O.B. Kalinin

ULTRASONIC THREAD PROFILE RESTORATION TECHNOLOGY. RESTORATION OF USED OCTG PIPE THREAD PROFILE.

ZAO "Neftetruboservis"
21, Moskovskaya St., Khimky, Moscow region, 141400, Russian Federation
Ph.: +7 095 573-76-85; fax: +7 095 572-55-93
E-mail: nts@himky.ru

Threaded joints are the most crucial and vulnerable parts of OCTG pipes. Substantial static and dynamic stresses during operation cause the fast wear of thread profile and as a result pipe thread loses its initial strength and leak-tightness. The report contains description of a totally new technology of repair and increase of wear resistance of threaded joints. The technology is based on plastic flow of thread profile by a calibrated tool which moves in a rotation and reciprocal motion manner and intense ultrasonic vibrations are applied to it. There is an analysis of ultrasonic effect on a process of a plastic flow thread restoration and specific statistics reflecting changes of basic geometric parameters stipulated by GOST and strength and wear resistance of threaded joints before and after ultrasonic treatment. It is demonstrated that ultrasonic technology allows both to restore the quality of threaded joints and even increase (compared to the initial condition) such a crucial parameter of operational capability of tubing strings as the number of round-trips.

The OCTG pipes (tubing, casing and drill pipe) are usually operated in extreme working conditions, due to temperature and aggressive environment impact as well as various static and dynamic mechanical stresses. The analysis of accident rate of tubing strings shows that the main cause is the reduction of strength of threaded joints, forming a tubing string. On an example of tubing – the damage of threaded joints is the cause of 50 % of failures, including a leak tightness loss. [1]. Taking into account the aforementioned, the after operational repair of threaded joints is the task of utmost importance. This repair allows to restore and even possibly improve the initial quality parameters of threaded joints. To perform this task NTS-Leader JSC has developed a new unique technology of ultrasonic treatment (UT) of OCTG pipe threads. Let's see the results of application of this technology on an example of tubing (size 73) from Tatneft Oil Company.

The technology of thread restoration is based upon a plastic flow process with the use of a special calibrated tool and the ultrasonic vibrations are applied to this tool. The technology is illustrated by a simplified structural flow chart, see Fig.1.

A pipe *1*, the thread of which is to be restored, is fed along the ways *2* to the treatment unit, which consists of magnetostriction emitter *3* and transmission wave guide *4* . The coupling *5* (it has the wear resistant coating on a calibrating t read) is attached to the transmission wave guide *4.* The coupling itself occasionally rotates clockwise h and counterclockwise a few turns. At the same time it moves along the thread of the pipe *1* in a reciprocal motion manner.

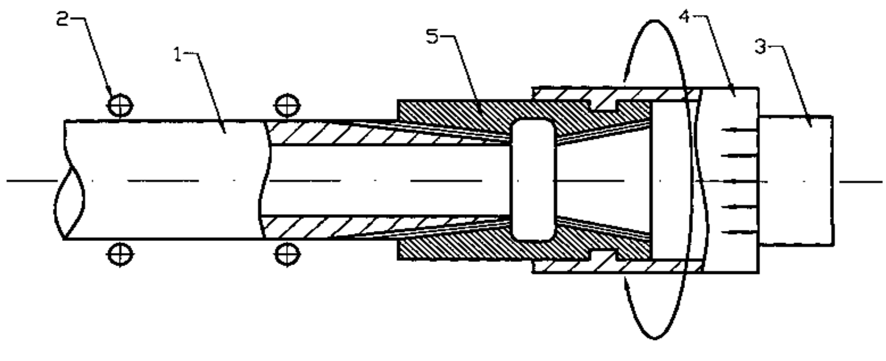


Fig.1. Scheme of installation for the ultrasonic treatment of a tubing thread

A similar at its principle scheme is used for couplings' thread restoration. The only distinction is that the task tool performing the plastic flow and rigidly fixed to the ultrasonic wave guide constitutes the threaded element which is reciprocal to the coupling thread being treated.

The ultrasonic treatment (UT) is done within approximately 30 seconds at a working frequency ≈ 20 Khz at the amplitude of oscillatory shifting of the tool ≈ 5 micron. The main role of the ultrasonic treatment within the framework of the described technology comes to an increase of dislocations mobility and, as a result, to a reduction of yield stress of the metal and an increase of its plasticity (Blagg-Langenekker effect). Besides, the ultrasonic vibrations applied to the calibrating coupling reduce friction between the thread being restored and the coupling. In the aggregate, all that ensures a highly efficient restoration of the initial geometrical parameters of the thread.

The relevant metallographic research has proved that the plastic flow in combination with the ultrasonic treatment result in a substantial (1.5 – 2 times as stronger) strengthening of the thread surface and reducing nearly by an order the height of micro irregularities on surface. Thus, the depth of highly strengthened layer is 15-20 micron for the pipes of grade Д. The hardness of the metal in this layer by Rockwell (scale C) reaches 38 HRC, whereas the hardness of the metal in the basic pipe body (not strengthened) does not exceed 22 HRC.

The deformated pearlite structure is typical for the highly strengthened surface layer. A ferrite structural component in this layer is not virtually observed.

We should point out that the metal of grade Д has coarse-grained Widmanstatten pattern, represented by quasi-eutectoid grains edged by a thin ferrite coating. Such a structure is characterized by an increased resistance to the plastic flow.

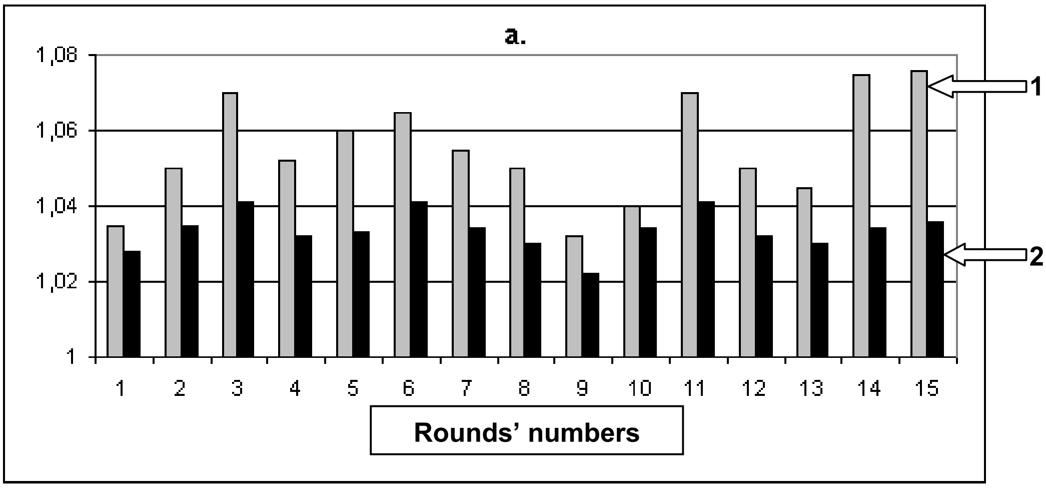
The analysis of microhardness curves at threads of Дс grade pipes proves that a highly strengthened layer is substantially deeper than that of Д grade pipes and reaches 25-30 micron. The latter is due to the fact that the grade Дс metal has the structure consisting of uniformly allocated fine ferrite grains and divorced pearlite. Owing to that it can be relatively easily deformed, forming a uniform highly strengthened layer, in which the metal hardness reaches 36 HRC. The microstructure of the highly strengthened surface layer at Дс grade pipes is represented by alternate layers with fine-dyspersated carbide of high density and round shape and deformed ferrite as well.

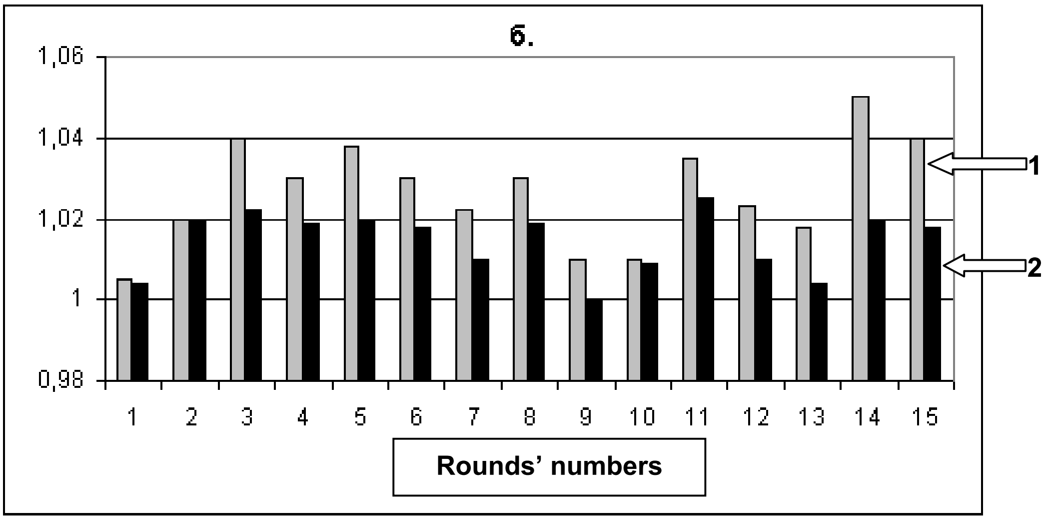
After strengthening by plastic flow and ultrasonic treatment we can observe a smooth transition (up to 100 micron long) from highly deformed layer to the base metal in grade Дс pipes and in grade Д pipes – abrupt transition.

It is important to note that according to metallographic analysis the fibers in the highly strengthened area are oriented along the thread profile line. Such orientation should favorably influence the service life of threaded joints

The efficiency of the said technology is proved by results of the each round analysis (each round of thread is analyzed) of changes of thread profile angles owing to the ultrasonic treatment (refer Fig.2). The said angles are corrected and their parameters are brought to the nominal as per GOST.

That is especially clearly seen by angles A and B, where the average divergence from GOST after ultrasonic treatment is less than 1 %.





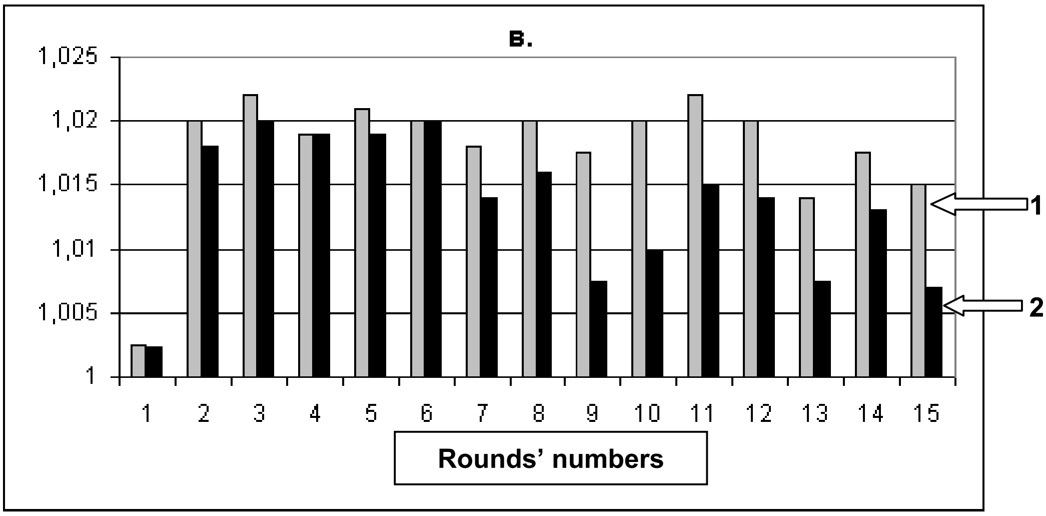


Fig.2 Normalized with respect to the nominal values (by a round) of thread profile angles G (a), A (б), B (в) before 1 and after 2 the ultrasonic treatment.

The experimental data which have been obtained as results of ultrasonic treatment use for restoration of thread profile parameters of pin ends of tubing, shown in Table 1 are also significant. The data itself is the result of averaging-out of measurements, done at three sections of each of inspected 60 pin-ends of tubing before and after ultrasonic treatment. Measurements were made by a high-precision computerized laser system VK-RT [3]. The latter has measured the following thread profile parameters, specified by GOST 633-80: pitch (*P*), height (*H*), profile angles (*A*, *B*, *G*), thread length to the basic surface (*L*), as well as stand-off by thread ring gauge (TG) and plain ring gauge (PG), accordingly $A_т$ and $H_т$.

The analysis of data given in Table 1 demonstrates that by virtually all the main parameters on which the strength and leak tightness of threads (of used tubing) depends, do not meet the GOST requirements. However, after treatment with use of the proposed technology a qualitative improvement of the thread profile geometry took place by all of the parameters. The quantity of pin-ends which didn't meet the GOST requirements had been reduced after UT: by pitch – 3.5 times, by thread height – 3.2 times, by thread profile angles – 2 times upon average, by thread length – 8 times, and by stand-off – 4 times upon average.

Table 1

Averaged-out thread profile parameters of tubing pin-ends
before and after ultrasonic treatment

Name of parameter and its dimensionality	Tolerances by GOST	The average value of measurement results		% of pin-ends not meeting GOST requirements	
		Before UT	After UT	Before UT	After UT
Pitch (*P*), mm	2.465-2.615	2.537	2.539	30	8.3
Profile height (*H*), mm	1.312-1.462	1.309	1.322	37	11.6
Profile angle (*A*), deg	58.000-62.000	63.403	61.156	87	45
Profile angle (*B*), deg	29.000-31.000	32.005	30.702	85	42
Profile angle (*G*), deg	29.000-31.000	31.496	30.359	81	37
Length to the basic surface (*L*), mm	37.800-42.800	38.378	38.585	25	3.3
Stand-off TG ($A_т$), mm	0.000-5.080	4.495	4.331	32	8.3
Stand-off PG ($H_т$), mm	–2.540-2.540	3.168	2.411	30	5

The tests conducted have also proved that the ultrasonic treatment of threaded joints enables to increase the number of round-trips of tubing up to 10 times as more compared to the similar brand new tubing.

R E F E R E N C E S

1. Kershenbaum V.Y., Avanesov V.S., Polikarpov M.P. The standard required. At least by clubbing together // Neftegazovaya Vertical. – 2000. – No.4. – Pages. 142-145. (In Russian).
2. Ultrasonics. Small encyclopedia / Editor-in-chief. I.P. Goliamina. – Moscow: Soviet encyclopedia, 1979. – 400 page. (In Russian).
3. Kalinin O.B. Automated laser-optical electronic systems for measuring the thread parameters of OCTG tubing and couplings// Reliability and certification of oil&gas equipment. – 2002. – No. 1. – pages 42-44. (In Russian).