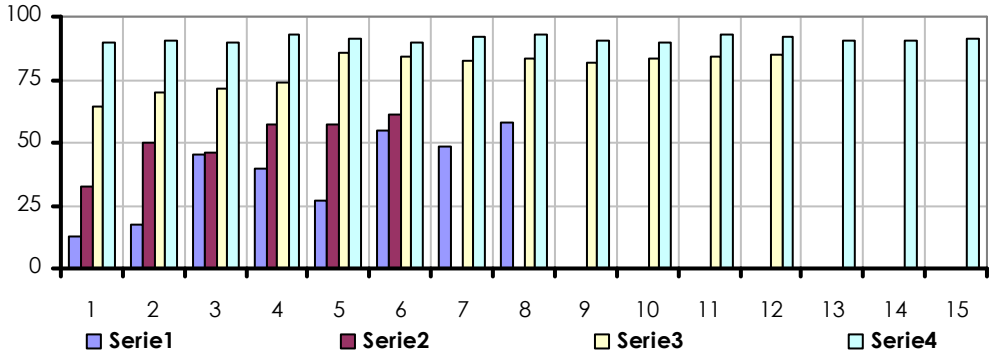

Fig.2 The assimilation degree of the sulphur in the analysed charges

3. Conclusions

After the experiments, it results the following conclusions:

- to improve the workability of the engineering machine building steel, it can be used different steel grades;
- looking at the above mentioned versions, it can be observed that the best results are obtained using the sulphur filled wire;
- the greater cost for producing of the filled wire is recovered by increasing the steel quality, the workability of the products and the working life of the cutting tools.

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