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STUDY UPON THE INFLUENCE EXERTED BY THE DIAMETER SIZE OF GENERAL USAGE STEEL WIRES ONTO THE CONSTITUTIVE MATERIAL'S MECHANICAL AND TECHNOLOGICAL CHARACTERISTICS

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ABSTRACT:
The aim of this paper is to determine the influence exerted by the diameter size of general usage steel wires, onto the mechanical characteristics triggered through traction trials (the traction resistance R_m; the elongation percentage after the A breakage; the necking coefficient), as well as the technological feature, obtained by means of torsion. The spectrum of characteristics is proper to the wires' constitutive material.

KEYWORDS:
mechanical characteristic, sample, diameter

1. INTRODUCTION

What laminated steel wires are concerned, one aims at determining their mechanical characteristics, resulting after traction trials (SR EN 10002-1: 2002), as well as trials of resistance to shearing (STAS 7927-67). At the same time, the technical features are equally pursued, namely through torsion tests (STAS 1750-90) and tests centered on bending (SR ISO 7801: 1993) and alternative bending (SR ISO 7438: 1993 / A99: 2002).

The brand of steel chosen for this study is OL 37.I.k., destined for laminated wires with diameters ranging from ϕ 6, ϕ 8 and ϕ10 to ϕ12. Such an option also contributes to determining the previously mentioned characteristics.

2. THE TRACTION TRIAL

The trial was carried out on short samples; hence, the manner of sampling was performed according to SR EN ISO 377:2000. Furthermore, the following aspects were inferred from the resulting characteristic conventional curves: the limit of conventional flow $R_{p0,2}$, the traction resistance R_m, the elongation percentage after the A breakage, as well as the necking coefficient Z.

3. THE TORSION TRIAL

The trial consists of subjecting a wire sample to torsion, i.e. twisting it around its own axis, up to breakage or until a specified number of torsions is reached. The torsion can be executed with or without a change of direction. Thus, the first approach bears the name of *simple torsion*, whereas the second one is torsion *followed by de-torsion*. The sample (test wire) has its free length between the stand reamers and its torsion revolution occurs in terms of diameter ($d>5$ mm, $L= 50$ d and $n= 0, 25$ rot/s); moreover, the steel wire, which has already been subject to torsion tests, must be elongated with a force representing a max 2% of the breakage force during traction.

What is more, the experimental stand allows trials on steel and non-ferrous wires equally, yet belonging to a spectrum of diameters ranging from 0, 5 mm to 16 mm, and nonetheless abiding to the prescriptions of STAS 1750-90 (the alteration in length between the reamers, the revolution variation of the mobile torsion head, the change of torsion direction and the axial charging of the sample).

The main sketch of the stand is displayed in Figure 1.

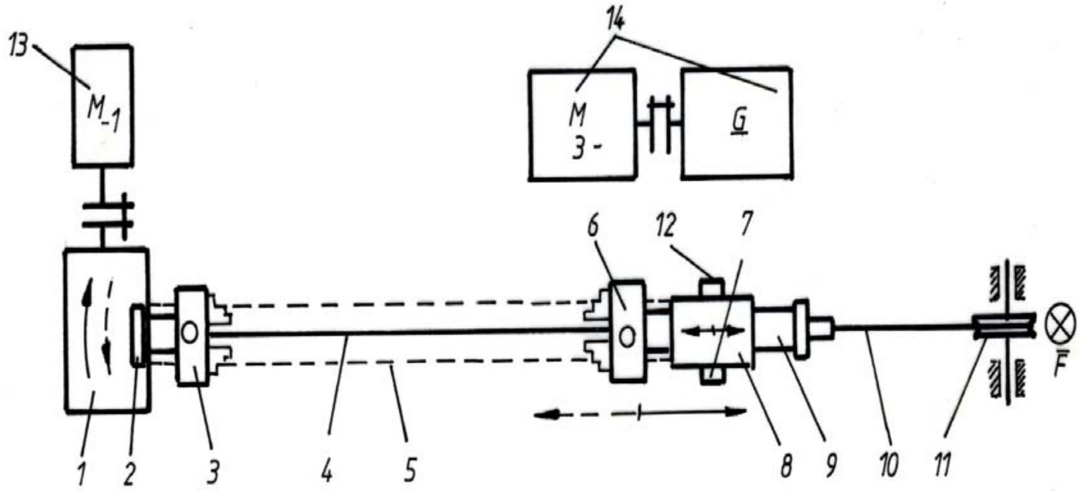

Figure 1

The sample (4) is fixed on two clamping heads: one is mobile in torsion (3), whilst the other is immobile (6). The torsion head (3) is assembled onto the outlet axle belonging to the snail-shaped reducer (1); the latter is set into motion by an engine of direct current (13). This (13) is fuelled by an engine group of: alternating current- direct current generator. Consequently, one is permitted to alter the revolution of operating with the sample (4); the clamping head (6) is set up on the device (8) regulating the active working distance of the sample; the clamping head also finds itself in the position of moving onto the guide (5). Additionally, the device (8) is equipped with a catcher (7) and a charging catcher (12).

The elongation of the sample is achieved by a force F, through the specimen (9), the cable (10) and the reel (11). One can thus obtain the elongation force by means of standardized weights, fixed to a scale, which is itself fastened to the cable (10). A gauger (2) is placed within the reducer (1); the former deals with the instrument keeping track of the number of shifts.

All in all, the experimental stand only witnessed the torsion trial without change of direction (the simple torsion); this resulted in determining the number of twists the sample endured, until its breakage, N_t.

Table 1

Diameter		Mechanical characteristics for:											
		Traction								Torsion			
ϕ d [mm]	d real [mm]	$R_{po,2}$ [N/mm^2]		R_m [N/mm^2]		A_5 [%]		Z [%]		L [mm]	N rot/s	N_t	
		individual	average	ind.	av.	ind.	av.	ind.	Av.			Av. for 3 samples	Av.
6	6,00	261	259,6	367	363,6	43	43,2	75	74,6	300	0,25	38	39,6
	6,00	254		353		45		71				39	
	6,00	263		385		43		73				42	
	6,00	261		360		42		76				40	
	6,00	254		353		43		78				39	
8	8,00	284	279,4	457	470,0	34	33,2	69	66,6	400	0,25	29	31,6
	8,00	289		437		36		60				29	
	8,05	287		477		32		70				30	
	8,05	287		467		30		72				32	
	8,00	278		512		34		63				34	
10	10,01	260	297,0	401	446,0	38	33,8	70	70,2	500	0,25	25	25,2
	10,00	292		439		34		70				25	
	10,00	299		471		33		70				24	
	10,00	324		458		32		71				27	
	10,07	310		461		32		71				25	
12	12,01	278	268,4	468	448,0	35	35,8	62	65,6	600	0,25	23	22,8
	12,00	278		442		37		68				25	
	12,01	256		437		37		63				21	
	12,00	256		433		37		68				22	
	12,00	274		464		33		67				23	

4. EXPERIMENTAL RESULTS. CONCLUSIONS

A number of five samples were subjected to trial for each diameter in turn, not only in terms of traction, but also what torsion is concerned. The test pieces were sampled from scraps of wire, so that the length chosen could be appropriate for both processes previously illustrated. These pieces were successively sampled from the same wire coil.

The experimental results obtained have allowed the determination of the mechanical and technological characteristics presented in the above table.

Furthermore, Figure 2 aims at highlighting the manner of variation according to diameter for the characteristics R_m, $R_{po,2}$, A_5 and Z, obtained as a result of traction trial. Also taken into account through Figure 2 is the feature N_t, which is a result of torsion trial.

By analyzing the manner of variation of the R_m and $R_{po,2}$ characteristics, one can observe their increment for ϕ6 and ϕ8 mm, followed by a slight decrease for ϕ10 and ϕ12 mm. This is due to the phenomenon occurring in the clamping zones of the wire samples, namely those which are not processed with a clamping head; thus, the homogenous tension field, achieved through monoaxial elongation, is perturbed because of local contortion. That is why torsion occurs under a weaker force than the real one. Once the size of the wire section is increased, the phenomenon lessens.

Examining the curves outlined for the characteristics A_5 and Z, one is able to notice an analogy between the variation of these dimensions, in terms of the sample diameter: a decrease from ϕ 6 to ϕ 8 mm, followed by their slight increment for ϕ10 and ϕ12. An explanation for this phenomenon would be that the degree of necking anisotropy increases with the dimension of the torsion resistance R_m.

The decrease of the necking coefficient with the increase of the sample's diameter is also justified through the mechanical fiber structure; the latter is due to a preferential alignment in the direction of the alteration (through lamination) of structure discontinuities, such as: inclusions, vacancies, non-homogenities and the subsequent steps in this phased approach.

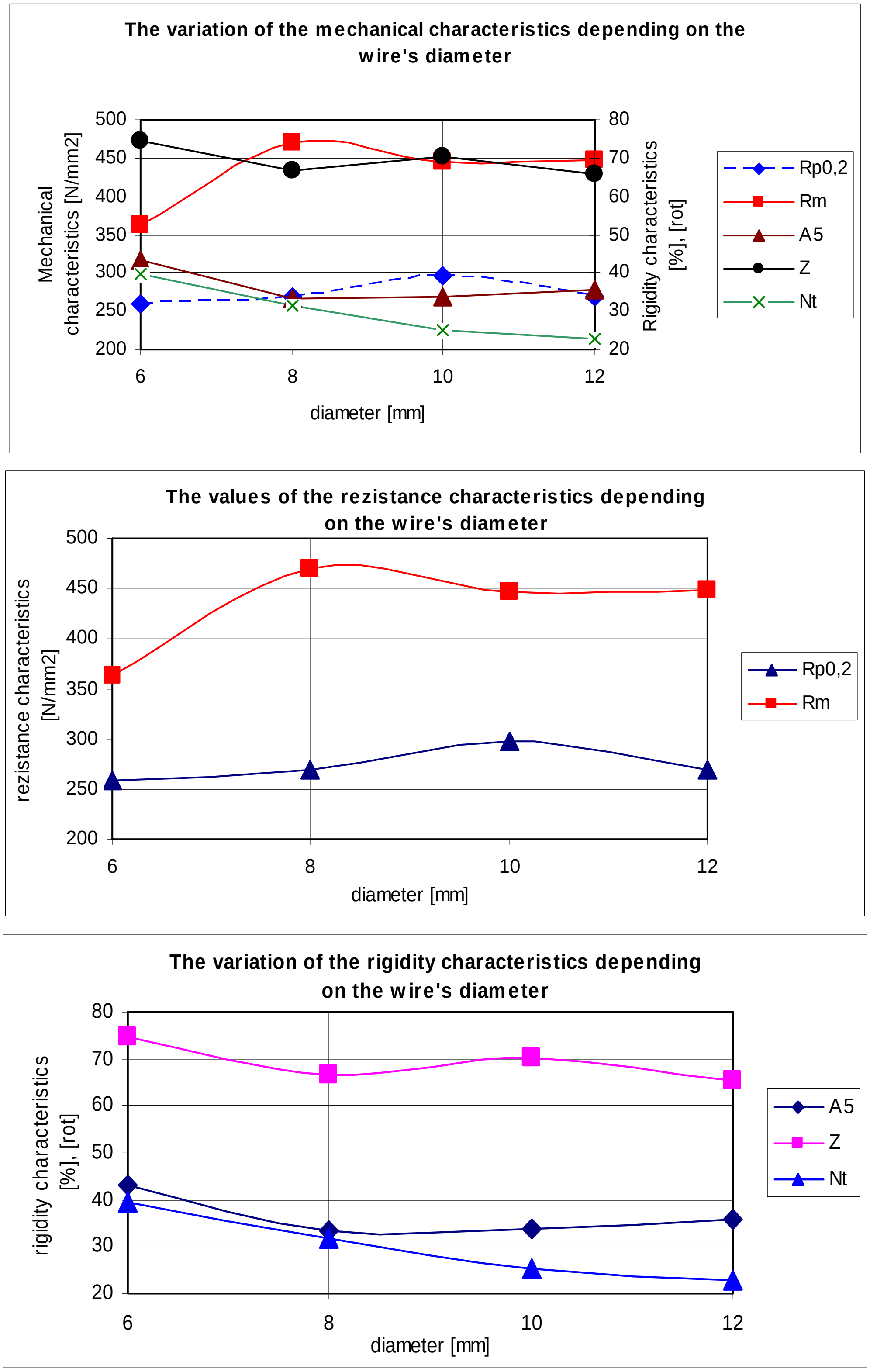

Figure 2

Likewise, due to the fact that the elongation after breakage is proportional with the total length of the sample, it becomes influenced by the way in which the alteration occurs during necking; the elongation is even only to the point when the loading torque corresponds to the maximum charge undertaken by the sample. Above this point, the deformation is no longer even longways the sample, also because necking commences.

The values of the characteristics obtained from the traction trial for the spectrum of diameters taken into account have proven themselves superior to the minimum values imposed by STAS 500/2.-80 ($R_{p0,2}$=240 N/mm^2; R_m=360 N/mm^2, A_5= 25 %) for the brand OL 37.l.k. Consequently, the $R_{p0,2}$ characteristic ranges from 259,6 to 297,0 N/mm^2, R_m on the other hand, ranges from 363,6 to 470,0 N/mm^2, whereas A_5 stretches between 33,2 and 43,2%.

The torsion trial is useful for determining the malleability of the material the sample is made up of. Its main advantage is the fact that during the actual trial, the sample does not practically alter its dimensions; that is why the trial conditions remain fairly constant.

Nonetheless, by analyzing the experimental results triggered through the torsion trial, one is bound to notice a slight decrease in terms of malleability, which is ultimately expressed by the number of torsions the sample undergoes until breakage, once the wire diameter increases. What accounts for this fact is the higher probability of internal faults (bearing the role of tension concentrators), as well as of the tension state characterizing the sample during the trial.

The breakage occurred along one of the plans in which the tangent tension reaches its maximum; in the case of OL 37.l.k., this plan is oriented perpendicularly on the sample's axis. The number of torsions undergone until breakage, N_t, together with the orientation of the breakage plan, indicate the ductile feature of the studied steel.

The average ductility of this steel brand is also confirmed by the analysis conducted onto the breakage section during traction; this provides the result that breakage began from the very centre of the sample section and then spread onto the directions of the maximum tangent tensions, at 45^0. Thus, the aspect of the breakage surface closely resembled the "cone-cup" figure.

To sum up, the plastic deformation of the sample through gliding into the crystalline network of the metal can be described as a phenomenon of spatial nature, all the same axial and symmetrical, nonetheless emphasized through the gliding surfaces, visible in the zone subjected to necking.

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