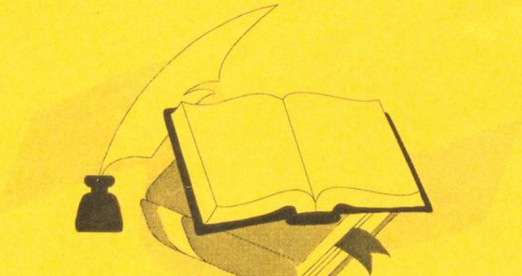
UNIVERSITY OF ŽILINA IN ŽILINA
Faculty of Mechanical Engineering
Department of Materials Engineering

SEMDOK 2012

17th International of PhD. students' seminar

under the auspices of
prof. Ing. Štefan Medvecký, PhD.
dean of the Faculty of Mechanical Engineering of the University of Žilina in Žilina



Žilina – Terchová, Slovakia
25 – 27 January, 2012

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SEMDOK 2012 – the 17th International of PhD students' and scholar's seminar (CZ, D, H, PL, SRB, SLO, SK) is aimed to provide the young scientists with an encouraging, stimulating environment in which they present and discuss the results of their research activities. SEMDOK 2012 is traditional European international seminar from the Materials Engineering and Threshold State of Materials. It has a tradition of being held since 1996. It is organised for PhD students and scholars every year. The seminar will last for three days. Seminar languages are English, Slovak and Czech. Each participant will obtain proceedings from the seminar. The selected papers accepted by Scientific Committee will be published in the Materials Engineering Journal – SK (in English).

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Welcome, we hope you are going to have a pleasant stay at Žilina - Terchová, Slovakia.

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DETERMINATION OF THE MOST PROPER TEMPERING TEMPERATURE IN HARD FACING OF THE FORGING DIES

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Abstract
In this paper only a part of the complex procedure, which must be conducted in order to regenerate successfully damaged forging dies by hard facing, is presented. After identification of the type and cause of the dies damage, we have selected the procedure and parameters of hard facing, which were further corrected by test hard facing on models. This made possible selection of optimum hard facing technology.
Key words: *hard facing, forging dies, tempering brittleness, micro hardness*

1. Introduction

The forging dies are in exploitation subjected to numerous cyclic loads, thus, after certain operating time, the impression damages occur, and the tool has to be replaced or repaired [1]. The main causes of damaged dies withdrawal from exploitation could be: change of dimensions and form of impressions due to friction and wear, cracks all over the die due to thermal fatigue, and micro cracks caused by action of the stress concentrators.

Factors that are leading to thermal fatigue at elevated temperatures are: material thermo-physical characteristics (thermal conductivity, specific heat and coefficient of thermal linear extension), the geometry of part (size, shape, type of surface), and other material properties (mechanical, chemical, structural) [2].

Some of reasons of failure occurrences are, increase of the forged pieces dimensions due to worn die, deformation of the thin-walled portions of the die (ribs, mandrels), appearance of cracks at certain parts of the die, local fractures etc. In order to select the optimum technology of forging dies hard facing, numerous tests were conducted at the model whose sizes were determined according to the similarity theory principle, namely the non-dimensional analysis.

Manufacturing of new dies made of construction carbon steels with working surfaces hard faced by tool steel presents an exception.

2. Materials for forging dies manufacturing and their characteristics

Refractory steels are used for temperatures above 300°C. Here we are talking about small, eventually medium and large dies, for hot forming, tools for pressing and extrusion of non-ferrous metals at elevated temperatures, tools for hot trimming, dies for pressurized casting of pure Al, Zn and Mg.

In the considered case, all experiments were conducted on forging dies made of steel Č5742 (DIN 17350, 56NiCrMoV7) and Č4751 (DIN 17350, X38CrMoV51). Chemical composition, mechanical characteristics and microstructure of these steels are given in Tables 1 and 2 [2].

On selected samples (models) we have measured hardness after thermal treatment and it was 40-42 HRC for Č5742 and 41-49 HRC for Č4751. Since the samples of thicker cross sections were also hard faced (s = 40-45 mm), made of steels prone to self-hardening (C>0.35%), the preheating was necessary. The preheating temperature was determined according to Seferian formula, obtaining $T_p \approx 300°C$.

Tab. 1

Chemical composition and comparative marks of steels Č5742 and Č4751

No.	Mark by YUS	Chemical composition, %									Relation to other standards	
		C	Si	Mn	P	S	Cr	Ni	Mo	V	DIN	UNI
1.	Č5742	0.55	0.3	0.7	0.035	0.035	1.1	1.7	0.5	0.12	56NiCrMoV7	U52NiCrMo6KU
2.	Č4751	0.40	1.0	0.4	0.025	0.025	5.0	-	1.3	0.4	X38CrMoV51	UX35CrMo05KU

Tab. 2

Mechanical characteristics and microstructure of steels Č5742 and Č4751

No.	Mark by YUS	Soft annealing			Tempering			Preheating temperature, T_p, °C	Microstructure B.M.
		t, °C	HV_{max}	R_m, MPa	T, °C	HRC	R_m, MPa		
1.	Č5742	670-700	250	850	400-700	50-30	1700-1100	≈ 300	M+B (Interpass)
2.	Č4751	800-830	250	850	550-700	50-30	1700-1100	≈ 300	M + B (Interpass)

3. Selection of procedure, technology and filler material

Technological parameters of hard facing were determined according to [2, 3, 4], and hard facing was performed in two and three passes to decrease the degree of mixing (dilution). As a filler material we applied highly alloyed basic electrodes UTOP 38 (DIN 8555 E3-UM-40T ϕ 3.25 *mm*) and UTOP 55 (DIN 8555 E6-UM-60T ϕ 5.00 *mm*) [2, 3, 4]. The filler materials were aimed for hard facing of dies that are used for forming of steels and other metals both in hot and cold state. Hard-faced layers are tough, resistant to wear and impact. The hard faced layers hardness is constant up to temperature of 600°C.

These basic electrodes were dried prior to application according to the following regime: heating up together with the furnace up to temperature of 350-400°C, keeping for 2 hours at the drying temperature, and cooling in the furnace for 1 hour, while the temperature did not fall below 150°C. Thus heated electrodes were used for hard facing of the preheated samples, with eliminated possibility of appearance of hydrogen induced cracks.

Tab. 3

Parameters of the MMA hard facing (HF)

No.	Electrode mark		Core diameter, *mm*	HF current, *A*	Voltage, *V*	HF velocity, *cm/s*	Heat input energy, *J/cm*
	SŽ "Fiprom"	DIN 8555					
1.	UTOP 38	E3-UM-40T	3.25	115	26	≈ 0.28	8543
2.	UTOP 55	E6-UM-60T	5.00	190	29	≈ 0.25	17632

Tab. 4

Filler material properties

No.	Electrode mark		Chemical composition, %					Type of current	HF layer hardness, HRC	Application
	SŽ "Fiprom"	DIN 8555	C	Cr	Mo	V	W			
1.	UTOP 38	E3-UM-40T	0.13	5.0	4.0	0.20	+	= (+)	36-42	HF of dies for elevated and normal temperatures
2.	UTOP 55	E6-UM-60T	0.50	5.0	5.0	0.60	+	= (+)	55-60	- II -