ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Ecological Safety and Resource-Saving Improvement of the Production Systems by the Technological Process Simulation.

Ilya Lobach[1]*, and Yury E Jakubowski[2].

[1]A Postgraduate Student Of The Applied Mechanics Subdepartment of the Tyumen State Oil and Gas University, a lead engineer of the pipeline operational service of the NOVATEK-YURKHAROVNEFTEGAZ Ltd., Noviy Urengoy.
[2]Professor, a Head of the Applied Mechanics subdepartment of the Tyumen State Oil and Gas University, Tyumen.

ABSTRACT

The purpose of this article is to show the creation process of the deethanized condensate (DEC) fluidal models. The deethanized condensate is supplied to the Yurkharovskoye field - Purovsky Gas Condensate Stabilization Plant (Purovsky Plant) condensate pipeline from the Yurkharovskoye, Samburgskoye and Urengoy oil and gas-condensate fields. The study of the deethanized condensate component-fractional composition and the exact creation of the fluidal models will let to set-up and update the hydraulic model of the Yurkharovskoye field - Purovsky Plant condensate pipeline most accurately.
Keywords: ecological safety, production systems, resource-saving, fluid, component-fractional composition, phase transition, modeling (simulation), deethanized condensate.

Corresponding author

ISSN: 0975-8585

INTRODUCTION

Ensuring environmental safety is one of the main conditions for the safe and continuous operation of pipeline transportation of hydrocarbons.

The operator of the hazardous production facilities has to organize and implement operations control over compliance with applicable industrial safety requirements. [1]

According to Federal Law No.116 "On industrial safety of hazardous production facilities", identification, analysis and forecasting of accidents as well as the planning and implementation of measures to reduce the risk of accidents at hazardous production facilities and their timely adjustment should be performed during the operation of hazardous production facilities.

The purpose of this study is the develop and manage of the production operation process, its results and also the environment quality increasing while operating due to the using digital model of the external pipeline object.

The digital model creation of the Yurkharovskoye field – Purovsky Gas Condensate Stabilization Plant (Purovsky Plant) condensate pipeline was implemented by Schlumberger OLGA v.7.2.2 software, using the PVTsim[1] v.20.2 program which simulates the fluid characteristics.

This choice was not accidental because of the OLGA dynamic multiphase flow model has a very wide range of using. Used numerical method makes the model most suitable for the flow transit regimes simulation. [2]

OLGA software is able to support substantially to take the pre-investment and operational decisions of the pipeline system optimization, including the systems transporting multiphase flows.

Currently this software does not have any analogues and it is the only one possible tool able to solve following tasks:

- Start / stop, changing the pipeline operation regime;
- Dynamic simulation of the paraffine-hydrate sediments in the pipeline taking into account different transportation regimes and transported products;
- The imbalance task solutions when operating the main oil pipeline (with many feedstock suppliers) which lead to the fluid pro rating fluctuations and spread the density along the pipeline unevenly;
- Slug analysis and solutions based on the study of the multiphase system process dynamics, including the simulation of the piping cleaning procedure by ramming pistons;
- Solution of the pipeline thermodynamic interaction with the soil (environment), which may be useful for the design decision analysis and forecast of the subsea pipeline operation process;
- Operation process analysis of the gas & oil industry pipeline using the inhibitors and turbulent viscosity reducing additives (or anti-turbulent additives, ATA) [2].

TECHNICAL SUPPORT OF THE PROJECT DOCUMENT PACKAGE PREPARATION

The North-Russian, East-Taz and Dorogovsky fields were connected to the Yurkharovskoye field - Purovsky Plant condensate pipeline of the NOVATEK-Yurkharovneftegaz Ltd., Yamal Peninsula.
Therefore authors decided to consider the possible increasing of the pumping the additional deethanized condensate volumes at the external pipeline objects mentioned above.
The digital hydraulic model of the Yurkharovskoye field - Purovsky Plant condensate pipeline was created to find the pumped volumes increasing possibilities.

[1] PVTsim is a versatile PVT simulation program developed for study and model the tabular fluid behavior and as well as to determine fluid’s physical and chemical properties. http://www.pvtsimnova.com/

[2] Anti-turbulent additives (ATA) - a high-molecular polymer compound reducing the liquid hydraulic resistance when pumping at the turbulent regimes.

ISSN: 0975-8585

The hydraulic model creation was based on the calculated scheme of the Yurkharovskoye field - Purovsky Plant condensate pipeline.

The pumped fluid characteristics simulation was the initial stage of the set-up and update the digital hydraulic model of the condensate pipeline and affected on the further model work.

When the pumped fluid characteristics set-up there were used the physical and component-fractional composition of the Yurkharovskoye field deethanized condensate study results performed by the laboratory of chemical analysis of the NOVATEK-Yurkharovneftegaz Ltd.

Component content on July 2014 and the results of the deethanized Samburgskoye field condensate study (performed by the laboratory of the Arctic Gas Company Joint stock venture) were taken for the updating the fluid characteristics by the PVTsim software.

The information about the Urengoy field Achimov deposit condensate characteristics was received from the report "Indentify the efficient AFS inhibitor (asphaltene-resin-paraffin deposits) and its optimal concentration" performed by the Scientific Design and Production Complex «TyumenNIIgiprogaz»[3].

MODELING OF THE COMPONENT-FRACTIONAL COMPOSITION AND MAIN CHARACTERISTICS OF THE YURKHAROVSKOYE AND SAMBURGSKOYE FIELDS CONDENSATES

The component-fractional composition and the main characteristics of the Yurkharovskoye and Samburgskoye fields deethanized condensates (DEC) were determed by the laboratory studies[4] in July 2013 and are shown in the table 1.

Table Error! No text of specified style in document.: **Component-fractional composition and the main characteristics of the Yurkharovskoye and Samburgskoye fields deethanized condensates (DEC)**

Name of indicator	Unit of measure	Quantity	
		Yurkharovskoye field	Samburgskoye field
C_1	$\%_{weight}$	0,006	0,029
C_2		0,622	0,6112
C_3		8,914	9,9139
iC_4		4,961	10,4198
nC_4		7,376	6,847
iC_5		5,449	6,4169
nC_5		5,023	6,4031
ΣC_6		67,649	59,385
Density at 20 °C	kg/m^3	673-677	713
Viscosity (kinetic) at 20 °C	mm^2/sec.	0,610-0,678	0,679-0,713
Viscosity (kinetic) at 0 °C	mm^2/sec.	0,812-1,058	0,834-0,858

The phase transition curves of the Yurkharovskoye and Samburgskoye fields deethanized condensates based on the PVTsim software simulation results and are shown on the Figure 1 below.

[3] Scientific Design and Production Complex «TyumenNIIgiprogaz» is a subsidiary of OAO «Gazprom», established in 1966. A distinguishing feature — a complete cycle of scientific and design, as well as industrial softwaredevelopment of deposits from seismic to production and commissioning. http://www.tngg.ru/en/main

[4] Minutes of the meetings ## № 4978, 5262 «Deethanized gas condensates».

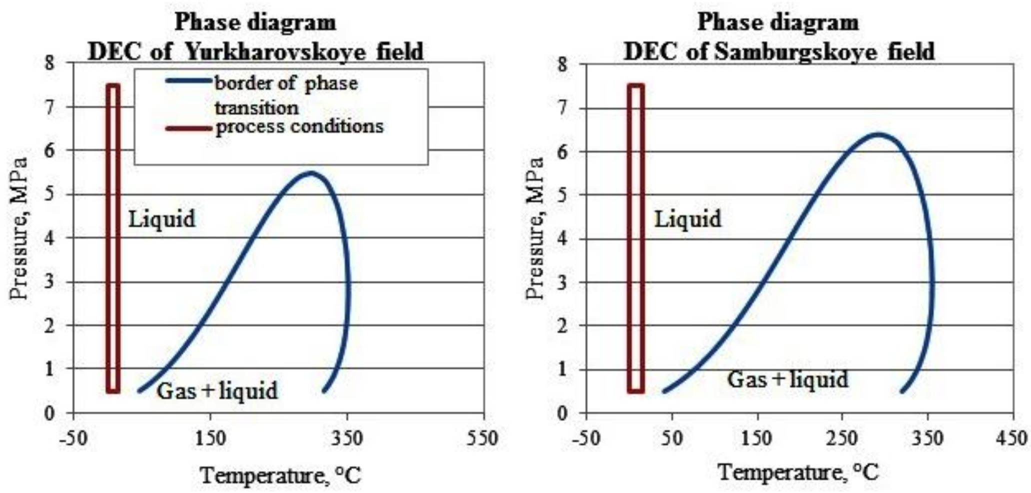

Figure Error! No text of specified style in document.**: The phase transition curves of the Yurkharovskoye and Samburgskoye fields deethanized condensates**

The phase transition curves above show the Yurkharovskoye and Samburgskoye fields deethanized condensate is liquid for all operating conditions (temperature = 0 – +15 °C, pressure P = 0,5 – 7,5 MPa).

The main physical and chemistry characteristics of the Yurkharovskoye and Samburgskoye fields deethanized condensate were simulated by the PVTsim software in order to make not above 1% deviation from experimental data and taking into account the close to operating conditions.

Experimental data and modeling results of the Yurkharovskoye and Samburgskoye fields fluid characteristics are compared in the table 2 below.

Table 1: The characteristics of the Yurkharovskoye and Samburgskoye fields deethanized condensates simulated by the PVTsim software with standard operating conditions.

Indicator		Experimental data		Fluid Model	
		Yurkharovo	Samburg	Yurkharovo	Samburg
Density at 20 °C	kg/m^3	673-677	713	686,59	714,2
Viscosity (kinetic) at 20 °C	mm^2/sec.	0,610-0,678	0,679-0,713	0,907	0,921
Viscosity (kinetic) at 0 °C	mm^2/sec.	0,812-1,058	0,834-0,858	0,909	0,856

MODELING OF THE COMPONENT-FRACTIONAL COMPOSITION AND MAIN CHARACTERISTICS OF THE URENGOY FIELD CONDENSATES

The fractional composition of the Achimov deposits condensates is significantly heavier in comparison with the Valanginian deposits condensates.

Table 3 below shows the deethanized gas condensate study results were taken as a base for the Urengoy field Achimov deposits fluid simulation.

Table 3: Component-fractional composition of the Urengoy field Achimov deposits deethanized condensates

Name of indicator	Unit of measure	Quantity
Weight percentage	$\%_{weight}$	
C_1		0,68
C_2		1,54
C_3		3,03
iC_4		1,88
nC_4		2,53
iC_5		2,02
nC_5		1,27
ΣC_6		87,05

Table 4: Average physicochemical characteristics of the Urengoy field Achimov deposits deethanized condensates

Name of indicator	Unit of measure	Quantity
Density at 20 °C	kg/m^3	719,8-796,7
Viscosity (kinetic) at 20 °C	mm^2/sec.	2,41
Viscosity (kinetic) at 0 °C	mm^2/sec.	5,79
Molecular weight (common unit)	c.u.	120-140
Turbidity temperature	°C	20-30
Freezing temperature	°C	-5 - +5
Paraffin content	$\%_{weight}$	3,0-5,2

Achimov deposits condensates contain the significant quantity of the heavy hydrocarbon fractions with the 350-500 ° C boil temperatures range and with normal paraffin hydrocarbons inside.

This is the reason why the solid condensate phase appears when the temperature is about 30 ° C and lower.

The quantity of solid paraffines increases according to the temperature decreasing; at the same time the branched paraffin crystals form the cohesive spatial structure which changing the rheological properties of the system significantly. [3]

It should be necessary noted that Achimov deposits condensate flows like usual Newtonian liquid at the standard temperature. But the condensate flow is changed during the temperature decrease process and when paraffin crystals accumulation inside the condensate. During the condensate pumping through the pipeline the system viscosity is not stable and becomes dependent on gradient of the shift speed, i.e. dependent on the pipeline productivity. [4] These effects increase significantly when decreasing of pumping temperature.

The simulation results show that the condensate has the Newtonian characteristics and its viscosity depends on temperature only when flowing at minus 5 ° C temperature.

When the temperature is lower than - 5 ° C the condensate loses its Newtonian characteristics and becomes the viscous-plastic system, which is the suspension of solid paraffines of the liquid hydrocarbon. Besides the viscosity of system becomes dependent on the system flow speed (pumping speed through the pipeline), i.e. the viscosity becomes the effective.

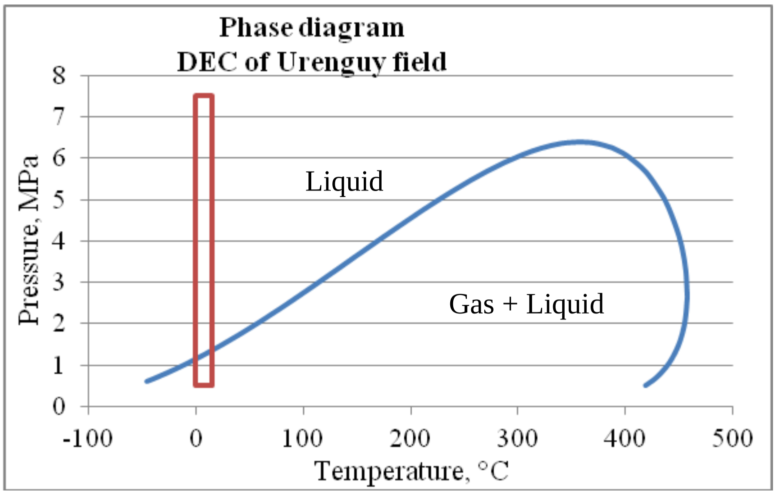

Figure Error! No text of specified style in document.**.1: The phase transition curve of the Urengoy field Achimov deposits deethanized condensates**

Table 5: The characteristics of the Urengoy field Achimov deposits deethanized condensates at standard terms simulated by the PVTsim software.

Indicators		Experimental data	Model
Density at 20 °C	kg/m^3	719,8-796,7	760,2
Viscosity (kinetic) at 20 °C	mm^2/sec.	2,41	4,21
Viscosity (kinetic) at 0 °C	mm^2/sec.	5,79	5,68

The fact that condensate effective viscosity depends on main liquid characteristics was determined according to the Achimov deposits deethanized condensate characteristics monitoring.

The DEC fluid models creation and updating taking into account supply from the Yurkharovskoye, Samburgskoye and Urengoy fields could let to set-up and update the hydraulic model of the Yurkharovskoye field - Purovsky Plant condensate pipeline and also to consider the following questions:

- Identify the opportunity of increasing Yurkharovskoye field - Purovsky Plant condensate pipeline capacity by means of the pipeline looping construction and using the anti-turbulent additives under conditions of the DEC volume increasing planned by 2017.
- Risk analysis of the condensate pipeline looping commissioning taking into account different volume ratios of the condensate supplied from different fields.
- Process analysis of the Yurkharovskoye field - Purovsky Plant condensate pipeline.
- Risk analysis of the big volume pumping of the Urengoy field Achimov deposits DEC with increased paraffins inside.
- The study of process regimes of the Yurkharovskoye field - Purovsky Plant condensate pipeline and finding the optimal ATA concentration taking into account pumped feedstock and pipeline looping distance.

DIGITAL MODEL CREATION OF THE YURKHAROVSKOYE FIELD - PUROVSKY PLANT CONDENSATE PIPELINE

The hydraulic calculations of the condensate pipeline work using ATA performed by Giprotyumenneftegaz R&D engineering company[5] were checked. During the checking there was planned a comparison with the similar calculations exercised by authors by the OLGA software.

According to the soil engineering survey of the condensate pipeline area the soil temperature is minus 0,1 ° C in summer and it is minus 5,1 ° C in winter at 1.5-2m depth for both cases.

The deethanized condensate of the Yurkharovskoye field is to be supplied to the design condensate pipeline at temperature plus 4 °C. By the reason of the soil heat exchange the product temperature is to decrease to - 5 °C in the cold period (October - June) and to + 2,3 °C in summer period (July - September) - according to the thermotechnical calculations did by the Giprotyumenneftegaz R&D engineering company. Yearly average condensate temperature is lower than 0 °C and is close to zero for all sections of pipeline.

According to the project documentation of the condensate pipeline construction there were used seamless steel pipes (13CrVN) protected from corrosion effect using the three-ply cover with thickness not less 2.5mm.

The depth of subterranean stringing is about 2m. The heat insulation of the subterranean part of pipeline is absent. Above-ground parts of the condensate pipeline, connect pieces and valve are heat seal by the mineral cotton mates with 60mm thickness.

[5] Giprotyumenneftegaz R&D is one of the leading R&D engineering companies in Russia and CIS. They provide integrated field development for the oil & gas companies. Giprotyumenneftegaz has been a part of the HMS Group since 2010. http://www.gtng.ru/en/about/common-info/

During the OLGA software work there was created the operation process model of the Yurkharovskoye field - Purovsky Plant condensate pipeline.

Technical characteristics of the pipe wall used by the OLGA software are following:

- steel heat-absorption capacity is 480 J/(kg·°C), thermal conductance is 50 W/(m·° C), density is 7850 kg/m3.
Operating condensate pipeline regime (flow, pressure and temperature at inlet / outlet / at valve locations) was given according to the clients data. The condensate pipeline layout is below (Figures 1, 2).

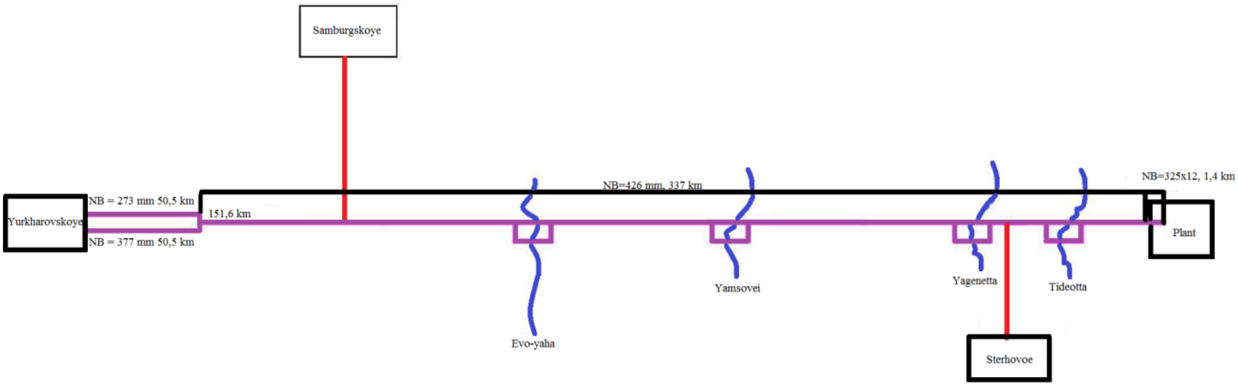

Figure 1 – Principal layout of the Yurkharovskoye field - Purovsky Plant condensate pipeline

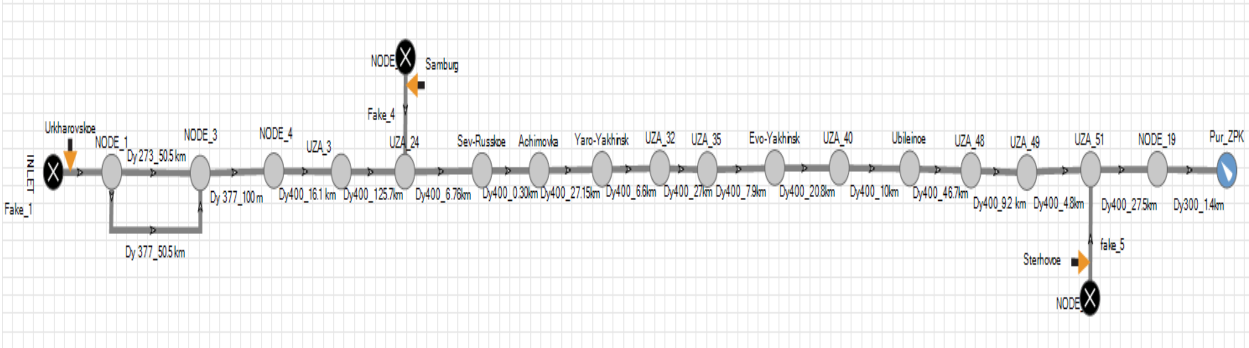

Figure 2: Process model of the Yurkharovskoye field - Purovsky Plant condensate pipeline by the OLGA software

UPDATE MODEL AND OPERATION REGIME ANALYSIS OF YURKHAROVSKOYE FIELD - PUROVSKY PLANT CONDENSATE PIPELINE

The digital model updating was performed in accordance with the condensate pipeline operation characteristics.

In the model were assumed: the soil temperature around 0 ° C at the 2 meters depth.

Due to the fact the fluid is a single-phase inside the condensate pipeline when any operating conditions and the regime of feedstock flow is steady, there is no need to do the long dynamic calculations by OLGA software. The steady-state condensate pipeline operation regime was calculated by the OLGA software using the STEADY STATE option.

Because of the supplied condensate is prepared and treated the roughness of the condensate pipeline while its operating is not to be significant different from the new pipe roughness. Therefore, authors of the article have made an assumption that the roughness of the pipe is equal to 0.05 mm throughout the distance.

For this simulation was chosen the following condensate pipeline stationary regime.

While operating in this regime at the Yurkharovskoye field outlet there was determined the average flow at the average outlet pressure. At the same time, the average flow was determined at the Purovsky Plant intlet.

Calculation results are presented in the Table 6.

Table 6: Calculation results of the Yurkharovskoye Field - Purovsky Plant condensate pipeline hydrodynamic model by the OLGA software

Name of indicators	Fact	Model	Relation deviation, %
Pressure at the Yurkharovskoye field outlet, kgf/cm2	63,41	65,6	3,5
Pressure at the Samburgskoe field outlet (valve unit-24), kgf/cm2	41,34	40,98	1,0
Pressure at the valve unit-48, kgf/cm2	16,81	15,25	9,0
Pressure drop at the Yurkharovskoye field - Purovsky Plant condensate pipeline, kgf/cm2	56,08	58,27	3,9
Flow temperature at the Yurkharovskoye field outlet, °C	7,14		
Flow temperature at the Purovsky Plant intlet, °C	0,81		
Flow speed at the Yurkharovskoye field outlet, m/s: - pipeline area NB = 273 mm 50,5 km - pipeline area NB = 377 mm 50,5 km	 0,7 0,88		
Flow speed at the Purovsky Plant intlet, m/s: - pipeline area NB = 404 mm 27,5 km (after the Strekhovo field tie-in) - pipeline area NB = 301 mm 1,4 km	 1,19 2,14		
Flow-moving regime in the pipeline	laminated		

The initial assumption concerning the condensate pipeline roughness has been justified according to the calculation results above.

Without using any additional set-up modifications the model has a quite similar results in comparison with experimental data (the condensate pipeline pressure drop is less than 2 kgf/cm2 or 4%).

The maximum difference between modeled and experiment pressure is 1.5 kgf/cm2 (9%) and may be explained by the following wide range of uncertainties:

- The volatility of the steady-state condensate pipeline operation regime (inlet operation regime changes are apparent at the outlet only in long time period (several tens of hours) because of the flow speed of 390 km long condensate pipeline is not more than 2 m/sec);
- Difference between the fluid model set-up date based on laboratory study and the latest model updating date;
- Inaccuracy measure of the OLGA software calculation model.

The main conclusion of this study is that the condensate pipeline digital model has the similar results in comparison with experimental data.

Due to the created digital hydraulic model of the Yurkharovskoye field - Purovsky Plant condensate pipeline there were solved the followings tasks:

1. Identify the opportunity of the increasing Yurkharovskoye field - Purovsky Plant condensate pipeline capacity by means of the pipeline looping construction and using the anti-turbulent additives under conditions of the DEC volume increasing planned by 2017.
2. Risk analysis of the condensate pipeline looping commissioning taking into account different volume ratios of the condensate supplied from different fields.
3. Risk analysis of the big volume pumping of the Urengoy field Achimov deposits DEC with increased paraffins inside.

Implementation of this project is economically efficient.

ISSN: 0975-8585

Dynamic modeling implementation results of the process transport decisions of the Yurkharovskoye field - Purovsky Plant condensate pipeline were successfully presented on the Fourth All-Russia Research-to-Practice Conference for young academics and specialists "Providing of the effective process in gas industry ", where authors won and were ranked the 1st place.

REFERENCES

[1] Federal Law No.116 "On industrial safety of hazardous production facilities"
[2] OLGA Dynamic Multiphase Flow Simulator [IT source]. – Access regime is here: http://www.software.slb.com
[3] A.N. Markin, R.E. Nizamov, S.V. Sukhoverov. Oil feed chemistry. Implementation Guidance. Vladivostok, Dal'nauka, 2011, 294 p.
[4] G.I. Fuks. Viscosity and oil ductility characteristics. Moscow, 2003, 331 p.