ARCHIVES
of
FOUNDRY ENGINEERING
DOI: 10.2478/v10266-012-0080-3
ISSN (2299-2944)
Volume 12
Issue 3/2012
Published quarterly as the organ of the Foundry Commission of the Polish Academy of Sciences
49 – 52

The Decreasing of Die Cracking for HDPC Technology by Changing Parameters of Heat Treatment

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Received 16.04.2012; accepted in revised form 02.07.2012

Abstract

In earlier works were described trends in the production of tools for die casting (hot work). Almost the entire set of issues dealt with may seem insignificant when incompletely assembled acceptance of the material and the associated risks of processing a material with an inappropriate structure, leading to a very early defect of the die. Therefore, further work will focus particularly on identifying the causes of thermal cracks and preventing a suitable choice of acceptance criteria conditions and heat treatment.

Keywords: Metallography, Heat Treatment, Mechanical Properties, Die material for HPDC technology

1. Heat Treatment

Assuming compliance with the production process of the basic material (as-delivered state), we can focus on the process parameters of heat treatment. Production of the new tool steel (W403, TQ1, Dievar, EFS Supra...) applies the procedure whereby in short intervals is quenching followed by three stages of tempering.

1.1. The delivered condition

Material is delivered in the form of blocks with dimensions requiring minimal machining to final dimensions (dies, cores ...). In these blocks annealing is already done. The W403 is a material specifically for hardness up to 205 HB [cited in material data sheet], similar to other tool materials - TQ1 is supplied in the annealed hardness max 220 HB.

This annealing is carried out at a temperature of 800-850 °C. Battery life depends primarily on the shape and thickness of the workpiece, but usually ranges between 2-4hrs. This is followed by slow cooling in the oven (10-20 ° C /hr) and up (approx.) at room temperature or at temperatures around 600 °C and then cooling in air. It is specifically soft annealing.

1.2. Hardening

The first stage is the process of heating to quenching temperature. Parts should be heated slowly and evenly. Uneven heating leads to shape distortions and in extreme cases to the development of cracks. It is therefore appropriate to heat in several stages (steps with several delays). This applies especially to the high alloyed steels. Parts should be protected from oxidation of the surface during the heating process. Heating in a vacuum or in an inert atmosphere is therefore advantageous.

The recommended temperature range of 1000-1050 °C with the holding on the temperature ensures even heating throughout the section. Cooling takes place in an oil bath. Again achieved hardness depends on the type of material, but usually varies in the range 49-55 HRC.

1.3. Tempering

The final stage of the heat treatment process is tempering of three phases to obtain the required toughness and hardness. The resulting structure should be sorbit. When used tempering temperatures (above 500 ° C), significant increase in hardness occurs, related to the precipitation of carbides of the alloying elements (vanadium, chromium, molybdenum) and the transformation of retained austenite to martensite occurs in the alloyed materials. Thus is due to the secondary hardness.

2. Experiment

Two types of materials were tested - Dievar and 1.2343 EFS Supra. These were delivered in the form of bars for impact testing in default annealed condition. The first phase of the experiment was prepared from a total of 8 bars of each material, where each underwent a different procedure of heat treatment. Hardening was done at the same temperature of 1020 °C, annealing was carried out in two steps with a graduated temperature for bar 1 to bar 8. The second stage of tempering, in which we temper to the desired hardness, took place at all bars at 10 ° C higher than in the previous step.

Holding temperature corresponded to the size of components and thus did not exceed 30 minutes and was same for all bars. It should be noted that the notch on the test bar was made prior to quenching.

2.1. Measuring the hardness

After each of the processes of the heat treatment was done a series of punctures on the Rockwell hardness test on each bar. The average value of hardness was measured after elimination of gross errors recorded in the table (see Appendix).

Fig. 1. Test specimens and 1.2343 Dievar

2.2. Measuring the impact strength

Samples were also subjected to the Charpy test hammer to detect changes in the size of the impact work (impact strength). The results are connected to the attached table. The objective was to detect the possibility of the occurrence of significant step changes of this magnitude at specific tempering temperatures.

2.3. Measuring the chemical composition

The optical emission spectrometer was used to carry out chemical analysis. We encountered a problem with the accuracy specifications of the percentage of important elements. The vast majority of suppliers state only concrete values without possible variance of the range or precision. When comparing the analysis with tabular data from the manufacturer we get to three-tenth difference - which is in the value to about 5% of representation of the element almost essential difference.

Table 1.
For example we present values obtained for the material 1.2343 EFS Supra

	%C	%Si	%Cr	%Mo	%V
Producer	0,38	1	5,3	1,3	0,4
Spectral analysis	0,23-0,42	0,99-1,01	4,99-5,02	1,29-1,33	0,49-0,51

3. Evaluation and Conclusion

An experiment with this low number of specimens served mainly to confirm previously known facts about changes in hardness depending on the heat treatment. We believe that certain configurations can significantly affect the heat treatment durability of dies for pressure die casting. The aim of further work will be prescribing the optimal process parameters of heat treatment.

We expect a significant effect on the excluded carbide to material properties during thermal cyclic loading, which leads to an increase in hardness, but also to a decrease in the impact strength. We expect that tempering at significantly lower temperatures will be preferable to those previously used (around 570 °C). The obtained experimental value confirms the increase in hardness in this area, including a drop in impact strength. A possible way could be also modify the chemical composition of materials used with a limited count of carbide-creating elements.

Table 2.
Obtained values Average values of a series of measurements are always highlighted

HT		Hardening	tempering		hardness after												Impact strength [J]
			1.	2.	hardening				1st tempering				2nd tempering				
Dievar	1	1020	480	490	51	50	50	**50,33**	48	47	46	**47,00**	47	46	46	**46,33**	**12**
	2	1020	500	510	50	49	50	**49,67**	46	47	48	**47,00**	47	48	48	**47,67**	**9**
	3	1020	520	530	49	51	51	**50,33**	49	49	49	**49,00**	52	52	53	**52,33**	**8**
	4	1020	540	550	50	49	49	**49,33**	50	51	52	**51,00**	50	51	51	**50,67**	**8**
	5	1020	560	570	48	48	47	**47,67**	47	46	46	**46,33**	50	52	52	**51,33**	**8,5**
	6	1020	580	590	50	50	50	**50,00**	52	54	53	**53,00**	51	51	52	**51,33**	**8,5**
	7	1020	600	610	48	50	48	**48,67**	45	47	45	**45,67**	48	47	47	**47,33**	**9**
	8	1020	620	630	50	50	49	**49,67**	49	49	48	**48,67**	48	48	46	**47,33**	**9**
EFS Supra	1	1020	480	490	53	53	54	**53,33**	50	51	51	**50,67**	51	51	52	**51,33**	**11**
	2	1020	500	510	53	54	54	**53,67**	53	54	53	**53,33**	52	52	53	**52,33**	**10**
	3	1020	520	530	53	55	55	**54,33**	55	55	55	**55,00**	53	54	55	**54,00**	**8**
	4	1020	540	550	54	55	54	**54,33**	52	53	52	**52,33**	51	52	53	**52,00**	**8**
	5	1020	560	570	54	55	54	**54,33**	49	48	49	**48,67**	50	49	51	**50,00**	**8,5**
	6	1020	580	590	54	54	53	**53,67**	47	49	49	**48,33**	55	53	54	**54,00**	**13**
	7	1020	600	610	52	52	52	**52,00**	50	50	51	**50,33**	49	50	51	**50,00**	**11**
	8	1020	620	630	53	52	54	**53,00**	49	49	48	**48,67**	48	48	48	**48,00**	**16**

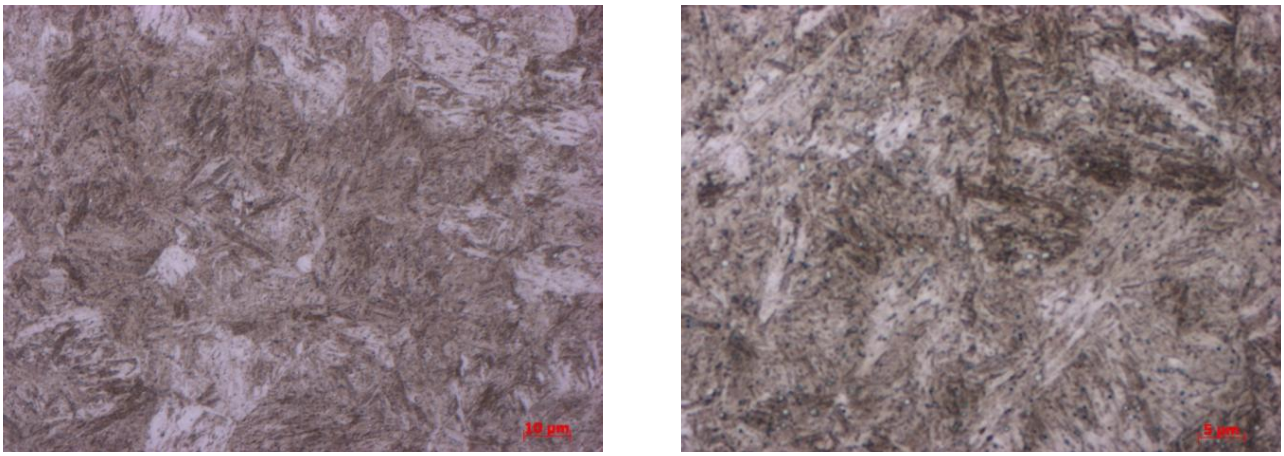

Fig. 2. Obtained structures (EFS Supra) – hardening, 3x tempering – 500x enlarged (left) 1000x enlarged (right)

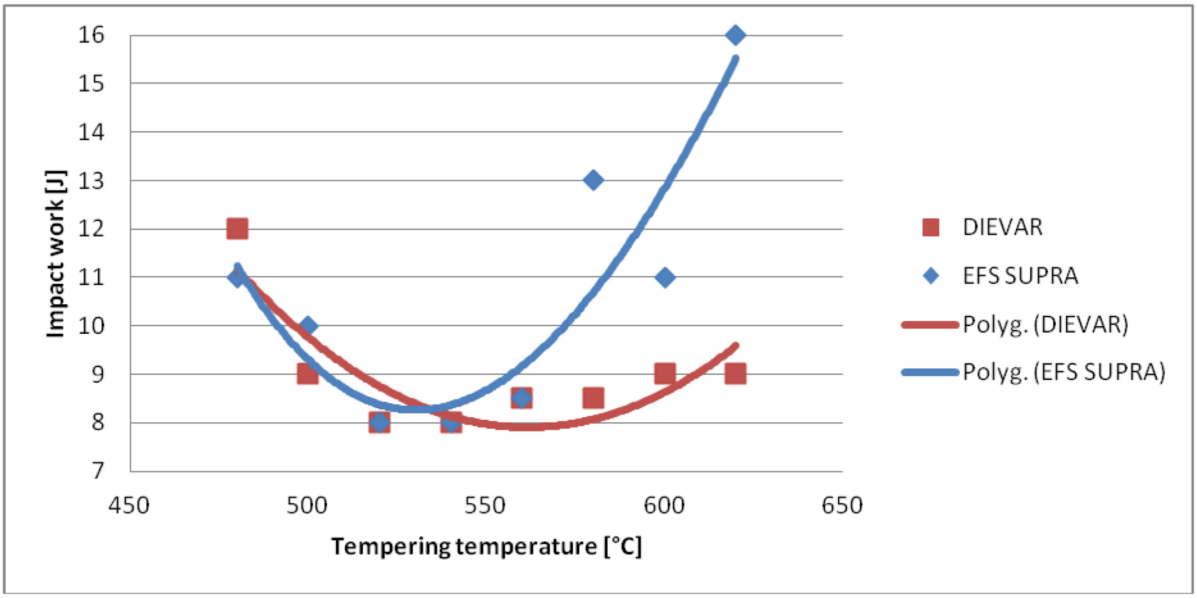

Fig. 3. Obtained values – impact characteristics of both materials with the changing tempering temp

Acknowledgement

This paper has been supported by project FR—TI1/164 „Výzkum zvyšování životnosti nástrojů pro technologii lití pod tlakem" (Program of The Ministry of Industry and Trade).

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