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MANUFACTURING TECHNOLOGIES OF SPRING-DISK MEMBRANES

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Abstract: *Manufacturing technologies of spring-disk membranes for clutches through thermo-mechanical controlled treatments on automated process lines of bend hardening, replaces the presently used technology on the national level of manufacturing spring-disk type parts made of light alloy steel, 51VCr11A type. The present technology is not an automated one, technological flow has a lot of operations, and there is no possibility to simultaneously execute the technological operations. Through implementing the proposed technology, the technological flow is simplified, some of the technological operations being simultaneously executed. Thus, the manufacture cost of the final product is lowered, maintaining at the same time its quality characteristics.*

Key words: *spring-disk membranes, thermo-mechanical treatments.*

1. INTRODUCTION

As a result of the researches, and for the first time on a national level, an implementation of the manufacturing technology is proposed for spring-disk membranes for clutches through thermo-mechanical treatments controlled on automated process lines of bend hardening [1, 6, 10]. The novelty of this procedure consists of correlation between the results obtained consistent to entry data of the process (the chemical composition of the semiproduct, technological parameters of the hardening and plastic deformation) and the exit data of the process (mechanical and structural characteristics resulted following the technological process, as compared to spring-disk membrane parts obtained through classical technological versions). Spring-disk membranes for clutches obtained through automated process lines of bend hardening, combine properties such as hardness, toughness, elasticity and wearing resistance. The technological process is fully assisted and computer managed, by observing the correlation: chemical composition of the material – technological parameters hardening + plastic deformation – membrane structure preponderantly troostite [2, 7, 9].

At present, high dynamics of the international and local economic and financial factors, places Romania in the centre of the new interest pole of the global market of automotive parts and equipment. The new market position, both local and abroad, outlines a wave of opportunities, limited in time, that must imperatively capitalized, considering the potential and the unique chance of the automotive industry in Romania.

2. INDUSTRIAL EXPERIMENTS

Main technological phases of manufacturing technologies of spring-disk membranes for clutches through thermo-mechanical treatments controlled on automated process lines of bend hardening are: selecting and defining the starting semiproduct (light alloy steel band, thickness = 2 mm); band stamping; semiproduct denting; semiproduct zoning; hot flattening of the semiproduct ($T_{flattening}$ = 680 ºC); thermo-mechanic complex processing (bend hardening = hardening, 850 ÷ 900 ºC, t_m = 0.5 h + water cooling Vr = 250 °C/s + plastic deformation by bending, plastic deformation ratio 10%); medium tempering and obtaining the elastic-hard troostite structure ($T_{tempering}$.= 400 ºC, t_m = 1.5 h + air cooling; equipment output 20 pcs./h); technological tests of education through gymnastication (deformation cycles + elastic recovery = min. 50 cycles/min without occurring of response delaying phenomenon); controlling the mechanical and structural characteristics of the final product (medium hardness of the membrane surface = 50 HRC, R_m > 1500 N/mm^2, metallographical structure: preponderant temper troostite); mounting the final product in the general assembly (clutch); final technical control: technological and quality tests; checking and functionality tests: automatization and implementing the technology [2, 11].

The technological line used for the industrial experiments is shown in Fig. 1.

Main sectors of the manufacturing line are: feeding, heating-deformation sector, hardening, tempering and storage.

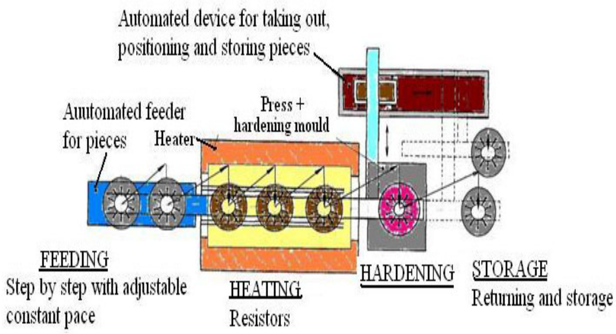


Fig. 1. Diagram of manufacturing line for spring-disk membranes through thermo-mechanical controlled treatments.

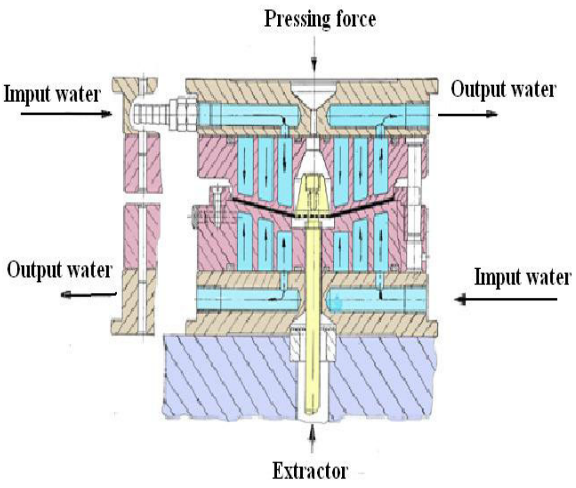
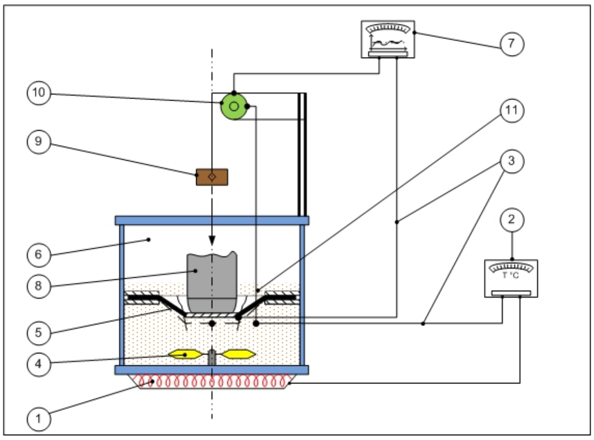


Fig. 2. Mold for spring – disk membranes.



1 - heating device; 2 - temperature controlling instrument; 3 - thermocouples; 4 - stirrer; 5 - spring-disk membrane (sample); 6 - gymnastication device chamber; 7- recording instrument for deformation cycles and deformation ratio; 8 - pushing rod; 9 - device for pushing-deformation; 10 - displacement transducer; 11 - grease

Fig. 3. Device for technological tests of education through gymnastication.

The main part for the manufacturing line is mold for the spring – disk membranes presented in Fig. 2.

Durability and functioning efficiency remain the major problems of the spring-disk membranes for clutches. Efficiency of the spring-disk membranes for clutches is given by their capacity to realize an optimum ratio between the three main characteristics: mechanical resistance to cyclic elastic deformation – surface hardness – elasticity (toughness capable to overtake the strengths) [3, 12].

Durability of spring-disk membranes for clutches is the result of convolution of the structural alteratins and of the thermo-mechanical fatigue resistance. Technological heredity of the spring-disk membrane for clutches will fundamentally determine its behaviour and its reliableness [4, 13]. In order to mark out the elastic characteristics, the experimented spring-disk membranes have been subjected to technological tests of gymnastication, using the device shown in Fig. 3.

Spring-disk membranes that posses an adequate elasticity, present a high response reaction speed.

3. MAIN TECHNOLOGICAL PARAMETERS

Variation margins for the main technological parameters of manufacturing technology for spring-disk membranes through thermo-mechanical controlled treatments of bend hardening are shown in Table 1.

Table 1

Experimental technological operations – experimental technological parameters

Symbol of experimental technological operation	Experimental technological parameter	Variation interval for technological parameters	Measurement unit
Chemical composition control	Chemical composition	0.47 – 0.55 % C; max. 0.40% Si max. 0.035 % P; max. 0.035 % S 0.10 – 0.25 % V; 0.90 – 1.20 %Cr; 0.70 – 1.10 %Mn	%
Structure control	Structure	Pearlite-ferrite structure + fine traces of carbides	Constituents, phases
Hardness control	Hardness	300 - 350	HB
Mechanical movements control	Mechanical tests	R_m = 1500 ; R_c = 1150	daN/mm^2
		A = 14; Z = 14	%
Band stamping	Stamping pace	500 - 800	No of op./h
Semiproduct denting	No of denting operations	170 - 210	No of op./h
Semiproduct zoning	No of zoning operations	170 - 210	No of op./h
Heating at 680ºC	Heating temperature	650 - 700	ºC
Flattening	Load time	10	s
Bend hardening	Hardening temperature	850 – 900	ºC
	Hardening time	0.1 – 0.7	h
	Cooling speed for hardening	200 - 300	ºC/s
Plastic deformation by bending-plastic deformation ratio 10%	Deformation ratio	8 - 15	%
Medium tempering obtaining the elastic-hard troostite structure	Tempering temperature	250 – 400	ºC
	Tempering maintaining time	1 - 2	h
Hardness control	Hardness	40 – 50	HRC
Structure control	Structure	T – preponderant troostite $T+S$ (90% T), $T+P_{lam}$ (80% T)	Constituents, phases
Mechanical resistance control	R_m	1200 - 1600	N/mm^2
Fatigue test, shocks	Shock resistance	40 - 110	J/cm^2
Durability analyses	Durability	1500 - 2000	h discontinuous load functioning

Variation intervals of the main technological parameters are reduced as in size, which determines the necessity to automatize the technology in order to obtain the anticipated results.

4. MICROSCOPIC AND STRUCTURAL RESEARCHES

From the spring-disk membranes samples were taken and subjected to a metallographic study [5].

Depending on values of the main technological parameters (hardening temperature, hardening time period, tempering temperature, tempering time period, cooling speed, degree of bending deformation) the following types of structures have resulted:

1 – Temper troostite preponderant over 80% - structure consistent with automotive clutches, giving elasticity and toughness.

2 – Temper sorbite – structure with medium behaviour – modest elasticity + toughness.

3 – Cubic martensite + Residual austenite – not an adequate structure – weak elasticity + toughness.

4 – Preponderant pearlite structure P = 80 - 90% - not an adequate structure – weak elasticity:

a – adequate hardness, HRC > 40 → elasticity + toughness;

b – inadequate hardness, HRC ≤ 40 → inadequate elasticity;

c – adequate gymnastication, no of cycles ≥ 80 cycl./min.→ adequate elasticity of membrane;

d – inadequate gymnastication, no of cycles < 80 cycl./min.→ inadequate elasticity of membrane.

The main structures with an adequate elasticity, obtained following the analyses of the experimental results are shown in Table 2.

Values of the technological parameters corresponding to troostitic layers abide the optimum values of those parameters [5, 8].

5. CONCLUSIONS

Machinery and equipment of line technological automated ensure manufacture spring-disk membranes through a new technology based on thermo-mechanical controlled treatments.

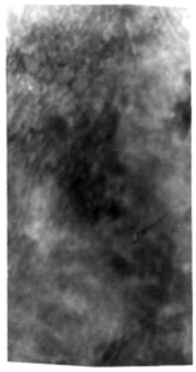
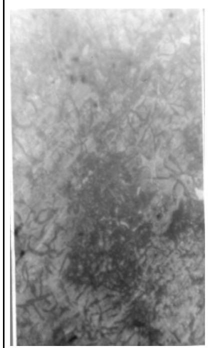
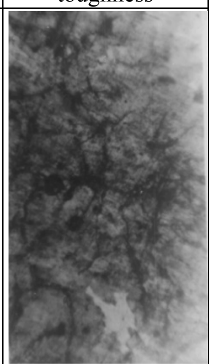
Temper troostite preponderant over 80% - structure consistent with automotive clutches, giving elasticity and toughness.

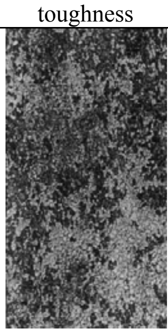
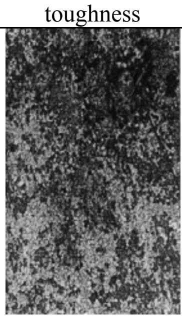
Troostitic structure was obtained under the following experimental conditions: hardening temperature 895 - 910 ºC; hardening keeping time 40 minutes; tempering temperature 430 – 450 ºC; tempering keeping time 85 - 90 minutes; cooling speed 240 – 250 ºC/min; gymnastication deformation ratio 16 – 17%. Medium hardness on the spring-disk membranes surface, in case of those with troostitic structure was 45 HRC, and the number of cycles on gymnastication test, through delaying the response reaction was over 85 de cycl/min → value that warranties an adequate behaviour in operation.

The experimental results confirm the viability of this technology and recommend it for its implementation on the existent technological flows at the potential beneficiaries.

Table 2

Study for microscopic and structural analyses – experimental results

No	Technological parameters	Experimental determinations - results	Structure: atack 2% nital × 150
1	*T hardening* = 900ºC $t_{hardening}$ = 40 min. *T tempering* = 430ºC $t_{tempering}$ = 85 min. *S* of cooling = 245ºC/min Deform ratio = 16 %	Hardness = 45 HRC Gymnastication = 85 [no.cycl./min]	 Temper troostite preponderant over 80% - structure consistent with automotive clutches, giving elasticity and toughness
2	*T hardening* = 900ºC $t_{hardening}$ = 40 min. *T tempering* = 440ºC $t_{tempering}$ = 85 min. *S* of cooling = 245ºC/min Deform ratio = 17 %	Hardness = 45 HRC Gymnastication = 85 [no.cycl./min]	 Temper troostite preponderant over 80% - structure consistent with automotive clutches, giving elasticity and toughness
3	*T hardening* = 905ºC $t_{hardening}$ = 40 min. *T tempering* = 440ºC $t_{tempering}$ = 90 min. *S* of cooling = 245ºC/min Deform ratio = 17 %	Hardness = 45 HRC Gymnastication = 90 [no.cycl./min]	 Temper troostite preponderant over 80% - structure consistent with automotive clutches, giving elasticity and toughness

4	*T hardening* = 905ºC $t_{hardenine}$ = 40 min. *T tempering* = 450ºC $t_{tempering}$ = 90 min. *S* of cooling = 250ºC/min Deform ratio = 17 %	Hardness = 45 HRC Gymnastication = 90 [no.cycl./min]	 Temper troostite preponderant over 80% - structure consistent with automotive clutches, giving elasticity and toughness
5	*T hardening* = 910ºC $t_{hardening}$ = 40 min. *T tempering* = 450ºC $t_{tempering}$ = 90 min. *S* of cooling = 250ºC/min Deform ratio = 17 %	Hardness = 45HRC Gymnastication = 90 [no.cycl./min]	 Temper troostite preponderant over 80% - structure consistent with automotive clutches, giving elasticity and toughness
6	*T hardening* = 910ºC $t_{hardening}$ = 40 min. *T tempering* = 450ºC $t_{tempering}$ = 90 min. *S* of cooling = 250ºC/min Deform ratio = 17 %	Hardness = 45 HRC Gymnastication = 90 [no.cycl./min]	 Temper troostite preponderant over 80% - structure consistent with automotive clutches, giving elasticity and toughness

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