TEMPERING OF BAND SAW BLADES AFTER ELECTRIC ARC WELDING WITH SMELT ELECTRODE

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Abstract

Electric arc welding of band saw with smelt electrode increasingly used in Bulgaria. The basic risk by welding of band saw blade made of low alloy tool steels is a possibility of shows up of hardened structures formation and cold cracks in the zone of heat influence. That reflected unfavourably on working capacity of the saw blade. Consequently, it is cracked or torn in the weld area under the influence of high inside tensions and outside loads. This article studied the processes of tempering of band saw blades after its welding using MIG/MAG methods with or without of heating in advance.

Key words: *band saw, welding, electric arc, smelt electrode, gas-protected, tempering*

INTRODUCTION

The basic indexes of band saw blade guaranteeing it stable and steady work during length cutting of logs are the correct choice of linear and angle parts also it qualitative preparation.

One of the important stages of the new saw blades or these, which have been already operated and got different defects, are its ends joint. There are different methods of joint but more widespread application in the practice of woodworking and furniture industry found *electric arc welding with smelt electrode in gas-protected surround* [2].

The basic difficulty by welding of low alloy tool steel, the band saw blades made is a possibility of tempered structures formation in the zone of heat influence (ZHI) as well cold cracks. It had an adverse effect on blade working capacity. In consequence of this it is cracking or tearing very often in the zone of weld under the influence of highly inner tensions and large external loads.

The reasons are different and dependent on the techniques and the technology of electric arc welding with smelt electrode and especially of correctly saw blade tempering in the place of it welding.

The aim of this article is to be investigating the processes of band saw blades tempering after welding according to both weld methods – MIG and MAG with and without heating in advance of its ends.

WORKING METHOD

The investigations carried out by using of band saw blade made in company "RÖNTGEN" – Germany. The blade was made of low alloy tool steel, brand CT75W3 according to DIN with hardness - HRC $44^{\pm1}$. The choice of this type of blade was defined because it is using in Experimentally Training Forestry Campus "Yundola". Table 1 shows it chemical compositions.

The linear and angular parameters of the blade were s = 1,06 mm; B = 100 mm; t = 35 mm; h' = 11 mm; b = 2,6 mm; $\gamma = 26 \div 27\ ^0$; $\alpha = 16\ ^0$. Permissible aberration: $s \in (0{,}8 \div 1{,}2) \rightarrow \pm 0{,}035$ mm; $B \in (40 \div 100) \rightarrow \pm 0{,}38$ mm/1000 mm; t up to ±0,3 mm; h' up to ±0,2 mm; for the angles $\pm 1^0$. Tooth profile PV.

Table 1. Chemical composition of the band saw blade steel

C	Si	Mn	Ni	Cr	V	P	S
0,75	0,35	0,53	-	0,20	-	0,025	0,025

The low alloy tool steels have a low heat-resistant and heightened toughness. When sawing the timber, the band saw blade due to the stretching device experiences a certain tension in addition to various other forces such a bending force, centrifugal force, cutting force, tension adjustment force, back tension adjustment force, etc., and therefore it needs high tensile strength sufficient to stand out these tensile forces. Furthermore the steel for saws have got to be with a heightened homogeneity and purity. Even if it has not large carbide heterogeneity makes worse the quality of saws. According to structure these steels are hypoeutectic, i.e. they contain up to 0,765 % C and to get higher toughness they are tempered to lower hardeness (40~55 HRC). In this way the steels obtained troostit/sorbit structure (fig. 1) [1, 4].

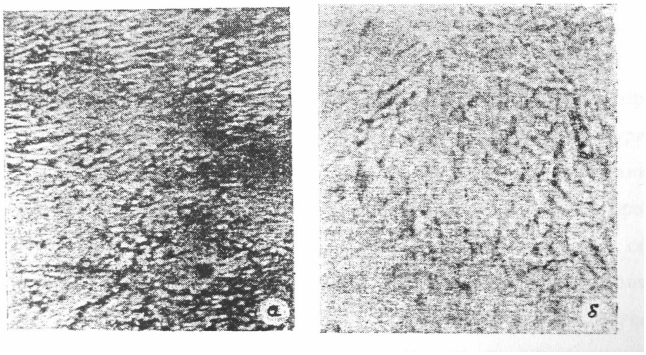

Fig.1 *Microstructure of hypoeutectic steels: a/ troostit; b/ - sorbit*

An electric arc welding machine in gas-protected surround had been used of the experimental examinations in the production conditions of ETFC "Yundola". The model of this machine was "AB-ARTI BILEME" MAKINALARI MIG-TAV, Turkey. This machine worked according to MAG (Metal Active Gas) – welding with active gas ($Ar+CO_2$). The welding has been without heating in advance [3].

The tempering of band saw blade in the zone of welding according to MAG method was done with a programme Pr-1 from the programming storage and basic function $F2 \rightarrow 1$; 2; 3 - annealing level. Each of next ciphers brings to sharpening of regime.

Extra experimental examinations have done in a general partnership "Chakarov-Davidkov&Co" – town Boboshevo. For that purpose was used an electric arc welding machine in gas-protected surround (Ar), worked according to MIG method (Metal Inert Gas). The welding and tempering of the saw blade had been done with heating in advance of both blade ends and it one and the same position on the machine. The temperature had been controlled with programme controller [3].

A quality joint of the band saw blades depends on observance of number factors as: condition of welding surface; the quality of the ends saw blade preparation and its joint; the techniques of welding including the methods of electrode conducting, the choice of welding regime, the gears and its methods of using, applying of heating in advance, mechanical cleaning of welding joint, tempering and etc.

- *Preparation of saw blade ends for welding:*

The precision of saw blade ends and its cleanness before welding have an effect on quality and economy of the process.

The band saw ends are made straight and cleaned up in advance to remove the pollution from the blade. The cleaning is made with naphtha to elimination of resin films and sawdust. After that followed dry wipe and cleaning with ethylated spirit. The blade is cut at right angles with the help of guillotine. This is done from the point under the middle of the blade tooth back and to a distance up to 2/3 from it top (fig. 2).

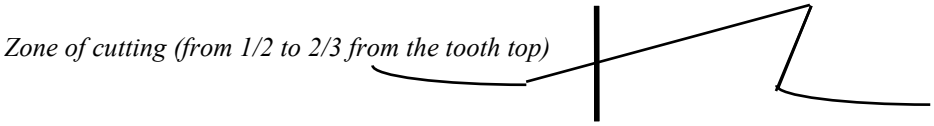

Fig.2 *Zone of saw blade cutting*

- *Technological characteristics of welding process and saw blade tempering:*

When welded according to methods MIG and MAG ought to take into account we've worked with a higher density of electricity. Therefore it is created larger quantities of heat in the welding material. Furthermore formed in a liquid state weld-tub is bigger in volume and surface. This requires respectively insurance with gas protected flow. Moreover in order to prevent from burning of both blade welding ends it is necessary to put restrictive lamellae (fig.3). These lamellae are cut from itself saw blade. They get out of the way after cleaning of welding zone. The weld is made perpendicular and with minimum distance between both blade ends is. The copper clamps of the machine link together the blade to a distance10~12 mm from the welding place.

- *Regime parameters:*

The basic factors that must observe are: force of welding current; tension current; kind and composition of protected gas; welding speed and feed speed of the wire [3].

- *Welding techniques:*

By welding of saw blades with thickness 1~2 mm doesn't allow any oscillatory movements with the weld burner. The process of welding is done with the most long arc and maximum welding speed. At that makes sure of good joint formation and good gas protection. The burner has a slight slant toward the blade at angle 30~40 ^{0}. The weld has to slowly cool.

After get the welding process over the saw blade is taken down from the machine and welding joint clean up on the both side using grind machine. The both flat side become polished along the length by hand grind machine with fine grainy sandpaper after that have a wash with ethylated spirit.

The control of mechanical characteristics of steel is defined through measuring of it hardness according to Rockwell method and observations of micro grind samples [6]. The measurements were carried out in the laboratory "Cutting of wood" of University of Forestry using apparatus for metal hardness measuring model "TK-14-250" (Russia).

STUDY RESULTS

The band saw blade is heated by welding and the joint zone got temperature corresponding of the phase transformation - 730^0C [5]. This place hardened to martensite structure because of rapidly cooling from the environment air (fig.4). In the presence of needles it showed superheated of the steel. The investigations concerning the steel hardness have shown, that it was of the order of 60~65 HRC in the zone of heat influence (ZHI). This structure is not suitable to saw blades and while working they will be cracked and broken.

This can restrict to heating in advance welding parts. The right temperature of heat depends on chemical composition of the steel and weld thickness ends.

The investigations according to method MIG with heating in advance of both saw blade ends were carried out when heated to 450^0C throughout 60 s. In this way the cooling is going on with a little speed and not large temperature difference and thereby limiting the circumstances for a big overcooling and rapidly grows cold in the process of welding. Moreover, the joint's homogeneity and diffusion between basic metal (the band saw blade) and secondary (the welding wire) is getting better.

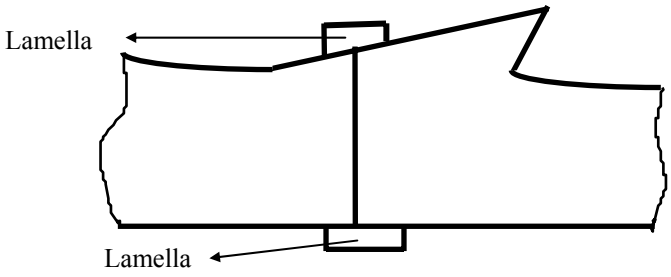

Fig.3 *Restrictive lamellas against embrace*

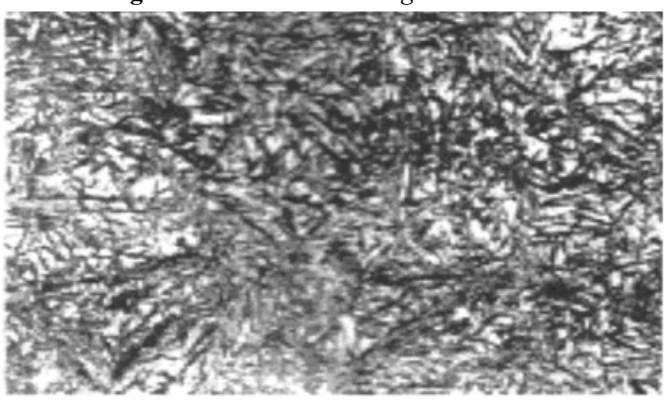

Fig.4 *Microstructure of martensite*

After welding of band saw blade ends, ZHI is processed obligatory on tempering. Thereby aim at decreasing of the inside tensions got by tempering and augmentation of the impact strength and wiriness of the steel (at the expense of the hardness decrease).

According to the temperature of the tempering and in accordance with the degree of the processes that are going on there is four basic transformations of the steels: *low temperature* - 150~240^{0}C. In this instance is kept a hardness near to this behind the hardened but a part of inside tensions is taken down by increasing (if only on a small scale) of the impact strength; *average temperature* - 420~520^0 C. In this case is got relatively a high impact strength of material while the hardness for the most steels is vastly reduced; *high temperature* - 550~650^{0}C – for carbonic and alloy construction steels with low and average carbon content.

Materially importance for the wide band saw blades characteristics has the size of grains. Therefore, the time-temperature regime for tempering of the metals should be such that can get small grains. The hardness in ZHI must not differ any more than ±10 % from the basic metal.

The tempering is taking under a temperature 450^{0}C as a result of this the microstructure which get is called *troostitout of tempering.*

Whit this temperature during 3 min experimental examinations were carried out at doing tempering of the band saw blade in the welding zone got according to MIG method with heating in advance.

The hardness to be Rockwell (HRC) in ZHI was within the compass of 30 to 35 HRC, what it is with 30 to 20 % less that the basic metal (44$^{\pm1}$ HRC). The reason for this was because the blade was kept on the machine's warmed-over copper plates in the presence of continued heating from 450^{0}C being no allowed it quickly cooling and hardening.

Every process of heat treatment is in a position to be described as a graphic in frame of reference *temperature-time*. The black and white drawing showed in a fig.5 is described with: t_1 – time for attain to temperature T_3; T_3 – temperature of retention (processing); t_2 – time of retention by temperature of processing; t_3 – time for cooling.

It is obvious that the retention after welding limited the speed of metal cooling by temperature with heating in advance for the both saw blade ends. In this instance it can't effect of hardening at hardness 60~65 HRC. Hence the applied regime of tempering in ZHI the hardness fell vastly under the basic metal.

The given regime of tempering requires taking down of the band saw blade from the machine in order to “take a rest” during 1~2 min whereupon it submits to tempering.

The results from the hardness test are shown in figure 6. In this instance the hardness of steel in ZHI and directly in the welding joint is in the borders of the limit by comparison with that of the basic metal.

The band saw tempering in the welding zone according to MAG method without heating in advance was carried out with programme Pr-1 of the programming system with basic functions F2→1; 2; 3 (annealing level). Every next number leads to sharpening of regime. A main failing of this machine is the impossibility for assign and control of tempering temperature. The temperature of heating for tempering (450^{0}C) is controlled visual according to colour change of the steel. When the tempering regime is carried out correctly with consistency pressing of a button F2, from the saw blade back and from the tooth chamber is received conical zone with dark-blue colour and brown nuance on the end. This zone fused and in the place of joint some strip is obtained. The strip has width about 20 mm and the same colour mentioned above. It doesn't allow any dark-red colour during the process of tempering. That is an indicator for presence of overheated.

Depending on the sharpness of regime, the process of tempering continues from 1 to 3 min. Figure 7 presents the test results of harness according to described regime.

The hardness in ZHI is a little more but yet it is within the framework in the borders of normally. A good tempering is achieved with a well qualification of the staff and good technical condition of the machine.

Figure 8 presents the test results of steel harness according to the distance from welding join with different circumstances of tempering. From it we can see that the hardness of steel to a 5 mm distance from the both side of the weld falls sharply to values which are lower than the band saw blade, especially with increasing of the time tempering. A tempering during 1,5 min could be accepted as optimum since further increase of the time reduced the hardness in the zones of the blade which contiguous to a welded part.

Lowering the hardness of some parts to a distance 5~10 mm from the welding joint increased the band saw strength. The blade works basically in the circumstance of bending what it at the expense of a large flexibility of those parts witch are in the close by the welding joint.

For comparison of the hardness distribution in figure 8 are given and curved lines for the hardness of unwelded saw blades which are subject to tempering as well and the distribution of the harness by welding without tempering.

CONCLUSIONS

On the basis of the studies carried out on the tempering of ban saw blades after electric arc welding with smelt electrode (MIG/MAG – method) with and without heating in advance of the both blade ends could be make it the following more important conclusions:

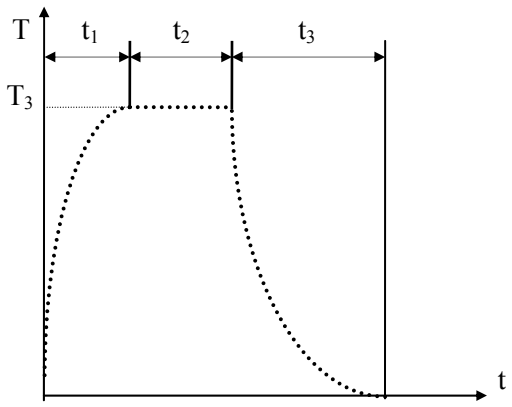

Fig.5 *Black and white drawing for heat-treatment*

1. By experimental way was determinate the regime of tempering of the welding joint and ZHI. The tempering according to MIG method with heating in advance of the width band saw blade is completed with temperature 450^0C during 60 s as the temperature is given and controlled with programmatic controller. The tempering according to MAG method without heating in advance was carried out with programme Pr-1 of the programming system with basic functions F2→1; 2; 3 (annealing level). Every next number leads to sharpening of regime. A main failing of this machine is the impossibility

for assign and control of tempering temperature. The temperature of heating for tempering (450^0C) is controlled visual according to colour change of the steel. Depending on the sharpness of regime, the process of tempering continues from 1 to 3 min.

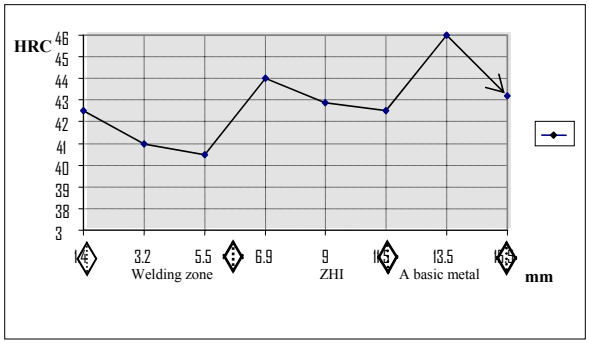

Fig.6 *Hardness of the steel after tempering in case of MIG - welding*

2. The heating in advance of the both band saw blade ends with temperature 450^0C during 60 s limited the circumstances for a large cooling and quickly hardening of the metal in the process of welding. Moreover the homogeneity of a joint and diffusion between basic metal (the band saw blade) and secondary material (welding wire) is improving.

3. Mechanical tests in laboratory circumstances were carried out and the hardness of metal in a junction point of the blade as well in the zone of it tempering was determined. Permissible divergences were in the range of ±10 HRC.

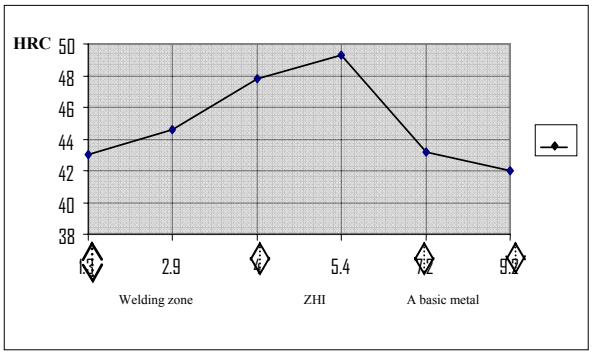

Fig.7 *Steel hardness after tempering according to MAG – welding*

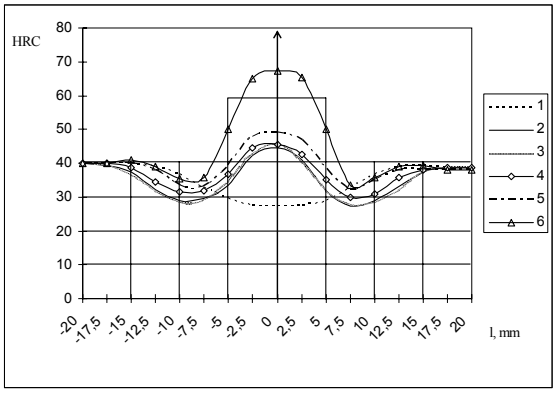

Fig.8 *The steel hardness of the band saw blade with different circumstances of tempering: 1-tempering without welding; 2-welding with tempering for 4 min; 3- welding with tempering for 2,5 min;4- welding with tempering for1,5 min; 5- welding with tempering for30 s; 6- welding without tempering*

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