HOT TWISTING TESTS UPON NEW TYPES OF STEELS FROM THE DACIA'S GEARBOX

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The most recent trends in high-tech of using new steel materials with special metallurgical elaboration, instead of the old steels with standard metallurgical elaboration, appear in the subject of our study. From the new (40CD4X) and old (42CrMo4) steels' charges were extracted round short samples ($L_0=5d_0$) and they were tested on the universal Zwick – Rel 1875 machine, with the following regimes:

- *were programmed two test speeds from the domain of quasi-static speeds;*
- *at every speed were programmed many temperature steps.*

The results obtained, processed and analyses have reflected the superiority of the special metallurgical elaboration steel, being justified their use in the new models of Dacia's gearboxes.

Keywords: 40CD4X steel; traction machine Zwick; mechanical resistance; test speed.

1. THE STUDY TARGETS

In this study, the activities for the determination of the mechanic properties of two steels (40CD4X AND 42CrMo4) carry on, all these activities beeing imposed by the new models of Dacia's gearboxes.

However the study's target consists of the hot twisting resistance determination for the two steels, this value being used in calculations for gear wheels dimensioning in the new models of Dacia's gearboxes, designed for high operation speeds[6].

2. THE SET UP OF THE RESEARCH PROGRAM

The determination of the mechanic properties of the two steels' charges has been made in the laboratories of ISGMP Metz, where the necessary samples have been also made from the two metallurgical charges, as follows:

- for the 40CD4X steel:
  - 5 samples for the hot twisting tests having the speed of $1,8^{*}10^{-2}s^{-1}$ (Table 1);
  - 3 samples for the hot twisting tests having the speed of $1,8^{*}10^{-1}s^{-1}$ (Table 1).
- for the 42CrMo4 steel:
  - 4 samples for the hot twisting tests having the speed of $1,8^{*}10^{-2}s^{-1}$ (Table 1);
  - 1 sample for the hot twisting tests having the speed of $1,8^{*}10^{-1}s^{-1}$ (Table 1).

The samples 1.9 up to 1.16 are made of steel 40CD4X.

The samples 1.23 up to 1.27 are made of steel 42CrMo4.

The test conditions are:

- samples 1.14, 1.15, 1.16 and 1.27 are submitted to the test speed of $1{,}8^{*}10^{-1}s^{-1}$ (10mm/min);
- samples 1.9 - 1.14 and 1.23 - 1.26 are submitted to the test speed of $1{,}8^{*}10^{-2}s^{-1}$ (1 mm/min);
- the settled operating temperatures are θ = 23°C; 200°C; 400°C; 600°C; 700°C.

3. THE DESCRIPTION OF THE ZWICK MACHINE'S TWISTING ASSEMBLY [4]

The universal machine Zwick Rel-1875 for traction, compression and twisting tests, from the ISGMP Metz endowment shown in the Figure 1, is provided with the measuring system controlled by the computer, with the following facilities related to the dynamic twisting tests's preparing:

- in the working space are accomplished:
  - the introduction and fastening between the lower and the upper jaws of the machine;
  - the proper positioning of the optical strain gauge ;
  - the upper jaw driving of a step by step (SSM) motor, with torque amplifier (EHC), through a speed variation device (VV), which controls by program the samples' test speed;
- a measuring system Volf type [3], processes the obtained primary experimental informations, it offers them as registrations diagrams (σ-ε) or it keeps them in the measuring system's memory.

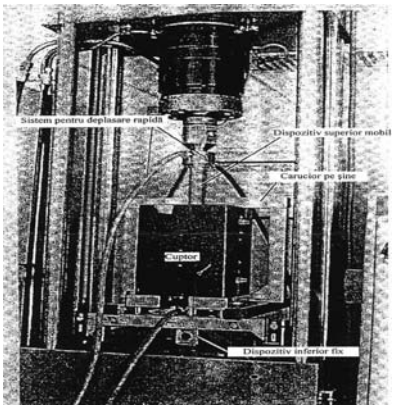


Fig.1. *The 10 MN universal machine for traction testing*

To assembly various appendixes in the machine's operating space the methodology recommended by Daverito shall be observed [1].

4. THE SAMPLES MANUFACTURING

According to Romanian Standard STAS 6967-73[5] in the chapter related to the classification methods for the mechanical tests, the following are found:

- for the static tension tests around ten specific standards exist;
- for the dynamic tension tests we have the STAS 8027-67;
- for the static and dynamic twisting tests no specific standards have been recommended.

In the ISGMP Metz laboratories, due to the small space appointed by the device for dynamic twisting testing, short round samples ($L_0=5d_0$) from the tension test have been chosen. The final operations for the samples manufacturing, are those usual in the preparation stages: grinding, ungreasing, and drying by hot air.

5. THE PRIMARY DATA COLLECTING

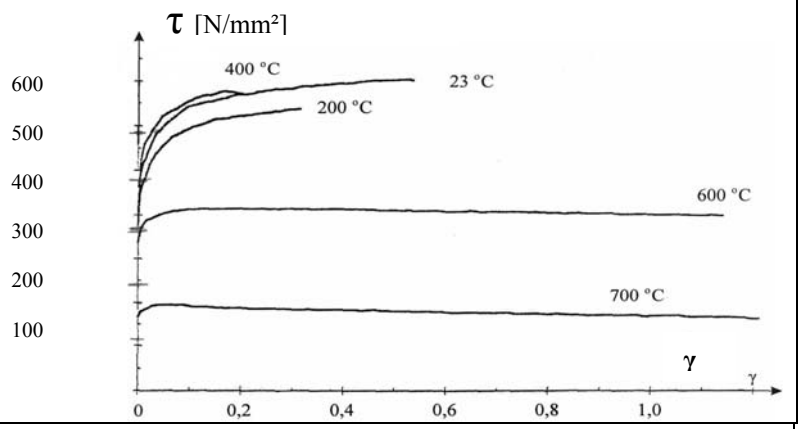
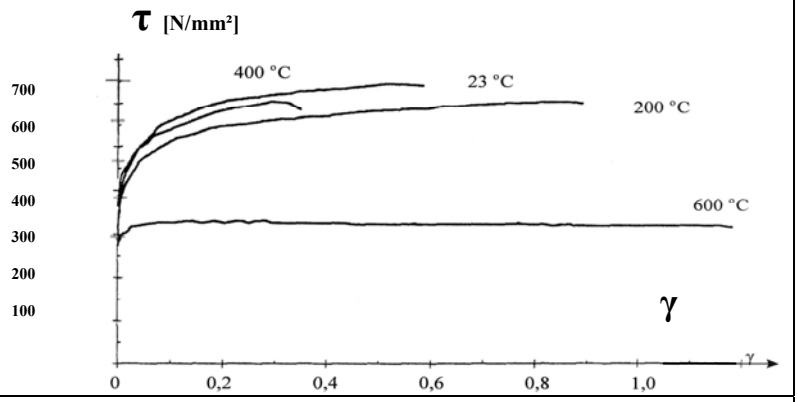
Based on the experiments planning, are prepared for measurements, a batch of thirteen short round samples from both steels' charges:

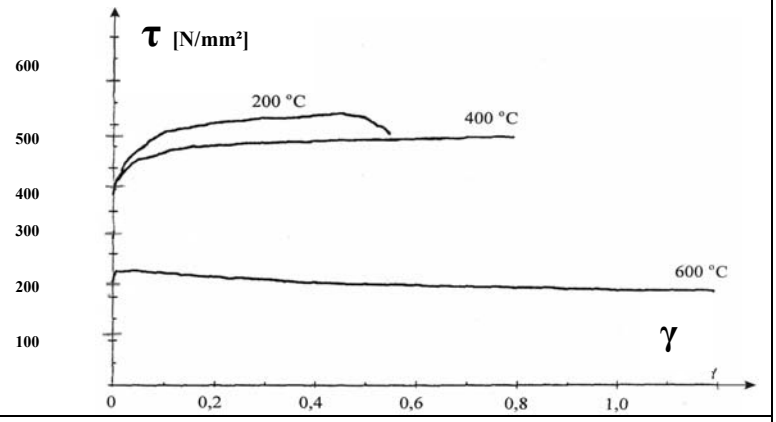
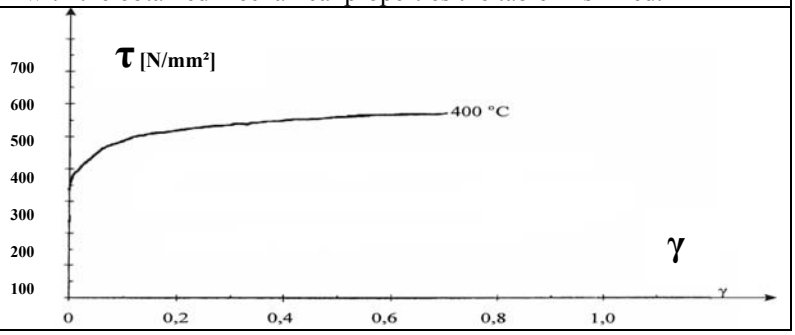
- eight samples for 40CD4X steel;
- five samples for 42CrMo4 steel.

Observing the test conditions settled in the research program from paragraph 2, assisted by the Volf measuring system [3] the primary experimental data direct recording is succeeded under the diagrams tension-strain shape, as shown in the following cards:

- card 1, for 40CD4X steel, and the measurements at the speed of $1,8*10^{-2}$ s^{-1} and the temperatures of 23°C, 200°C, 400°C, 600°C, 700°C;
- card 2, for 40CD4X steel, and the measurements at the speed of $1,8*10^{-1}s^{-1}$ and the temperatures of 23°C, 200°C, 400°C, 600°C;
- card 3, for 42CrMo4 steel, and the measurements at the speed of $1,8*10^{-2}$ s^{-1} and the temperatures of 200°C, 400°C, 600°C;
- card 4, for 42CrMo4 steel, and the measurements at the speed of $1,8*10^{-1}s^{-1}$ and the temperature of 400°C.

Heding Card 1	TWISTING TEST USING ZWICK MACHINE
Primary data	- we use five samples of 40CD4X steel having the granulation of 20 μm; - we made five measurements with the samples in the following conditions: ➥ to the deforming speed $\gamma'=1,8*10^{-2}s^{-1}$; ➥ temperatures of θ = 23˚C; 200˚C; 400˚C; 600˚C; 700ºC.
Results	❖ are be taken from the (τ-γ) recorded diagrams; ❖ are graphically represented in this card; ❖ with the obtained mechanical properties the table 1 is filled.

Sample 1.9 1.10 1.11 1.12 1.13	
Heding Card 2	TWISTING TEST USING ZWICK MACHINE
Primary data	- we use four samples of 42CrMo4 steel having the granulation of 25 μm; - we made four measurements with the samples in the following conditions: ↳ to the deforming speed $\gamma' = 1{,}8 * 10^{-2} s^{-1}$; ↳ temperatures of θ = 23ºC; 200ºC; 400ºC; 600ºC.
Results	❖ are be taken from the (τ-γ) recorded diagrams; ❖ are graphically represented in this card; ❖ with the obtained mechanical properties the table 1 is filled.
Sample 1.23 1.24 1.25 1.26	
Heding Card 3	TWISTING TEST USING ZWICK MACHINE
Primary data	- we use three samples of 40CD4X steel having the granulation of 20 μm; - we made three measurements with the samples in the following conditions: ↳ to the deforming speed $\gamma' = 1{,}8 * 10^{-1} s^{-1}$; ↳ temperatures of θ =200ºC;400ºC;600ºC;700ºC.
Results	❖ are be taken from the (τ-γ) recorded diagrams; ❖ are graphically represented in this card; ❖ with the obtained mechanical properties the table 1 is filled.

Sample 1.14 1.15 1.16	
Heding-Card 4	TWISTING TEST USING ZWICK MACHINE
Primary data	- we use one sample of 40CrMo4 steel having the granulation of 25 μm; - we made one measurement with the samples in the following conditions: ↳ to the deforming speed $\gamma' = 1{,}8*10^{-1} s^{-1}$; ↳ temperature of $\theta = 400^{o}C$.
Results	❖ are be taken from the (τ-γ) recorded diagrams; ❖ are graphically represented in this card; ❖ with the obtained mechanical properties the table 1 is filled.
Sample 1.27	

6. THE EXPERIMENTAL DATA PROCESSING

The activity for the diagrams tension-strain processing uses optical lighting projectors with which is determined, scaled: yield points (τ_c; γ_c); plastic strain limits (τ_{max}, γ_{max}); run out limit (τ_r, γ_r). The results are clearly recorded for each of the two steels in the Table 1.

No. of measurement	Sample's no.	Sample's material	Testing temperature	Deforming speed	Yiled points		Plastic strain limits	
			θ	γ´	τ_c	γ_c	τ_{max}	γ_{max}
			°C	s^{-1}	N/mm²	-	N/mm²	-
1	1.23	**42CrMo4 steel granulation of 25 μm**	23	$1{,}8*10^{-2}$	440	0,05	690	0,60
2	1.24		200		420	0,05	650	0,85
3	1.25		400		400	0,05	650	0,38
4	1.26		600		300	0,05	330	1,00
5	1.27		400	$1{,}8*10^{-1}$	350	0,05	590	0,70
6	1.9	**40CD4X steel granulation of 20 μm**	23	$1{,}8*10^{-2}$	365	0,05	610	0,55
7	1.10		200		320	0,05	540	0,35
8	1.11		400		365	0,05	580	0,25
9	1.12		600		240	0,05	340	1,10
10	1.13		700		140	0,05	160	1,10
11	1.14		200	$1{,}8*10^{-1}$	310	0,05	540	0,50
12	1.15		400		305	0,05	500	0,80
13	1.16		600		170	0,05	230	1,20

Table 1. *Quasi-static twisting tests made on Zwick machine - Rel 1875*

7. THE RESULTS RENDERING

Based on the Table 1, that offers the result of the experimental researches made in the low and medium speeds range, it can be said that the two steels present different gapes for the mechanical strength modification, depending on the testing speeds used:

- for the 42CrMo4 steel:
  - at the speed of $1,8*10^{-2}s^{-1}$, τ_{max} = 300 - 440 N/mm²
    γ_{max} = 40 - 85%
  - at the speed of $1,8*10^{-1}s^{-1}$, τ_{max} = 350 N/mm²
    γ_{max} = 70%
- for the 40CD4X steel:
  - at the speed of $1,8*10^{-2}s^{-1}$, τ_{max} = 160 - 630 N/mm²
    γ_{max} = 55 - 90%
  - at the speed of $1,8*10^{-1}s^{-1}$, τ_{max} = 230 - 540 N/mm²
    γ_{max} = 50 - 90%.

8. CONCLUSIONS

The sensitivity to the temperature of the 40CD4X steel is greater that the 42CrMo4 ones, because:

- for the speed of $1,8*10^{-2}\ s^{-1}$, in the temperature gape between 200°C and 600°C:
  - at 40CD4X steel, τ_{max} decreases from 610 to 160 N/mm²;
  - at 42CrMo4 steel, τ_{max} decreases from 690 to 330N/mm².
- for the speed of $1,8*10^{-1}s^{-1}$, in the temperature gape between 200 and 600˚C:
  - at 40CD4X steel, τ_{max} decreases from 540 to 230 N/mm².

If we maintain the temperature to 400°C, and we modify the speed, than:

- for the speed of $1,8*10^{-2}s^{-1}$ we have:
  - to 40CD4X steel, τ_{max} =580 N/mm²;
  - to 42CrMo4 steel, τ_{max} =650 N/mm².
- - for the speed of $1,8*10^{-1}s^{-1}$ we have:
  - to 40CD4X steel, τ_{max} =500 N/mm²;
  - to 42CrMo4 steel, τ_{max} =590 N/mm².

So, the 40CD4X steel, obtained by special metallurgic elaboration is better to the 42CrMo4 steel with standard elaboration because:

- the sensitivity to the temperature is greater;
- the sensitivity to the speed is greater.

9. REFERENCES

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