OBJECTIVE SETTING FUNCTION TO FORM THE RECONDITIONING METALLIZATION CRANKSHAFT

Prof. G**HEORGHE AMZA**, University POLITEHNICA of Bucharest
amza@camis.pub.ro

Abstract: *The paper presents the objective function of metal spraying process and optimizing its ultrasonic field. For CCR objective function, named quality function of resulted couple, were taken into account the following factors: resistance to adhesion surface; porosity; tensile strength; wear resistance; hardness of the material from couple; grain size of the deposited layer and the state of internal tension. To determine the function there are required numerous experiments using different metallization regimes, then placing the condition that it needs to have a maximum that is found among first-order derivative solutions of the objective function.*

Keywords: objective function, reconditionind, metallization, crankshaft

1. INTRODUCTION

The process of reconditioning the field ultrasonic auto parts industry is optimal if reconditioned has unrivaled reliability (at least 1.5 ... 3.0 times more durable than new song) and a minimum cost of processing (cost to represent 40 ... 60% of the cost of new parts) [1, 2]. Because reconditioned have unrivaled reliability must follow a couple deposited material support material that have the following characteristics [3]:

- resistance to surface adhesion (line) more than 40 MPa;
- porosity of between 8 % and 12 % (allow the absorption of large quantities of lubricant to substantially increase the wear resistance);
- the fatigue resistance by 50 ... 100 % higher than the carrier material;
- deposited layer hardness over 60 HRC; the thickness of the layer is greater than 0.5 mm in order to allow the correction to the functional size;
- final roughness R_a less than 0.02 μm;
- a fine grain structure with grains the axial; mechanical and functional characteristics better than those of the base material and structure without internal tensions.

To reveals operational behavior of remanufactured parts by metal spraying and to determine optimal technological reconditioning process by metal spraying ultrasonic field has made a large number of metallization experiments with and without ultrasonic activation after a methodical research experimental included the following steps [4]:

- couples the selection of materials the most used in the automotive industry, the most important parts of the reconditioning is effective;

- the establishment of standard test pieces on which to make charging without activation ultrasonic metal spraying and ultrasonic field;

- hoosing the method of reconditioning the metallization;

- calculation and design of an ultrasonic system can be used for metal spraying ultrasonic activation of the containing added material and / or the ultrasonic activation of the piece to be reconditioned;

- designing a gun metal spraying ultrasonic field;
- creation of a set of experiments on different types of surfaces to determine the infuence of various parameters charging regime by metallization with and without ultrasonic activation on functional characteristics of the couple resulting material;
- a set of tests being put on the couple resulting from the reconditioning by metal spraying with and without ultrasonic activation;
- the establishment of measures to increase the efficiency of reconditioning;
- reconditioning process optimization through metal spraying ultrasonic field;
- analysis of possibilities for implementation in the auto repair industry to new technologies in the field of ultrasonic metal spraying;

2. COUPLE SETTING THE MATERIAL RECONDITIONING METALLIZATION A CRANKSHAFT

Experiments were made considering the stages established research methodology and design objective was final-optimal technological process of reconditioning the field of ultrasonic auto-parts industry taking into account the requirements and conditions of the beneficiary, a very pretentious beneficiary because in this case the risk must be zero because it concerns the safety and health of persons participating in the auto traffic [5, 6].

The experimental results were obtained from the analysis of the technological process of reconditioning classic and of the possibilities for improvement at every stage of its development. The main stages of the technological reconditioning classic which were analyzed and which have established opportunities for improvement are analyzed further [7]. Couple choosing materials taking into account, first, the possibilities of achieving adherence with relatively high resistance and outstanding functional characteristics [8, 9].

Automotive parts are made of a very diverse range of materials (carbon quality steel, low alloy steels, stainless steels, gray fonte iron, nodular fonte, etc.) was selected for experimentation alloyed steel with Cr, Ni, Mo and V used in the construction of the crankshaft strongly requested, working in internal combustion engines, made by forging the preform into the mold whose composition is presented in table 1 and was determined by means of suitable chemical analysis [10]. Because some crankshaft is made of cast iron and cast iron was chosen special low alloy whose chemical composition is presented in table 2.

Table 1. Chemical composition of low alloy steels used as support material in experiments

	The content and alloying elements [%]					
The base material (material support) X30NiMoVCr11	C	Ni	Cr	Mo		Si
	0,20...0,33	3,75...4,0	1,11...1,13	0,45 ... 0,55		0,25...0,35
	Mn	V	P	S		Cu
	0,30...0,45	≤ 0,10	≤ 0,01	≤ 0,005		0,08
	Nb	TA	Ti	B		W
	0,001	0,001	0,002	0,001		0,02
	Ca	Ce	Al	N	Fe	H[ppm]
	0,002	0,006	0,017	0,001	Rest	2,0

Table 2. Chemical composition of low alloy special cast iron used as support material in experiments

The base material (material support) FxMo1Si2,4	The chemical composition and the content of [%]				
	C	Si	Mo	Cu	Cr
	2,1 4,7	1,0...2,4	0,7 ... 1,1	0,11...1,74	0,10 ... 0,28
	Ni	Mo	Mg	S	P
	1,0...1,5	0,8 1,0	0,05	0,08	0,02
	Nb	W	Ti	Fe	$H_{[ppm]}$
	0,002	0,03	0,001	Rest	8,0

After the heat treatment the steel can have a tensile strength up to 1200 MPa and alloyed cast iron up to 800 MPa.

The main mechanical and physical properties of basic materials chosen are presented in tables 3 and 4, according to the certificates issued by the manufacturer. Depending on user requirements, to increase resistance to wear and corrosion worn surfaces are loaded with hard alloys based on chromium, nickel, cobalt or wolfram carbides.

Table 3. Main mechanical and physical properties of an ally steel crankshaft used in construction and especially for experiments

Alloy steel X30NiMo1Cr11	Tempe-rature [^{0}C]	$R_{p0,2}$ [MPa]	R_m [MPa]	A [%]	Z [%]	K V-46 [J]	HB [HB]
	20^{0}C	850	960	20	33	160,9 178,2 198,0	460
	weight specify [kg/m^3]	Dilation thermal [m/m^{3}C]	thermal conductivity [W/m^{0}C]	electrical resistivity [Ω.m^2/m]	magnetic permeability	-	-
	7,851	11,7.10^{-6}	36,0	48,7	1,06	-	-

Table 4. Main mechanical properties of low alloy special cast iron used in the construction of automotive parts and selected for experimentation

	Temperature [^0C]	$R_{p0,2}$ [MPa]	R_m [MPa]	A [%]	Z [%]	KV -46 [J]	HB
Special low alloy iron FxMo1Si2,4	20^0C	310	550	3,0	8,5	8,0 10,0 16,0	350
	Density [kg/m^3]	Expansion thermal [m/m^3C]	Thermal conductivity [W/m^0C]	Electrical resistivity [$\Omega.m^2/m$]	Magnetic permeability	-	-
	7,45	$15,1...10^{-6}$	12,6	1,0	1,02	-	-

The filler materials used for waste loading areas are chosen so to satisfy severe imposed quality deposited layer, such as obtaining a porosity of 8 ... 10% ; obtaining high wear resistance; obtaining high corrosion resistance; obtaining a hardness of above 55 HRC; realization good adhesion between the coating and base material; making a thickness of the layer is small (max.2,0 mm); to obtain a final surface roughness of 0.025 μm.

The main fillers were analyzed:

- Cobalt alloys, also known as the "star". They have excellent resistance to wear, abrasion, corrosion and erosion. At present marketed a wide range of such alloys with a composition diversified and optimized for different applications. The current production DELORO STELLITE company, which has over 100 years of experience in the field of protection against wear are over 20 types of alloys type stars.

As addition material alloy was selected for experimentation STELLITE 12 AWS, W and alloy STELLITE 21, whose main chemical composition and mechanical properties are presented in tables 5, 6, 7 and 8.

PRAXAIR INC Company (USA) recommends to work charging suprafeţeler LCO-109 alloy, and the company HPALLO PROFILE (USA) recommends cobalt alloys with a nominal chemical composition: 30% Crt; 12% W; 2.5% C and the rest of the CO;

Table 5. Chemical composition of filler material STELLITE 12AWS

The addition material STELLITE 12 AWS,W	The components and chemical composition [%]					
	C	Cr	Si	W	Fe	Ni
	1,430	24,60	1,520	8,30	2,10	1,980
	Mn	Mo	B	P	S	O_2
	0,270	0,670	0,005	0,004	0,004	0,005
	Co					
	The rest					

Table 6. Principale mechanical properties of filler material STELLITE 12AWS,W

	Temperature [^{0}C]	$R_{p0,2}$ [MPa]	R_m [MPa]	A [%]	Z [%]	Hardness HB	KV [J]
The addition material STELLITE 12AWS,W	20^0C	664	772	23,814	65,0	H 60	160,1 166,5 170,2

Table 7. Chemical composition of filler material STELLITE 21

	The components and chemical composition [%]						
The addition material STELLITE 21	C	Cr	Si	W	Fe	Ni	Mn
	1,90	34,10	0,93	13,25	3,4	2,16	0,45
	B	Mo	P	S	Ti	O_2	Co
	0,004	0,78	0,004	0,004	0,02	0,005	Rest

Table 8. Principale mechanical properties of filler material STELLITE 21

	Temperature [^{0}C]	$R_{p0,2}$ [MPa]	R_m [MPa]	A [%]	Z [%]	kV [J]	HB
The addition material STELLITE 21	20	696	812	22,9	60	180,2 187,5 192,6	H 50

3. OBJECTIVE SETTING FUNCTION FORM

To optimize the technological process of reconditioning the ultrasonic field metallization we started from the main phenomena taking place during the deposition of filler material on the base and established a CCR objective function, which is a very complex function to be determined in each case under consideration, with a condition that according to the couple meet all the requirements of the resulting material so as to have outstanding reliability.

It can be assumed that the objective function CCR (quality resulting the couple) is a function of the form :.

$$CCR = F(p_{gc}^{x1} p_{02}^{x2}, k^{x3}, p_{qp}^{x4}, L^{x5}, \alpha_p^{x6}, \partial_e^{x7}, \upsilon_a^{x8}, Q_{ge}^{x9}, Q_{02}^{x10}, v_p^{x11}, p^{x12}, I_a^{x13}, f^{x14}, A^{x15}, p_u, R_{a0}^{x17}, \eta_a, n_b^{x18}, n_{gp}^{x20}, n_s^{x21}) \quad (1)$$

for oxygas flame metal spraying and ultrasonic activation wire electrode wire;

$$CCR = F(I_s^{x1}, U_a^{x2}, \sigma_e^{x3}, n_{gp}^{x4}, p_{gp}^{x5}, L^{x6}, Q_{gp}^{x7}, \upsilon_a^{x8}, v_p^{x9}, p^{x10}, I_a^{x11}, f^{x12}, A^{x13}, p_u^{x14}, R_{a0}^{x15}, n_a^{x16}, n_b^{x17}, \eta_s,^{x18}) \quad (2)$$

for electric-arc spray metallization three ultrasonic activation wires of the wire electrode, wherein the p_{gc} is the pressure of the fuel gas; p_{o2} - the oxygen pressure; k-volume ratio; p_{gp} - projector gas pressure; L-spraying distance; α_p - spray angle; b_e - wire diameter electrode; v_a - electrode wire feed rate; Q_{gc} - the flow of fuel gas; Q_{O2} - flame flow; Q_{gp} - gas flow projector; v_P - speed of the piece; p - step submission (case when several layers are deposited); I_u - intensity ultrasound; f - frequency ultrasound; A - amplitude of the longitudinal ultrasonic oscillations; R_{a0} - initial roughness of the surface; n_a - on material nature; n_b - basic material nature; n_{gp} - nature of the gas project; n_s - number of layers deposited; I_s - intensity arc; U_a - voltage arc; p_u - ultrasonic pressure.

For CCR objective function, quality function called the couple results were taken into account the following factors: resistance to surface adhesion; porosity; tensile strength; wear resistance; material hardness of the couple; grain size of the deposited layer and the state of internal tension.

To determine this based on numerous experiments were done using different metallization schemes and multiple modes putting ultrasonic activation is then provided as a function of (1) or (2) have a maximum, ie:

$$\frac{\partial CCR}{\partial x} = 0 \quad (3)$$

where in: x is the distance measured in the layer deposited on the surface of the deposited layer to line.

For example, consider a car crankshaft (Figure 1.) It is the most requested song of the engine because the pistons through balls take up the forces of pressure created by the explosion cylinders. The crankshaft and connecting rod forces take over, summed things produced in rolls and transmits mechanical energy produced by the wheels through the transmission.

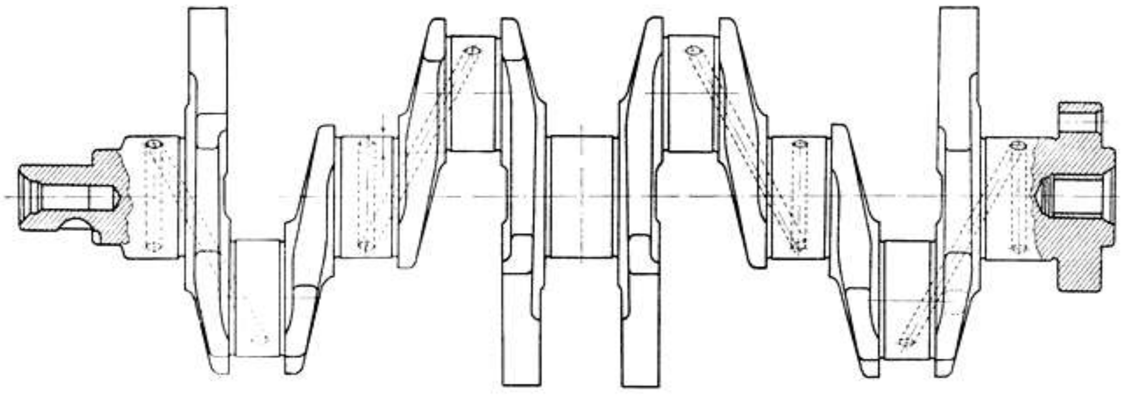

Fig. 1. The crankshaft

The components that wear from the operation and requiring reconditioning are journals by charging mechanisms (through which the shaft is supported on bearings in the engine block) crankpins and journals (they are caught on connecting rods). The technological process of repairing the crankshaft include: reconditioning spindles levels; crankpins spindles reconditioning; reconditioning keyway, eliminating fissures; cold correction of; balance; verification and control.

4. CONCLUSIONS

- in order to optimize the technological process of reconditioning by metal spraying ultrasonic field was considered a CCR objective function (the quality of the resulting couple) comprising the metallization process and all parameters that can be maximized;

  - objective function was determined considering the following factors: resistance to adhesion surface; porosity; tensile strength; wear resistance; hardness of the material from couple; grain size of the deposited layer and the state of internal tension;

  - by obtaining CCR objective function, it can be achieved the optimization of technological parameters specific for reconditioning by metallizing by spraying;

  - the use of objective function for determining the technological process of reconditioning allow a substantial improvement of operating parameters of the reconditioned pieces of the crankshafts type;

  - CCR objective function can be applied when the reconditioning process is ultrasonically activated by metallizing by spraying.

REFERENCES

[1] **Amza, Gh.,** *Tratat de tehnologia materialelor* - Editura Academiei Române, Bucureşti, 2002.

[2] **Amza, Gh., Dobrotă D.,** *Ultrasunetele: aplicaţii active*, Editura AGIR, Bucureşti, 2007.

[3] **Amza, Gh.–** *Theoretical and experimental contributions about acoustic paramethers influence in ultrasonic welding of the intelligent composite materials*, Materiale Plastice, MPLAAM, nr.1, 2007, pag. 6 – 65, ISSN 0025/5289

[3] **G. Amza, V. Petrescu, D. Dobrotă, Z. Apostolescu, R. Albulescu,** *Influence of use of ultrasound on the mechanical properties of plated pieces by welding in ultrasonic field*, Metalurgija, vol. 54, no. 3, pp. 531-534, 2015

[4] **Amza, Gh., Albulescu, R.,** *Ultrasound effect on the structure of parts loaded by GTAW în ultrasonic field,* AME 2014, Bankok, Thailanda.

[5] Welding Handbook vol.1 – *Welding Science &Technology*, 9-th edition 2001, AWS, Miami, SUA.

[6] **Elmer, J.W.**, ş.a., *The kinetics of Phase Transformation in Welds*, February, 2002.

[7] **Holman, J.P.** - *Heat Transfer*, 4th ed., Mc Grow-Hill, Inc., New York, 2006.

[8] **Radaj, D.** - *Heat effects of spraying metallisation*, Springer Verlag, Berlin, 1992.

[9] **Zaharia, T.** ş.a. - *Modeling of spraying metallisation*, Welding Journal, vol. 67, pag. 53-62, 2005.

[10] x x x *Guidelines for spraying metallisation*, Miller, 2005.