Practical experience with the application of NADCA for heat treatment of die casting dies

Jiří Stanislav, **Klára Tesárková**,
Bodycote HT, CZ, Tanvaldská 345, Liberec 30, liberec@bodycote.com

Abstract

Increasing the service life of die casting dies is significantly affected by the application of control mechanisms according to NADCA 207 to steel suppliers and heat treatment suppliers. These control mechanisms should be part of the die-casting tool production process and therefore part of the quality management system. Some practical experiences are discussed in this lecture.

1. Introduction

The current state of knowledge about the causes of thermal fatigue cracks in die casting dies clearly shows a correlation between the impact strength of steel and the formation and propagation of thermal fatigue cracks.

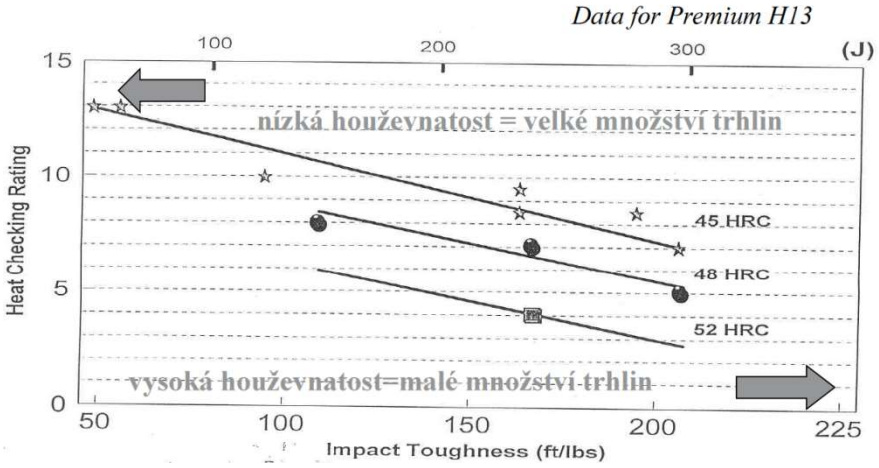

Fig. 1 *- Dependence between the impact strength of H13 steel and the rate of propagation of thermal fatigue cracks for different steel hardness*

The principle of determining the impact strength is outlined in NADCA 207-2008 rev. The regulation of which sets out precise acceptance criteria for selection steels for die casting molds, heat treatment procedures and mechanisms for systematic control of the resulting properties of steel after heat treatment of the di.

The quality of the steel is tested in two stages:

1. Incoming inspection of the material – the first test has the task of eliminating discrepancies in the delivered semi-finished product before entering the production process of the insert

2. Heat treatment control - the second test aims to eliminate defects in heat treatment

The aim of this testing is to measurably verify the quality of the input material and the supplied heat treatment within the NADCA recommendations.

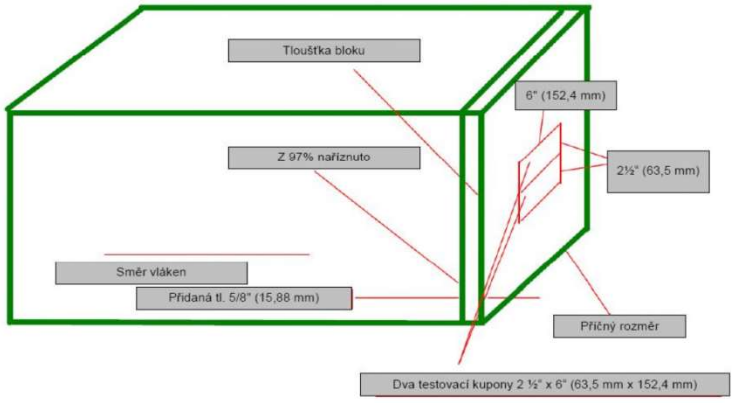

Fig. 2 - *Coupons with samples for test in the conformity to Nadca 207*

The steel supplier is obliged to prepare the material for the production of test coupons, on the one hand by adding approx. 16 mm for the length of the block, on the one hand by making 97% of the blank cut so as to ensure that the material to be tested belongs to the block of material from which the insert will be manufactured. The material to be tested cannot be delivered separately from the material block itself.

The manufacturer of the test blank produces two test coupons for the production of the impact test. Each coupon measures 63.5 x 152.4 mm.

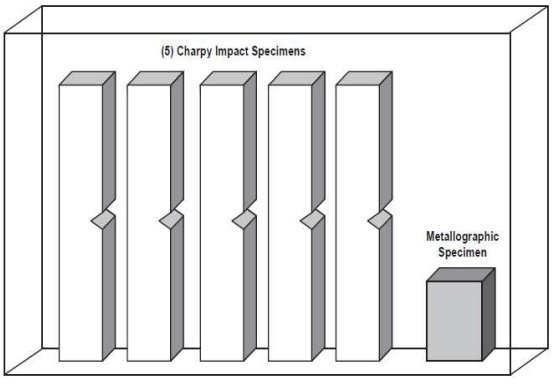

Fig. 3 - *Demonstration of the location and orientation of specimens for impact test and metallographic evaluation of microstructure, manufactured in accordance with ASTM A370-05 from hardened and tempered coupon.*

2. Principle of testing

2.1. Testing of incoming steel quality

The aim of the test is to determine the absolute yield of material for the production of inserts. This is therefore an ideal case when the coupon for the production of samples for impact tests is subjected to an ideal hardening with a maximum cooling rate, ie into oil.

Austenitizing temperature	according to material grade and NADCA recommendations (Tab. 1)
Oil temperature	max. 50 ° C
Tempering	min. 2 x
Tempering temperature	temperatures must be at least 590 ° C, time 2h
Cooling	always cool down to room temperature after each tempering
Hardness	44-46 HRc

Test coupon No. 1 processed in this way is sent to an approved supplier for testing, which will ensure both the production of samples for impact tests and its own test and certificate. The distribution of the samples within the test coupon is shown in Fig. 3. The direction of the fibers of the material is oriented in the direction of the notch.

	Austenitizační teplota [°C]	Hodnoty rázové houževnatosti po ideálním tepelném zpracování na zkušební desce č.1 [J]		Hodnoty rázové houževnatosti pro kalený stav na reálném kuse ze zkušební desky č.2 [J]	
		Průměr [J]	Min [J]	Průměr [J]	Min [J]
H13 Premium (1.2344)	1030	10,8	8,1		
H13 Superior (1.2344)	1030	13,6	10,8	10,8	8,1
Uddeholm Dievar	1010	19	14,9	14,9	12,2
Bohler W403 VMR	1030	13,6	10,8	10,8	8,1
Ellwood ExEll Hto Die	1030	13,6	10,8	10,8	8,1
Kind RPU	1030	13,6	10,8	10,8	8,1
Thyrotherm 1.2367	1030	13,6	10,8	10,8	8,1
Bohler 300 Isobloc	1000	19	14,9	14,9	12,2
1.2343 Supra	1000	19	14,9	14,9	12,2
Uddeholm Vidar Supreme	1000	19	14,9	14,9	12,2
Bohler W400 VMR	990	27	23	21,7	19
Uddeholm Vidar Superior	995	19	14,9	14,9	12,2
Kind TQ1	1010	19	14,9	14,9	12,2
Thyrotherm E38K	1010	19	14,9	14,9	12,2
Aubert Duval ADC3	1030	19	14,9	14,9	12,2
Dunn DSS#3	1030	19	14,9	14,9	12,2
Ellwood ExEll Tuf-Die	1030	19	14,9	14,9	12,2
Nippon Koshuha KDA-1	1030	19	14,9	14,9	12,2

Tab. 1 **-** *Recommended austenitizating temperatures for individual materials and impact values to be achieved during tests*

2.2. **Testing of heat treatment quality**

If the material input tests are satisfactory, the material is released for insert production. If the tests do not give satisfactory impact values, the steel supplier should supply the new material for both inserts and testing without delay and at his own expense.

Once the die is ready for the heat treatment process, the second coupon made for testing is spot welded to the die body to ensure full contact with the die and to ensure that it represents the hardening and tempering behaviour of the die material.

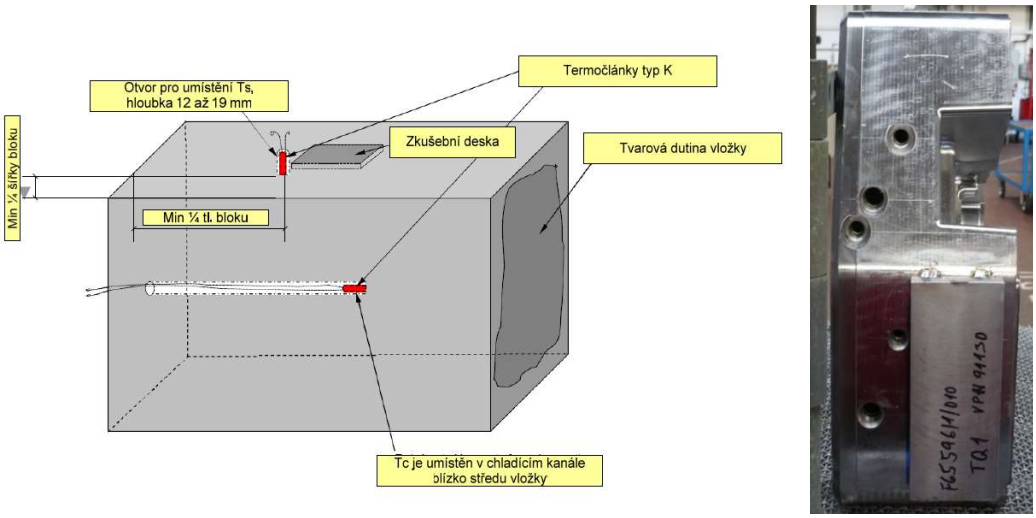

Fig. 4 *- Location of test coupon and thermocouples for hardening*

After performing the heat treatment of the insert, the heat treatment supplier separates test coupon No. 2 and sends it to the approved supplier for testing. As in the previous case, he produces samples for impact tests and performs these tests with the resulting protocol. If the values are in the NADCA range, the heat-treated insert will be released by the tool manufacturer.

If the required values were not reached, the input tests on the steel were OK, then a heat treatment complaint can be initiated. Under certain conditions, one corrective heat treatment is permitted, and the parts must be re-annealed soft according to NADCA regulations before classification.

3. Practical results

The tables below (Table 2) show some practical testing results for specific customers. We do not list sources of material. The practical results are supplied by the testing supplier in the form of a certificate with all the necessary data, from which a simple evaluation of the result can be performed with regard to NADCA requirements (Fig. 5).

Test Certificate

Bodycote HT s.r.o.
CTP Park - Turanka 100
Brno
627 00
627 00

Attn: PAN TOMES

REF No P 312730 : Issue 1
Page 1 of 1
Ord No NOB13-0525
Date Tested 15/07/13
Date Reported 16/07/13
Date Received 10/07/13

Item - 5x CHARPY TEST, TECHNOSERVIS
PLATE NO. 2 - 41324/034, MATERIAL 1.2367

Specification - NADCA 207-2008

Charpy Test - ASTM A370 - 12a

	Position	Dimensions [mm]	Denomination	Test Temp [°C]	Energy Absorbed [Joules]	Average [Joules]	Comments
001:Parent	N/A	10x10x2V	N/A	R/T	7	7	Nil
002:Parent	N/A	10x10x2V	N/A	R/T	8	8	Nil
003:Parent	N/A	10x10x2V	N/A	R/T	10	10	Nil
004:Parent	N/A	10x10x2V	N/A	R/T	8	8	Nil
005:Parent	N/A	10x10x2V	N/A	R/T	10	10	Nil

Fig. 5 *- Example of test certificate*

Materiál			Test vstupního materiálu					AVG	Výsledek testu
1.2367	AVG Nadca předpis	1	13,6	13,6	13,6	13,6	13,6		
	MIN Nadca předpis	1	10,8	10,8	10,8	10,8	10,8		
	41324	1	5,0	6,0	11,0	11,0	10,0	8,6	NOK
			Test tepelného zpracování					AVG	
1.2367	AVG Nadca předpis	2	10,8	10,8	10,8	10,8	10,8		
	MIN Nadca předpis	2	8,1	8,1	8,1	8,1	8,1		
	41324/034	2	7,0	8,0	10,0	8,0	10,0	8,6	NOK
	41324/033	2	9,0	11,0	8,0	8,0	8,0	8,8	NOK

Materiál			Test vstupního materiálu					AVG	Výsledek testu
1.2343	AVG Nadca předpis	1	19,0	19,0	19,0	19,0	19,0		
	MIN Nadca předpis	1	14,9	14,9	14,9	14,9	14,9		
	41377	1	23,0	21,0	21,0	22,0	23,0	22,0	OK
	55009961	1	26,0	24,0	27,0	25,0	23,0	25,0	OK
			Test tepelného zpracování					AVG	
1.2343	AVG Nadca předpis	2	14,9	14,9	14,9	14,9	14,9		
	MIN Nadca předpis	2	12,2	12,2	12,2	12,2	12,2		
	55009961	2	21,0	21,0	21,0	20,0	20,0	20,6	OK

Materiál			Test vstupního materiálu					AVG	Výsledek testu
1.2344	AVG Nadca předpis	1	13,6	13,6	13,6	13,6	13,6		
	MIN Nadca předpis	1	10,8	10,8	10,8	10,8	10,8		
	55010884	1	22,0	21,0	23,0	21,0	22,0	21,8	OK
	55010124	1	17,0	15,0	19,0	16,0	15,0	16,4	OK
	55010124	1	14,0	15,0	13,0	16,0	17,0	15,0	OK
	55010124	1	8,0	11,0	12,0	11,0	10,0	10,4	NOK
	55010124	1	10,0	10,0	14,0	12,0	17,0	12,6	NOK
	55010124	1	8,0	10,0	11,0	9,0	10,0	9,6	NOK
			Test tepelného zpracování					AVG	
1.2344	AVG Nadca předpis	2	10,8	10,8	10,8	10,8	10,8		
	MIN Nadca předpis	2	8,1	8,1	8,1	8,1	8,1		

Tab .2 - *Test result of toughness test in J for different cases*

4. Conclusion

The impact tests performed so far show that the reliability of the suppliers at the input is assessable. Failure to comply with the input values poses a serious threat to the resulting tool life and it is therefore in the interest of the tool manufacturers to perform these tests consistently.

No production or heat treatment process can improve the purchased material condition. Therefore, it is desirable to check at the entrance so as to exclude further subsequent defects or even damage, in order to detect and exclude unsuitable material before further, often very demanding and expensive processing.

From the tables it can be stated:

- Most customers use the tests primarily to evaluate the input material
- Impact tests show high reliability when one qualified and approved supplier is used
- The explanatory power of the test is very good and the input of low-quality materials into production can be significantly reduced
- If the entrance test fails, the steel supplier is clearly to blame, with the obligation to replace the defective material immediately without further work.

From existing experience, the following can be stated:

Entrance tests - in more than **24%** of cases (Fig. 5) the results of the entrance test of the material were unsatisfactory with a direct impact on the material supplier, ie the values of impact toughness according to NADCA were not achieved.

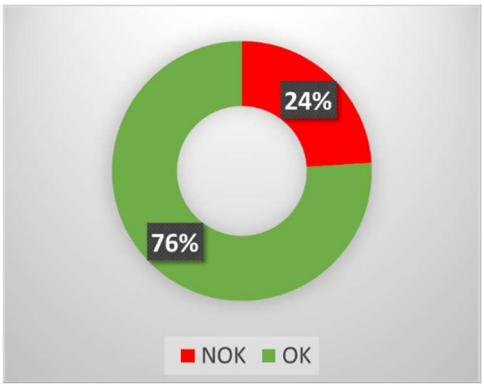

Fig . 5 *– Statistical evaluation of the results of the entrance test*

Tests after heat treatment - in all evaluated cases, the input inspection of the material was always performed according to the previous point. In all cases where the tests after the heat treatment were unsuccessful, it was a material that did not pass the input tests. Nevertheless, the customer believed that the applied heat treatment process could improve the purchased condition, which was not the case.

In conclusion, the NADCA testing procedure significantly improves the quality control of the material, especially with regard to its resulting mechanical properties and is a high-quality tool for distinguishing the quality of deliveries with respect to the target tool life. By applying both tests, it is then possible during the production of the tool to separate the responsibility of individual entities for individual operations, and thus significantly improves the probative capacity of all entities in potential disputes.

Based on the authors' own experience, it has already been proven that if the initial tests of the material have not been performed, it is not possible to credibly and successfully claim damages from the heat treatment supplier for evidentiary lack of prove

Sources:

NADCA 207-2008
Internal documentation Bodycote HT, s.r.o.