KAZAN NATIONAL RESEARCH TECHNICAL UNIVERSITY named after A.N.TUPOLEV-KAI

RESEARCH ACTIVITY OF DEPARTMENT OF HEAT AND POWER ENGINEERING

Kazan, Russia

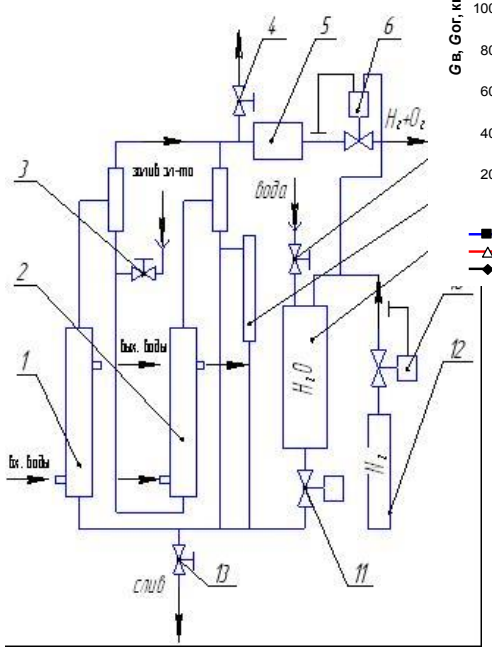
Main Scientific Interests:

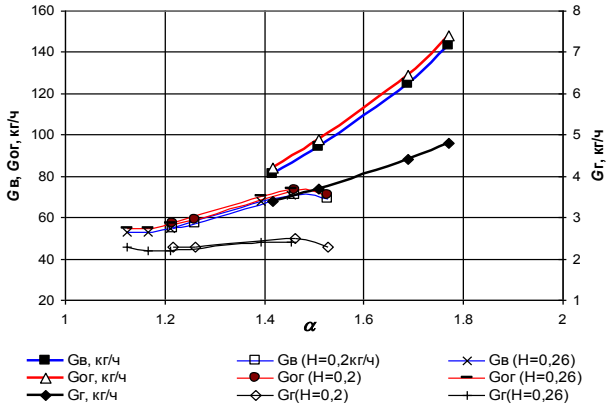
Energy Saving and Resource Effectiveness
• Heat Power Engineering Systems and Plants
• Optimization of Energy Supplies
• Effective Heat Exchange Equipment
• Refrigerators
• Alternative and Renewable Energy Resources
• Business-Education programs of Energy Management
•Research of hydrodynamic processes in journal bearings of rotors

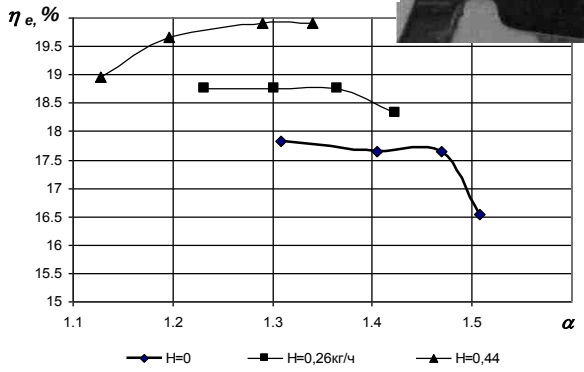
Experimental and Numerical Studies of Adiabatic Two-Phase Flow in Nozzles
• Technique of Diagnostics of Local Parameters Multi-Phase Flow
• Energy Equipment with Low-Boiling Fluids
• Hydrogen Energetics
• Condensed gas
• Energy Saving
•Optimization and calculation methods of processes in rotor systems using flow vision and fluent software
• Mathematical models, methods and software for analysis of transverse vibrations of rotor systems of modern turbomachines

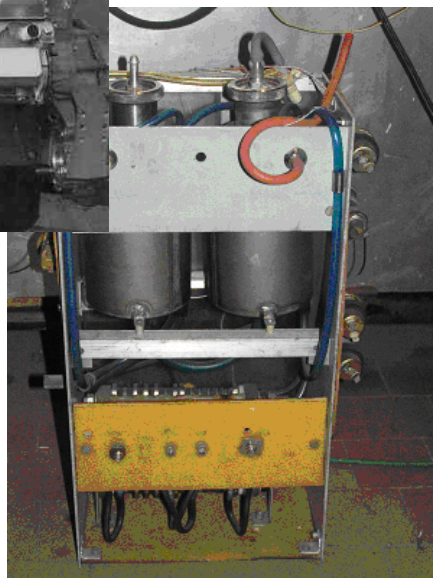
Project: Influence of Hydrogen Additives in Gas and Diesel Fuels on characteristics of KamAZ engines

Aim - to achieve new world standard based on the previous research efforts and development activities. The project is aimed on achievement of new world standard data and methods of significant improvement in energy efficiency and ecological characteristics of gasoline and diesel engines of KamAZ trucks.



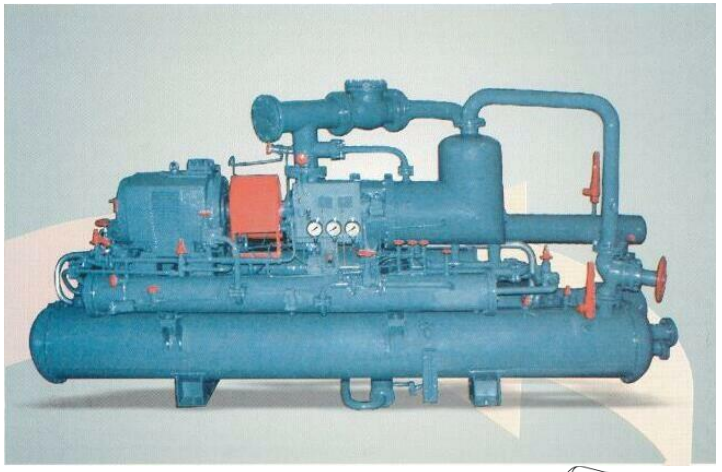


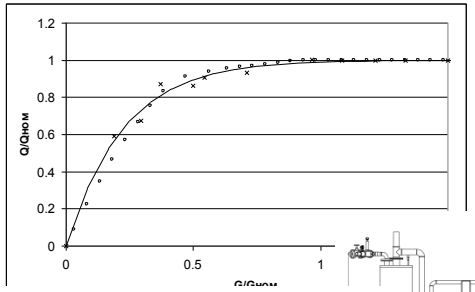


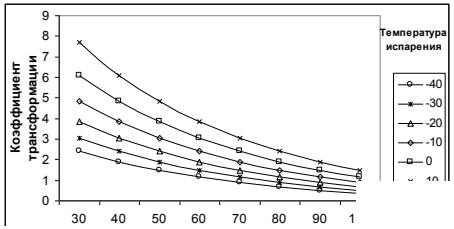


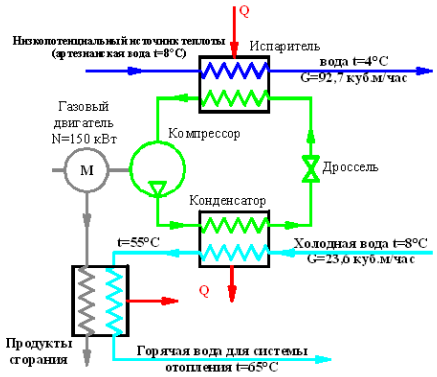
Project: Development of Trigeneration Power Plant Based on Vapour Compression Heat Pump System with Gas Piston Drive for Energy Supply of Manufacturing Enterprises with the Overall Heat Power of 0.7 MW

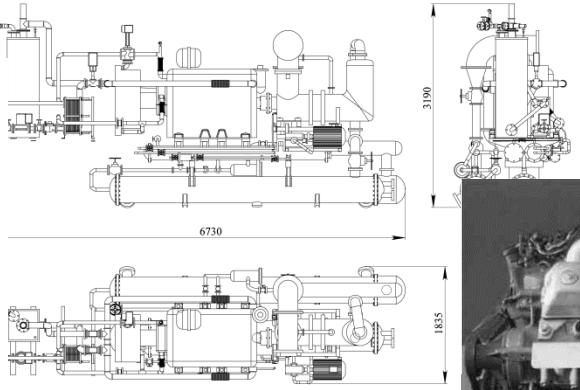
Aim - the development of high-performance and competitive trigeneration power plant designed for heat, electricity and refrigeration supply of manufacturing enterprises and optimization of its technical and economic characteristics.

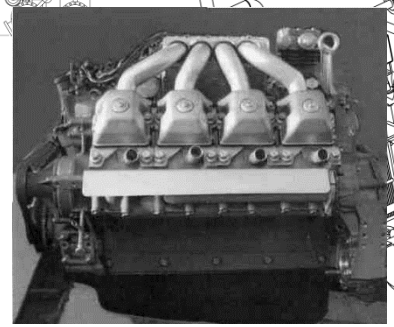


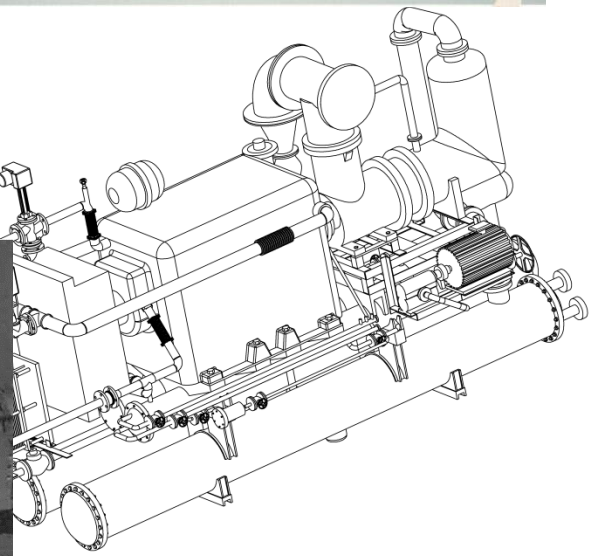




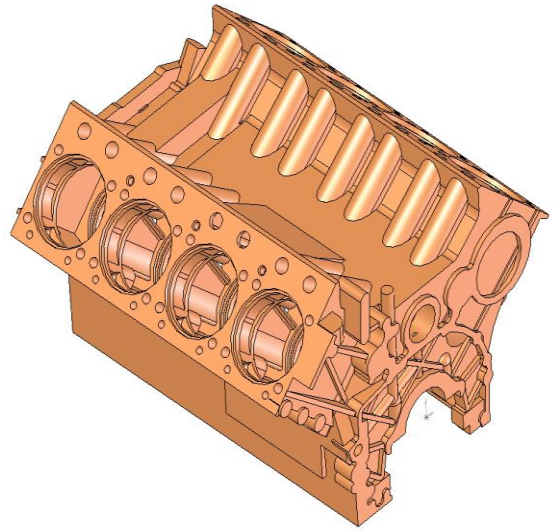


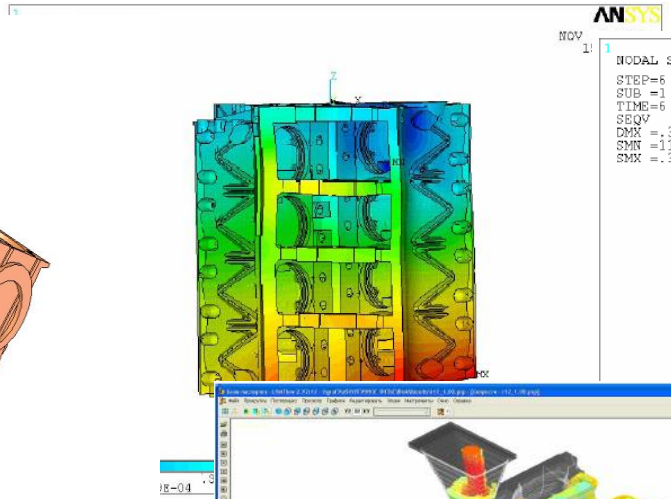


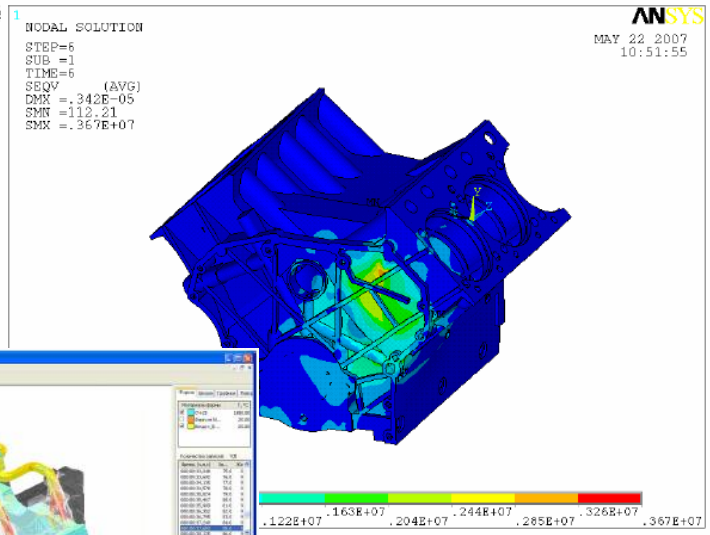


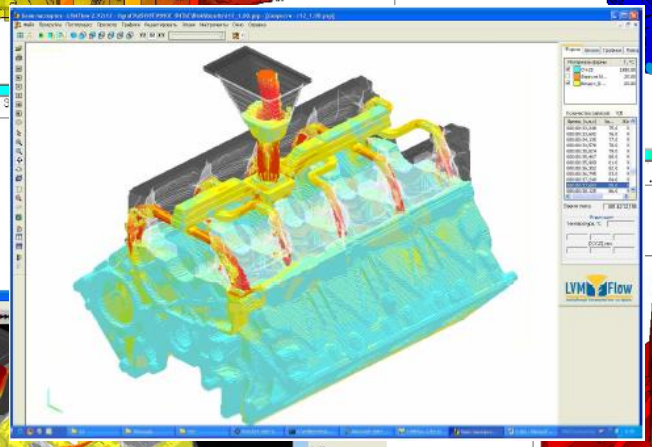


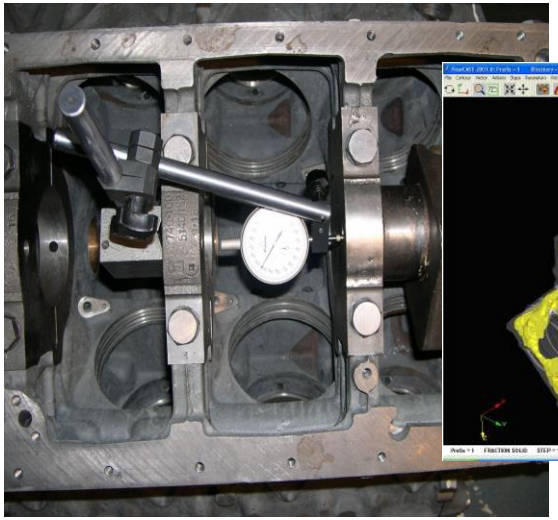
Project: Optimization of Mass and Strength Characteristics of ICE "KamAZ" Using Modern Computer Software

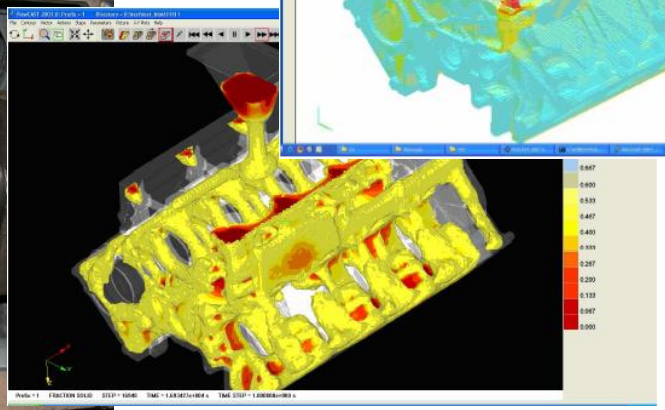


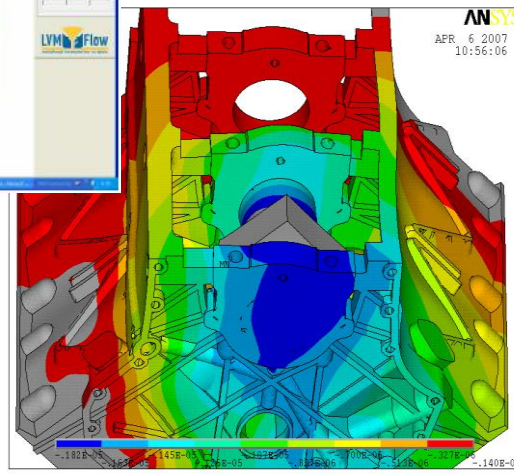




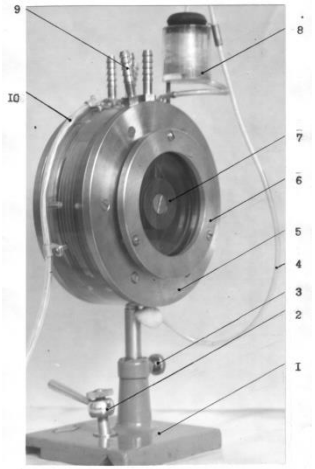


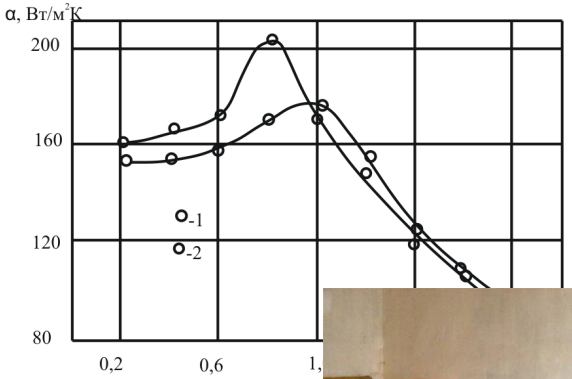


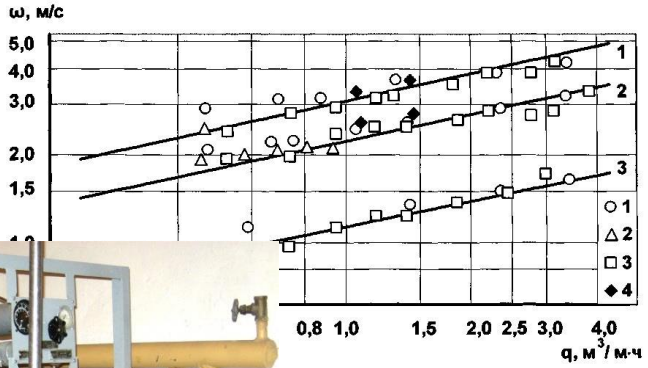


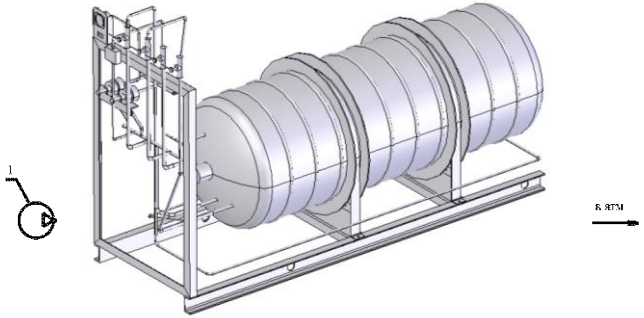


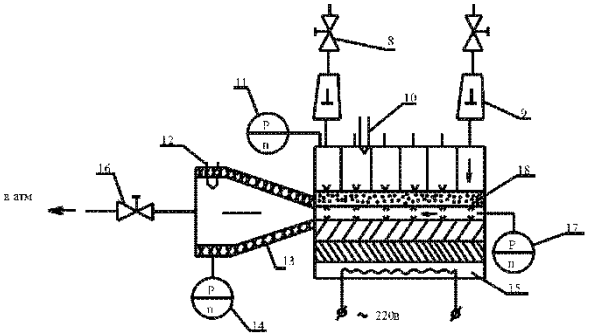
Project: Storage and transportation of Low-Boiling Fluids and Natural Gas.

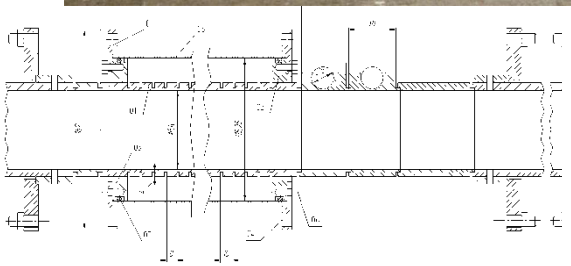


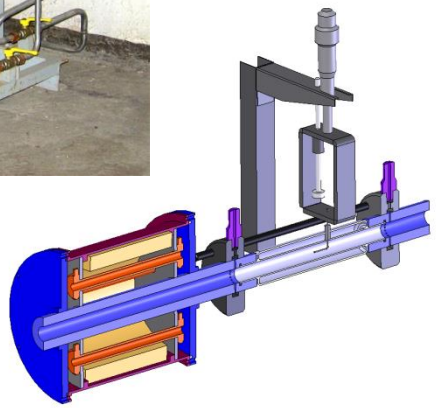




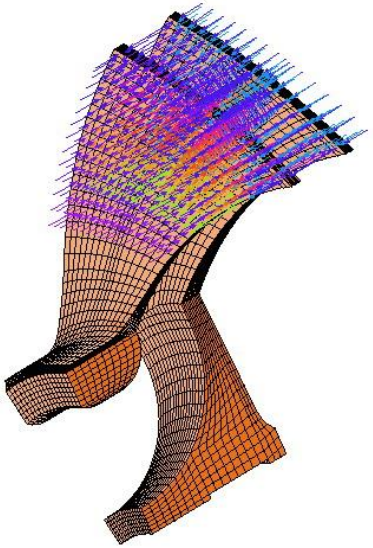




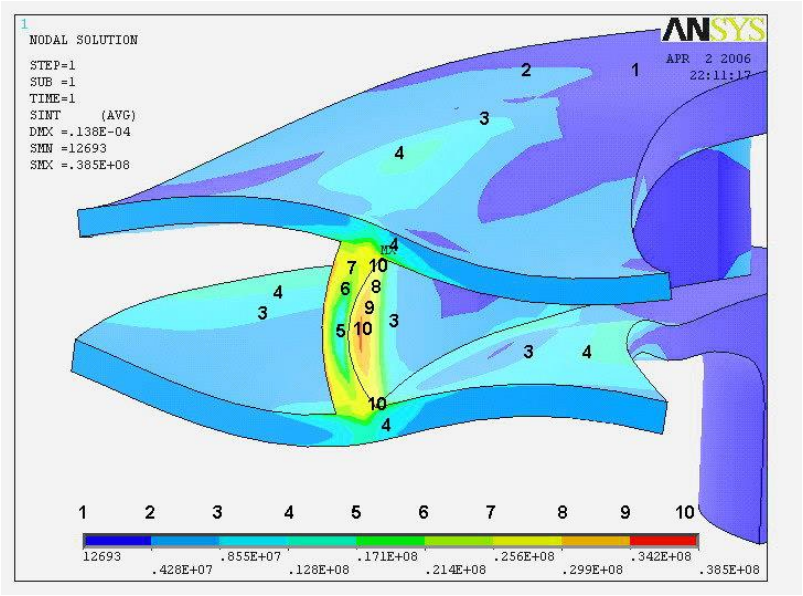


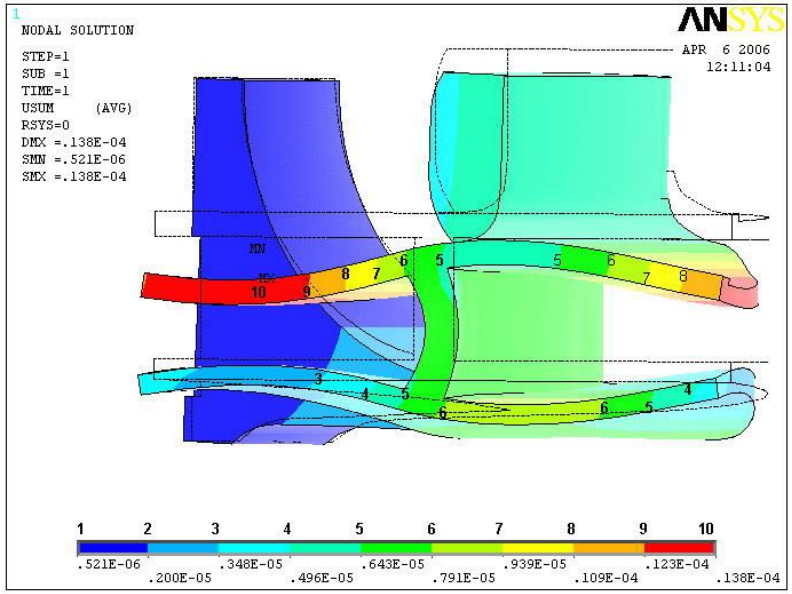


Dynamic strength of radial compressor‘ impellor

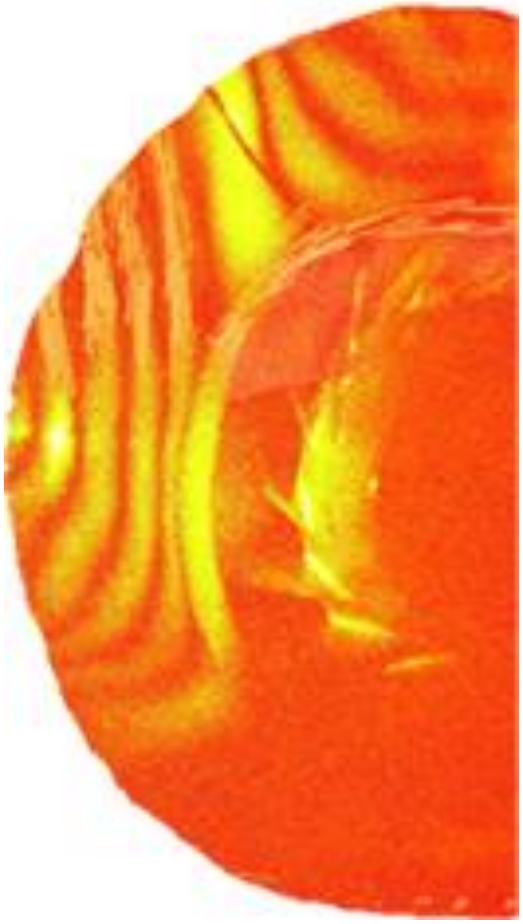


Isolines of strain intensity and deformation in closed-type impeller depending on aerodynamic loadings

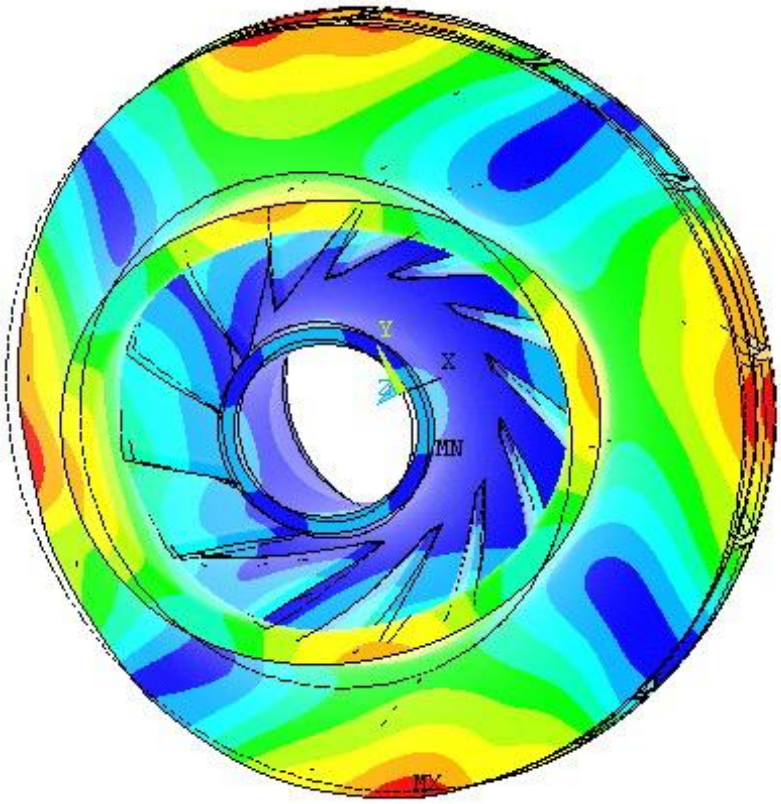




Frequency analysis of vibrations in radial compressor' impeller



Holographic interferometry
f=1856 Hz

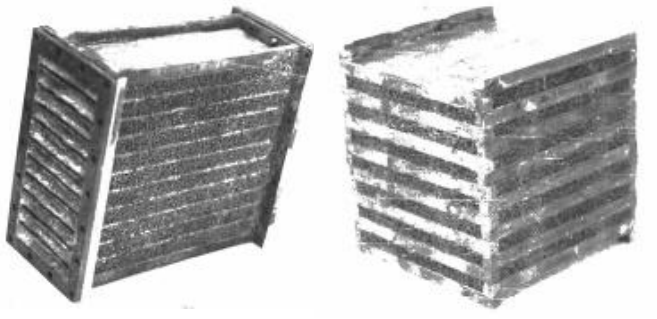


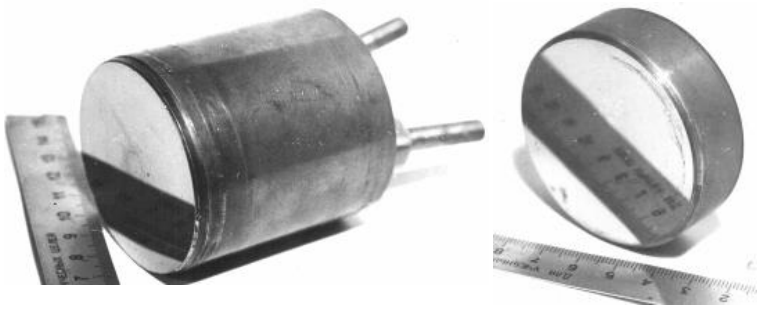
ANSYS analysis
f_p=1842 Hz

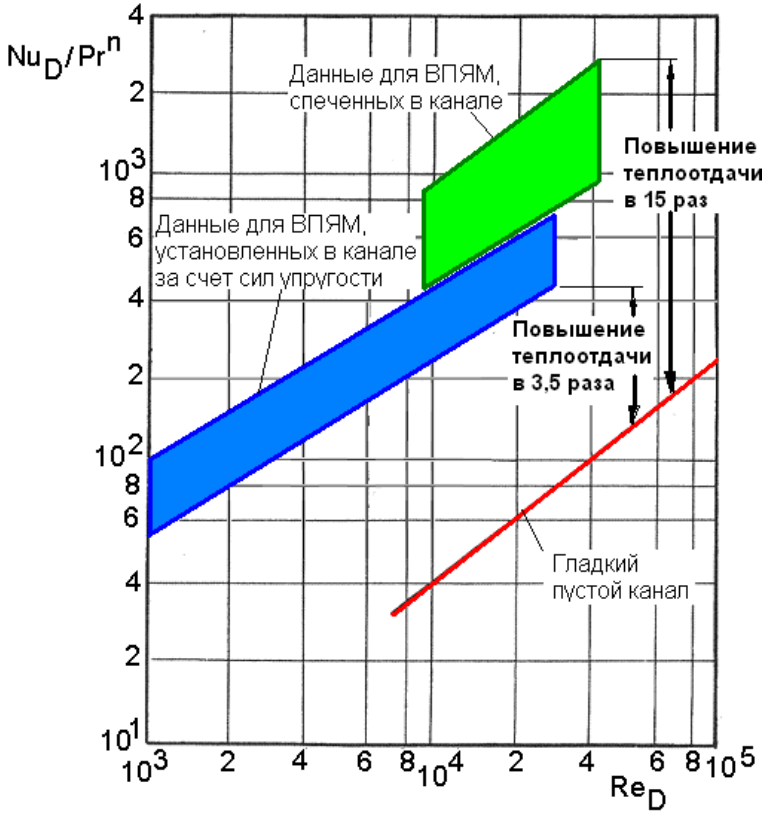
Scientific Interests:

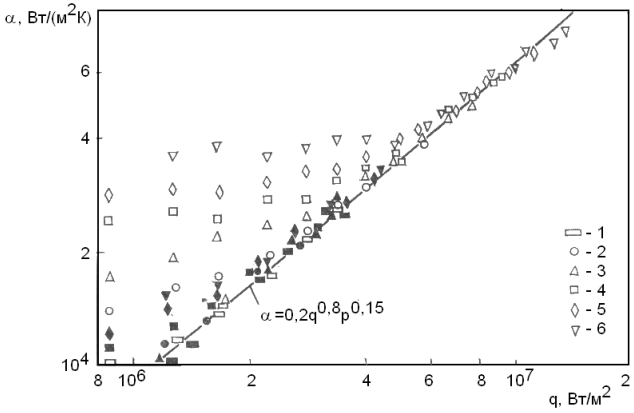
- Experimental Studies of Heat Transfer Enhancement (Surface Intensifiers at Forced and Natural Convection, Porous Media)
- Development and Studies of Enhanced Heat Exchangers and Heat Exchange Equipment
- Energy Saving in Industry
- Energy Saving in Municipal Power Engineering

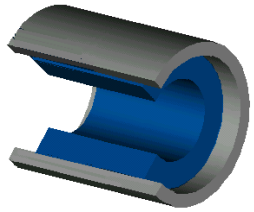
POROUS INSERTS IN HEAT EXCHANGERS

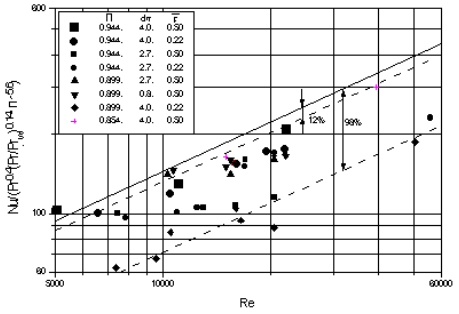


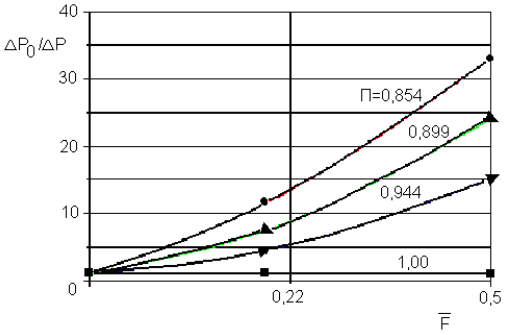




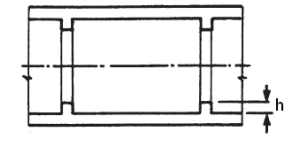




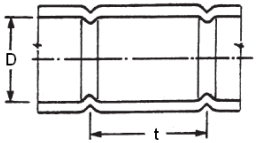




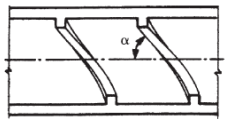
TUBES WITH DISCRETE ROUGHNESS



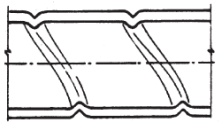
Поперечные кольцевые выступы



Поперечная накатка



Спиральные выступы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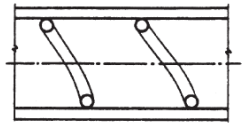
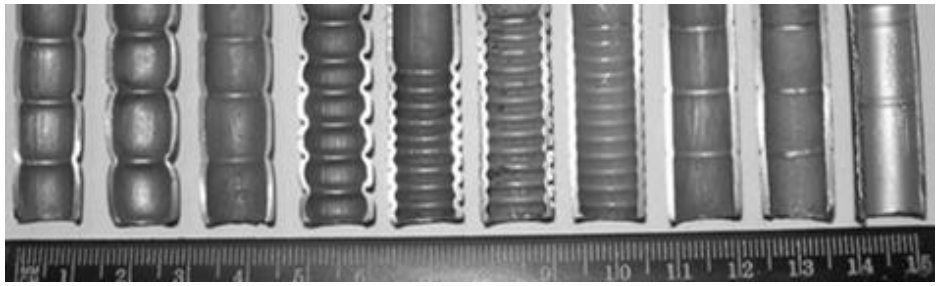
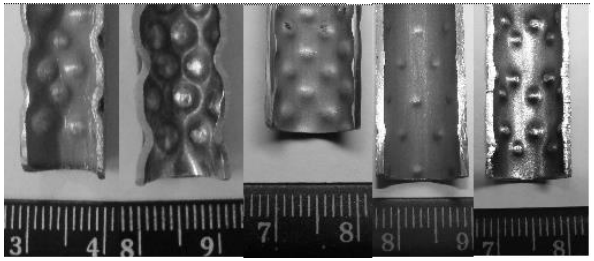
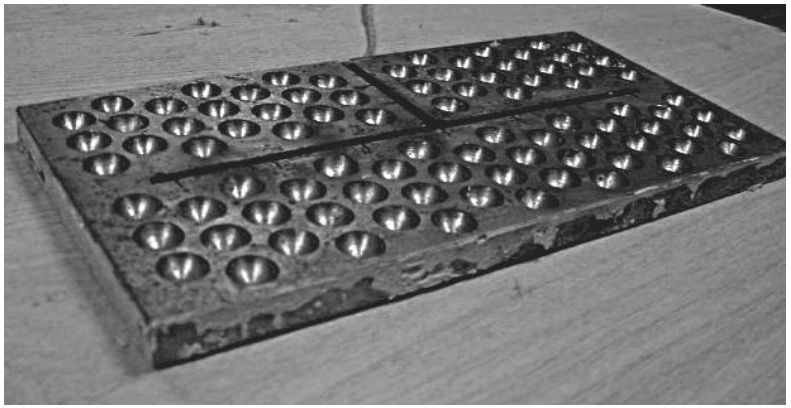
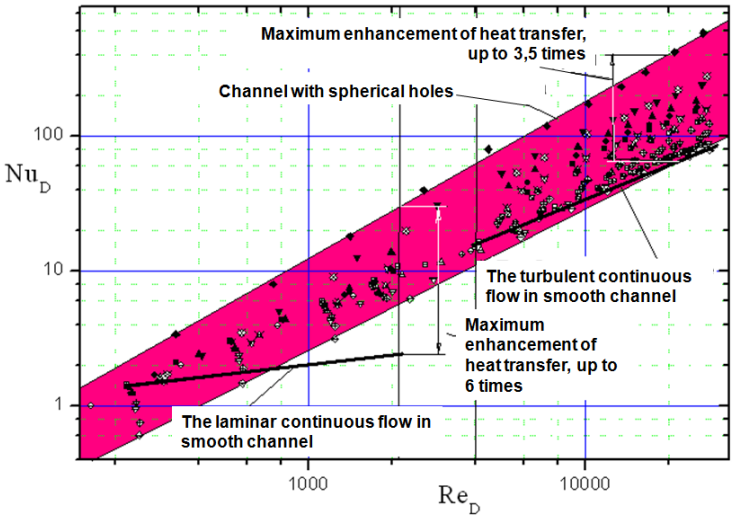

Спиральные проволочные вставки





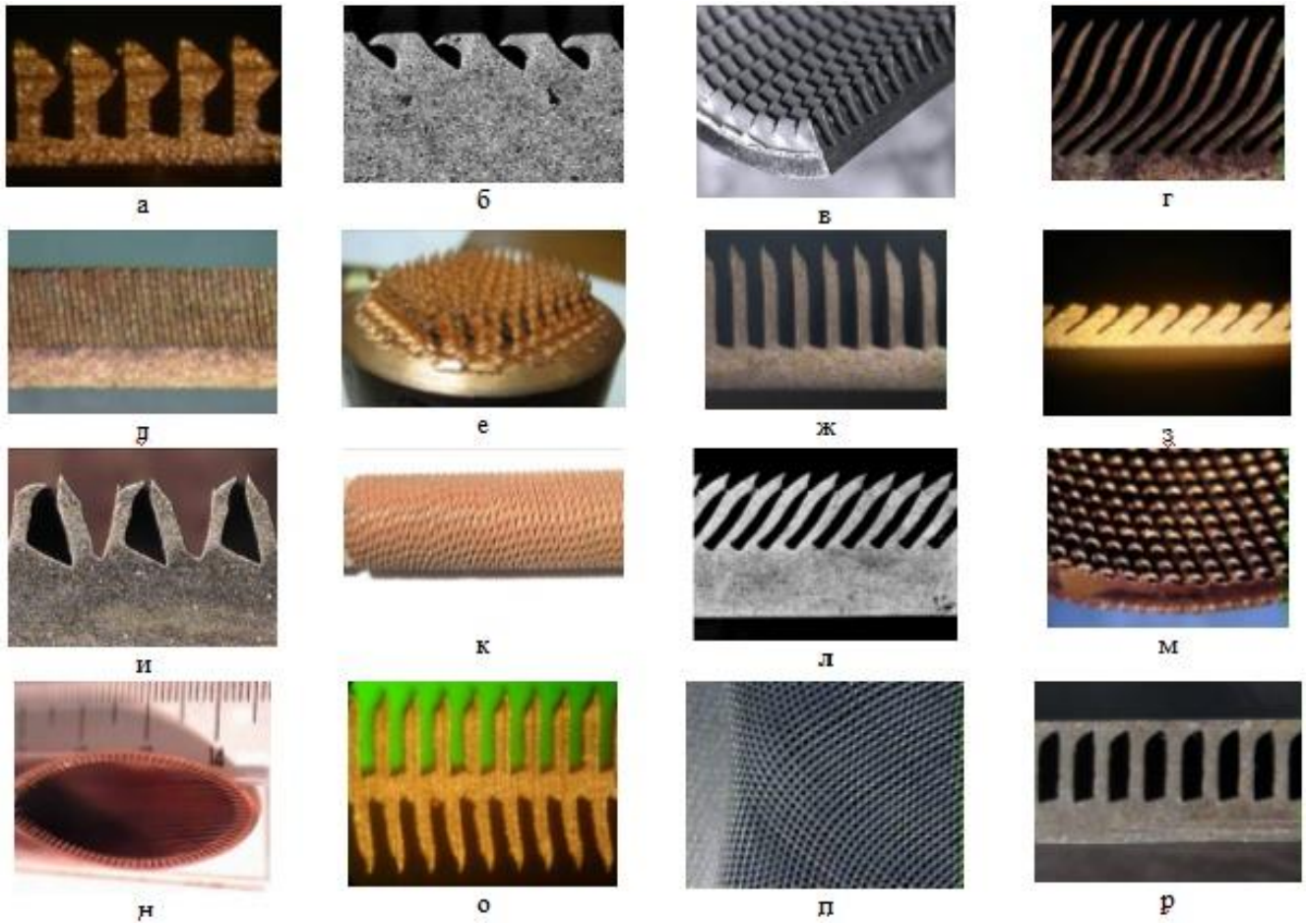
HEAT TRANSFER IN CHANNELS WITH DIMPLES





POOL BOILING HEAT TRANSFER ENHANCEMENT AND INCREASING OF CRITICAL HEAT FLUX

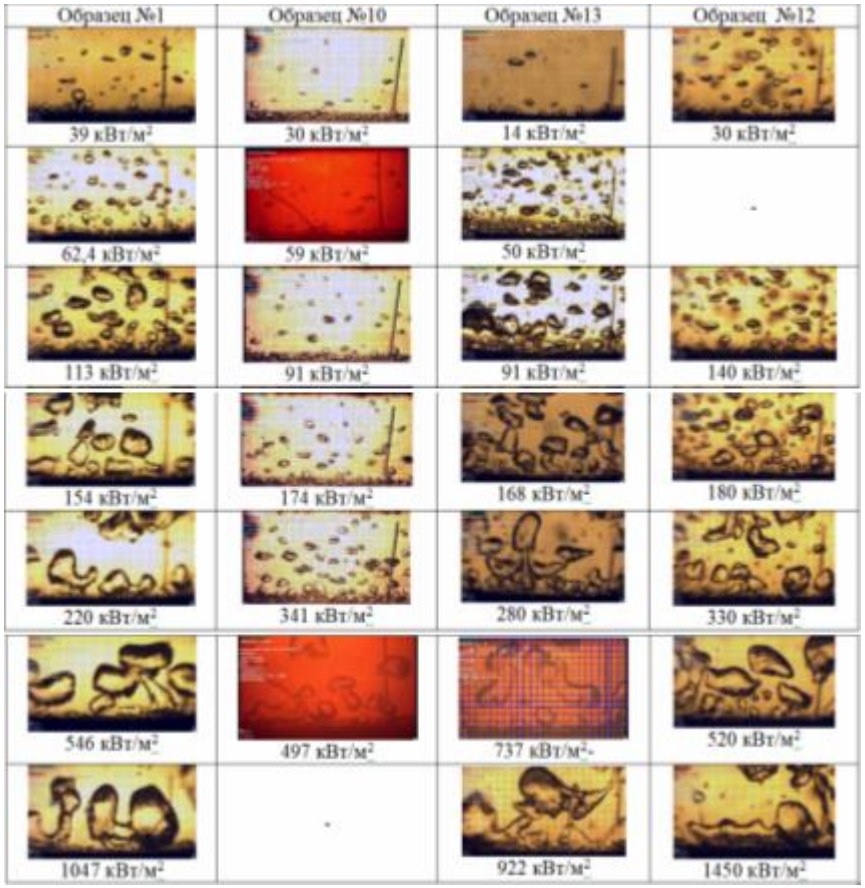
Treated surface for pool boiling (5-200 μm)



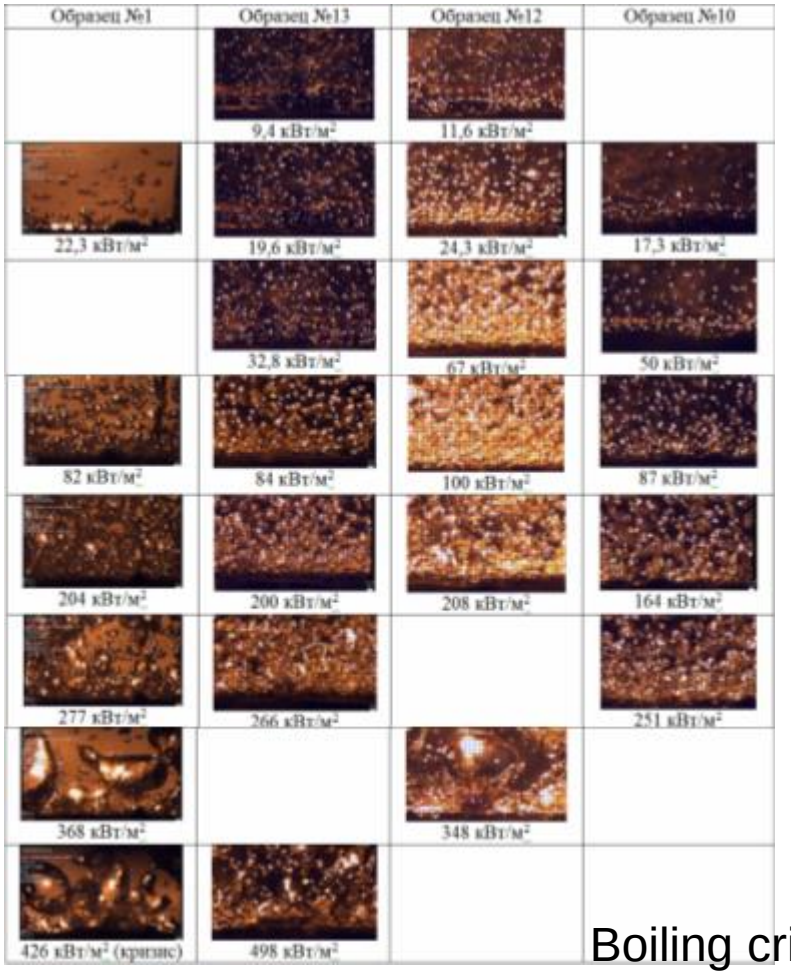
European Patent EP1692447. Method and tool for making enhanced heat transfer surfaces / Thors P., Zoubkov N.// European Patent Bulletin №34, 2006– 46 p.

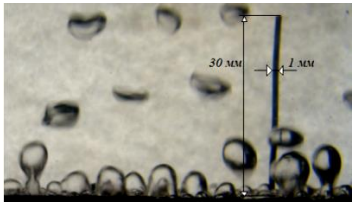
Visualisation of pool boiling, analys vapour bubble diameters, their velocity, separation and development of boiling curves

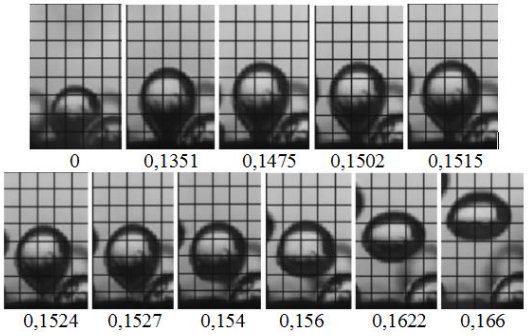
Water



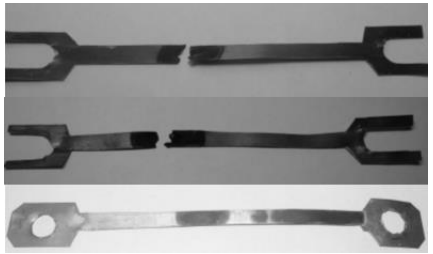
Ethanol







Boiling crisys



Scientific Interest:

• Heat and mass transfer and hydrodynamics of swirled one- and two-phase flows in various channels with smooth and rough surfaces

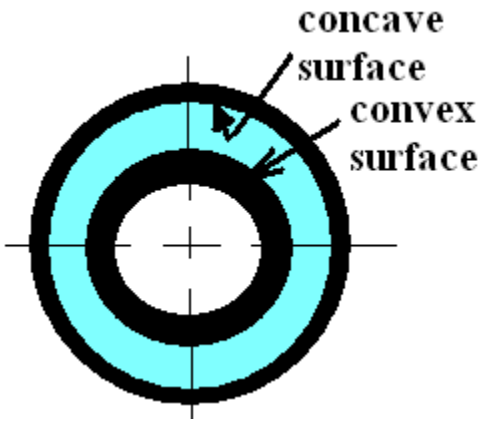
• Heat transfer enhancement

Methods of heat and mass transfer enhancement under study

- **Using rough surfaces**
  - **Discrete roughness**
    - **2D**
    - **3D**
  - **Continuous roughness (thread)**
- **Swirling or twisting of flow**
  - **Tubes with twisted tape inserts**
  - **Annular channels with flow twisting**
  - **Roughness + Flow twisting**
  - **Coil tubes**

EXPERIMENTAL AND NUMERICAL INVESTIGATION OF HEAT TRANSFER IN ANNULAR CHANNELS WITH FLOW TWISTING

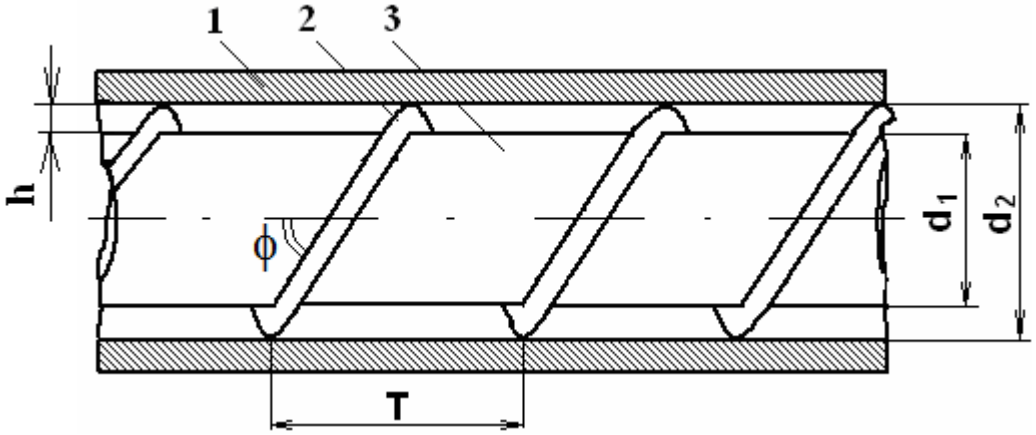
Cross-sections of annular channel:



Presence of annular channels:

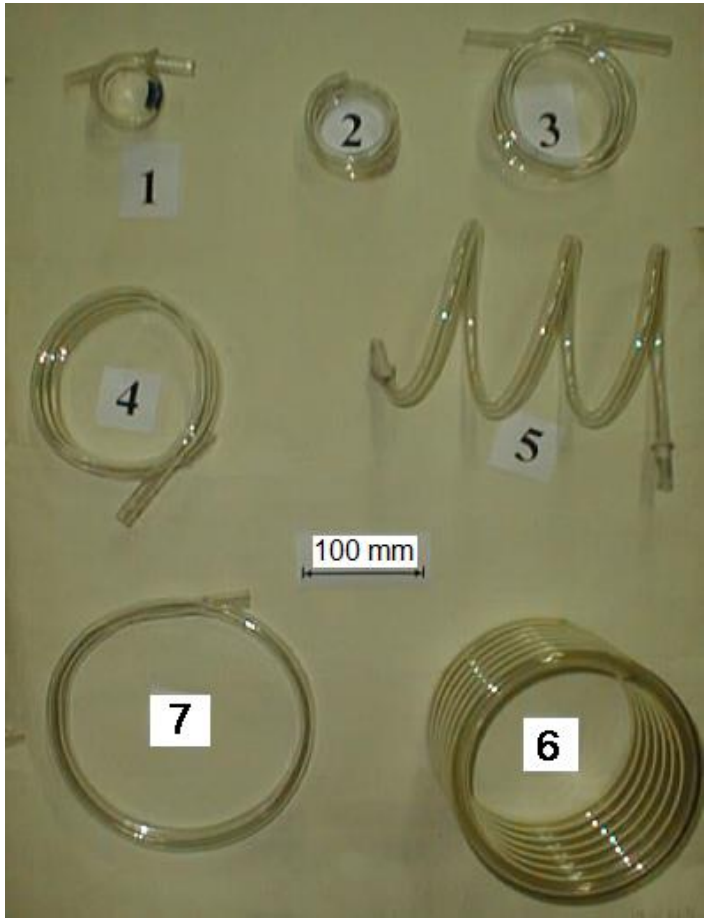
- nuclear reactors with coaxial fuel elements;
- cooling jackets of engines, nozzles and other power devices,
- heat pipes,
- Field-tube boilers (bayonet tubes);
- heat-exchangers ”tube-into-tube”,
- others.

Longitudinal section of an annular channel with a twisting

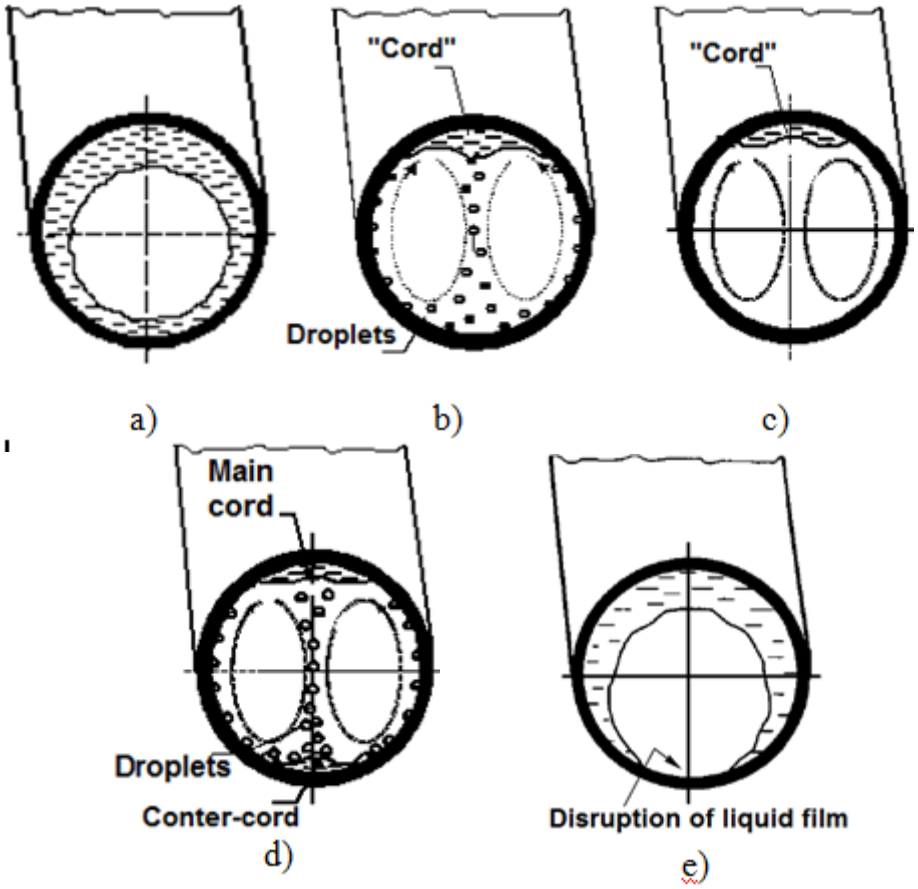


1, 3 – heat-generating elements,
2 – wire winding

Experimental transparent coil tubes



The pictures of gas-liquid flow regimes in cross section of helical coil:



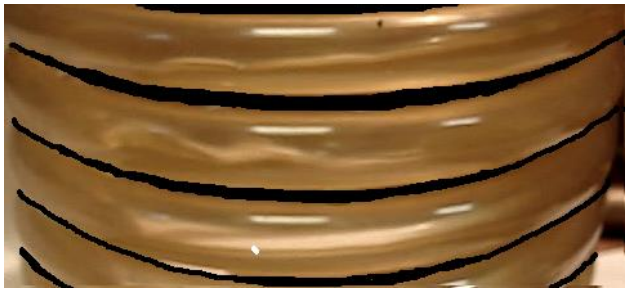
a) annular regime; b) disperse regime; c) cord regime; d) dual-cord regime; e) disruption of annular liquid film

VISUALISATION OF STRUCTURE OF TWO-PHASE SWIRL FLOW IN VARIOUS CHANNELS

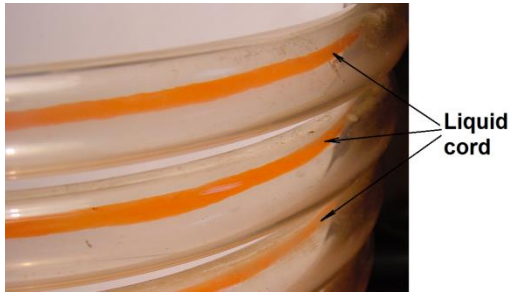
Slug flow in coil tube

Disperse regime in coil tube (the direction of sight is in parallel to an axis of channel coiling; the liquid is coloured)

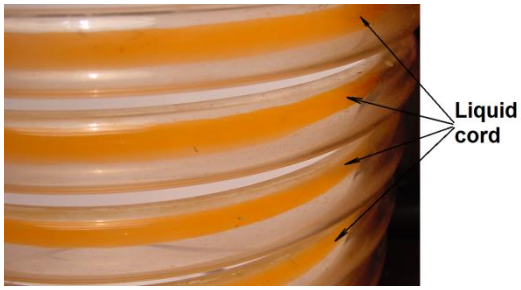
Wave flow in coil tube



Cord flow

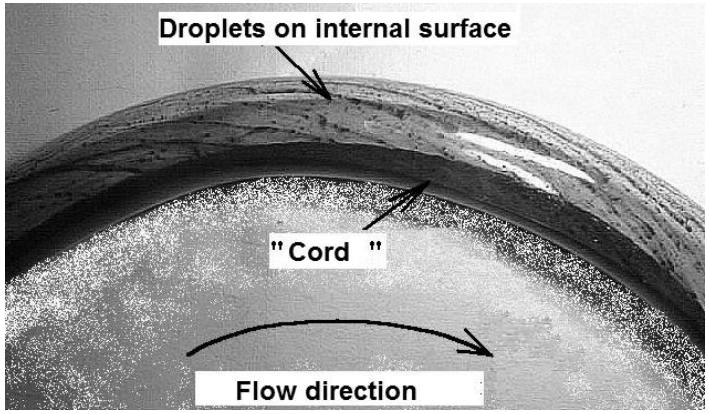


a) X=0.98



b) X=0.96

(the liquid is coloured)



STRUCTURAL FEATURES OF TWO-PHASE FLOWS IN TUBES WITH TWISTED TAPES INSERTS

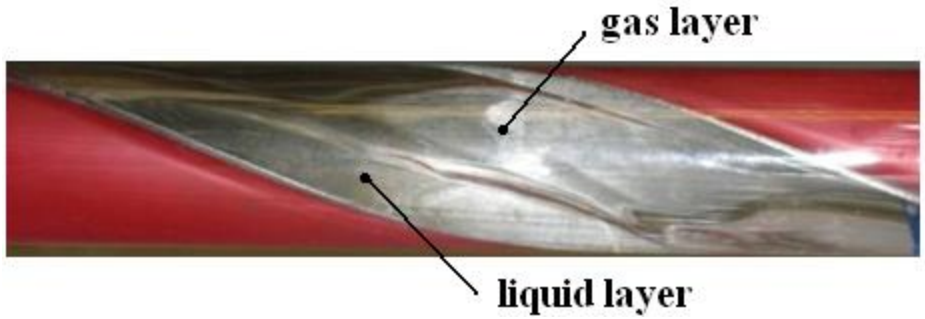
The photo of a transparent plastic tube with inserted twisted tape
(the one half of channel is blocked)

The inner tube diameter d=10 mm, the length L=800 mm, the relative step of twisting s/d=2.5-6

At visual research of an air-water flow structure in tubes with the inserted twisted tape the slug, wave, annular, disperse and cord regimes have been revealed as in helical coils (P=0.1-0.15 MPa)

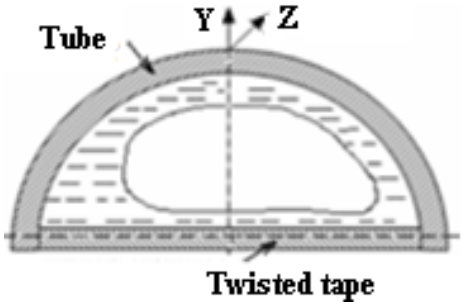
The photo of slug regime

The photo of stratified wavy regime



← flow direction

The pattern of annular regime in cross section of a channel



The pattern of uncomlete annular regime in cross section of a channel

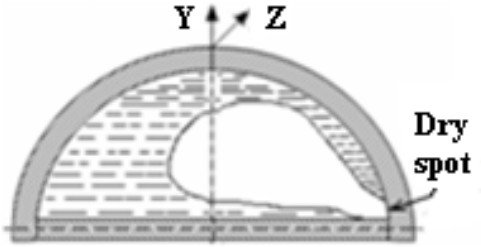
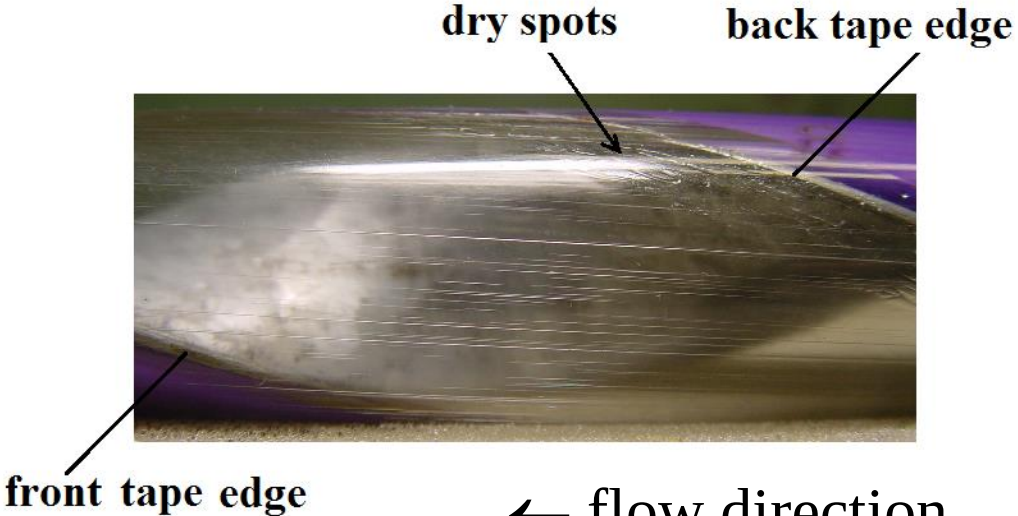


Photo of dry spots at disruption of annular film (side view)



The pattern of disperse regime

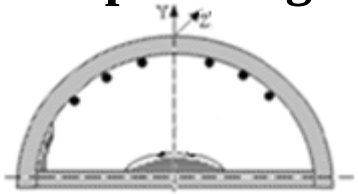
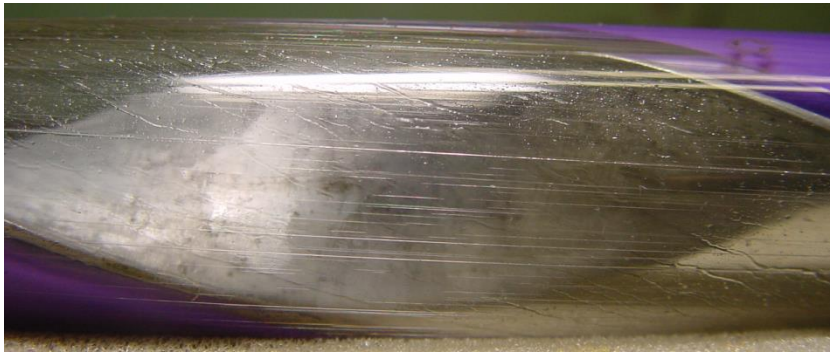
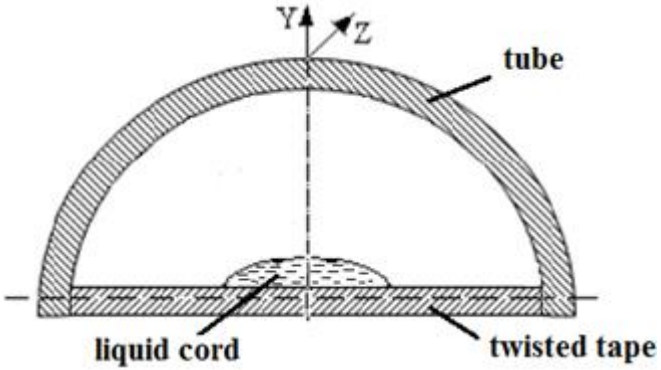


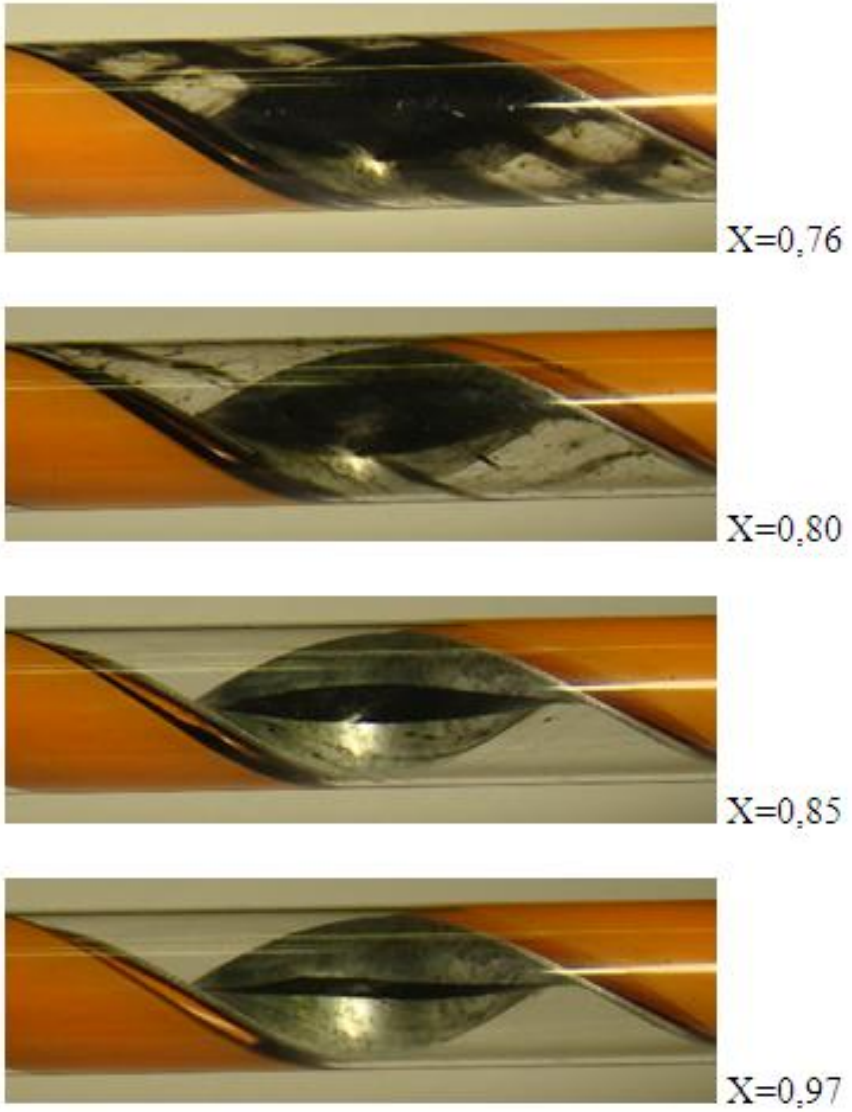
Photo of disperse regime



Two-phase flow pattern of cord regime in cross-section of a tube with twisted tape insert



Evolution of cord flow at change of relative mass gas content X (the liquid is dark coloured)

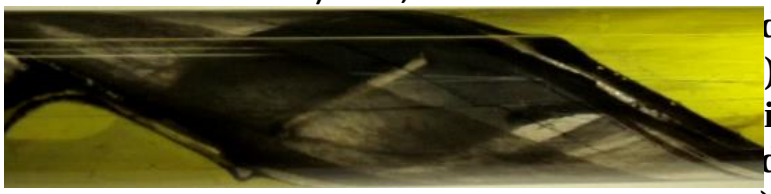


← flow direction

TWISTED TAPE WITH RIBS

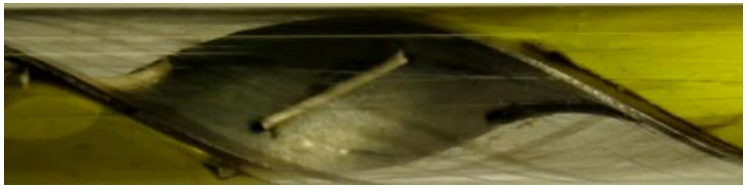
For a heat and mass transfer enhancement in tubes with inserted twisted tape at one- and two-phase flows and, in particular, for prevention of cord flow on the tape the ribs can be installed on a tape surface at an angle to it axis.

a) *X*=0,87



b) *X*=0,91

c) *X*=0,94

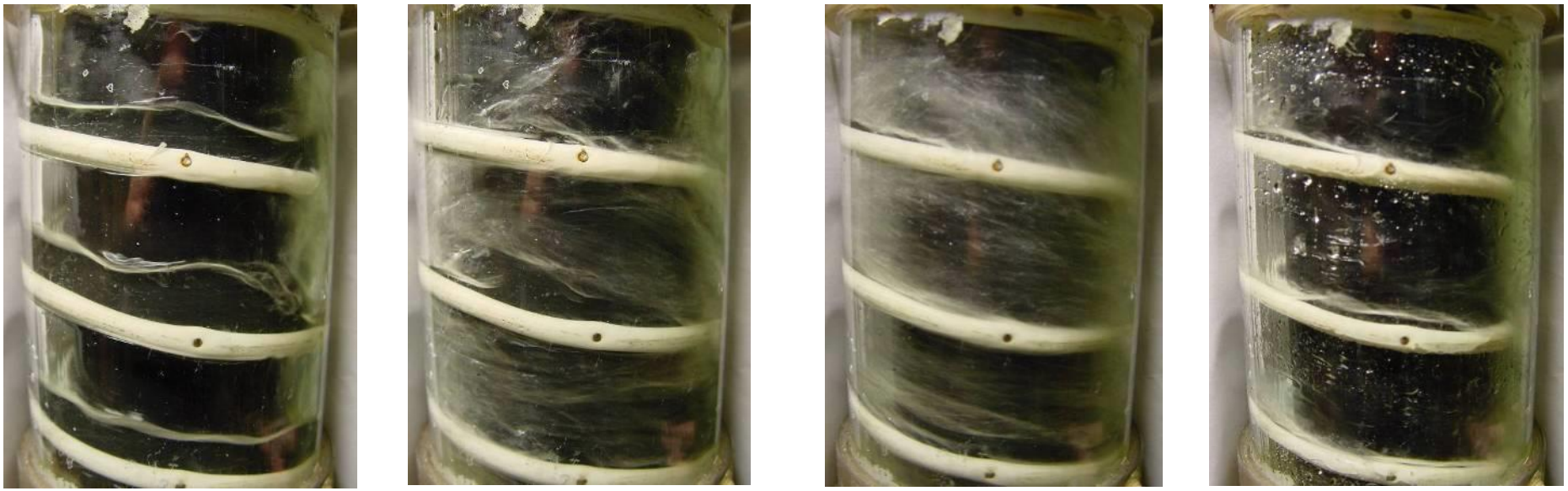


a) ribs are against a twisting direction;
b) ribs are in a twisting direction;
c) ribs are in the form of a wire wound on a tape in a direction of its twisting with a projection of ribs over tape edges of a tape;
d) ribs are in the form of a wire wound on a tape in a direction of its twisting, thus slots are available on tape edges of a tape in which ribs are entrained;
e) ribs are in the form of a wire wound on a tape through holes in a tape in a twisting direction;
f) ribs are serially in a direction and against a twisting direction;
g) chevron ribs

Photo

•Yakovlev, A.B., Tarasevich, S.E., Ilyin, G..K. and Shchelchkov, A.V., 2011, “The Device For a Heat Exchange Intensification In Channels of Various Cross-Section Section”, **Patent** for the invention RU № 2432542 C2, Demand № 2009147927 from 12/22/2009

STRUCTURAL FEATURES OF TWO-PHASE UPFLOW IN ANNULAR CHANNELS WITH LENGTH-CONTINUED FLOW TWISTING

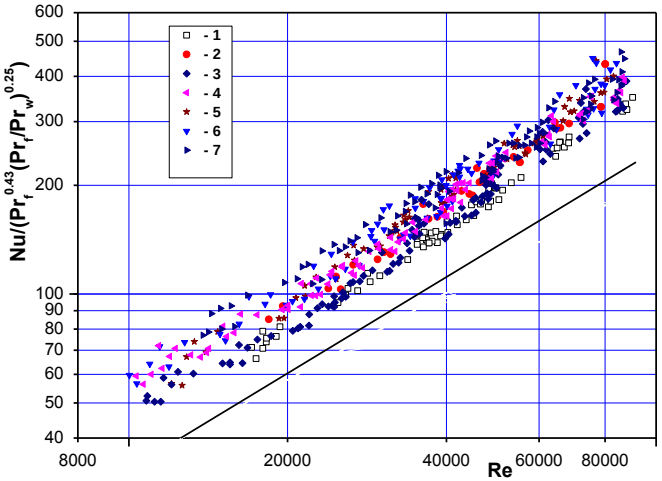


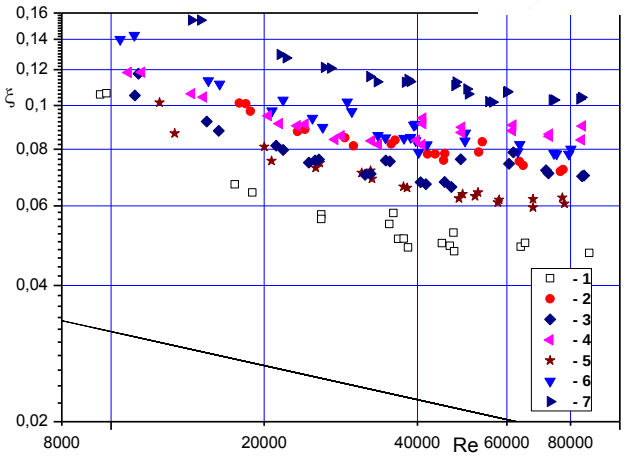
a) b) c) d)

a) stratified wave regime;
b) stratified wave regime at relatively high velocities;
c) annular regime;
d) appearance of droplets on the walls

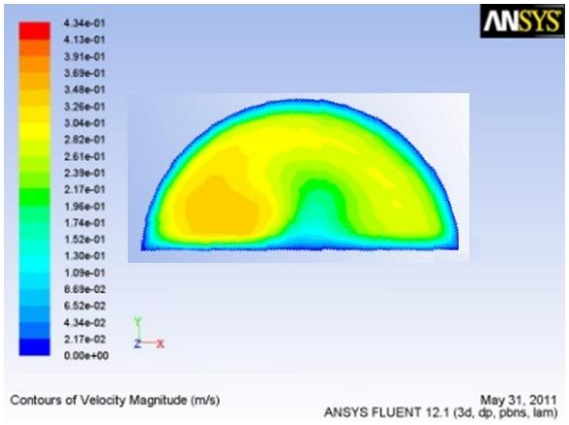
HEAT TRANSFER AND HYDRAULIC RESISTANCE OF TUBE WITH VARIOUS TWISTED TAPES

Twist ratio S/d=6

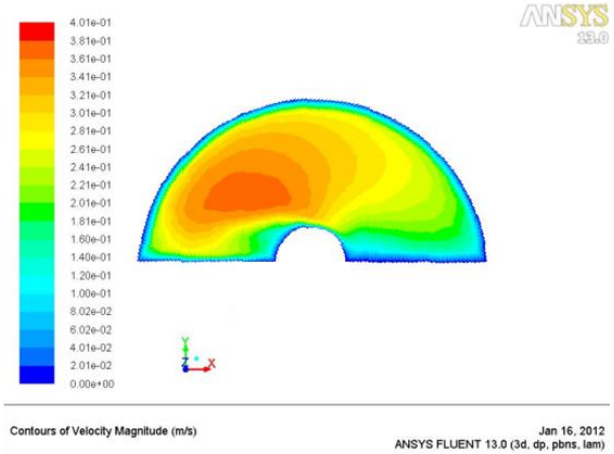




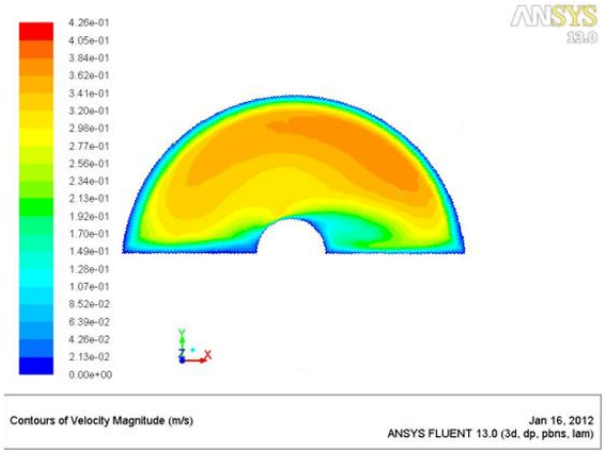
1 – without ribs; 2 - ribs are in the form of a wire wound on a tape in a twisting direction without gap in tape edge between a wall and a rib, t=2/3s, h=1.5 mm; 3 - ribs are in the form of a wire wound on a tape through holes in a tape in a twisting direction, t=s/3, h=0.7 mm; 4 - ribs are in the form of a wire wound on a tape through holes in a tape in a twisting direction, t=s/3, h=1 mm; 5 - ribs are against a twisting direction, t=s, h=0.7 mm; 6 - ribs are against a twisting direction, t=s/2, h=0.7 mm; 7 – ribs are against a twisting direction, t=s/2, h=1 mm; line – for direct tube



Twisted tape insert without ribs



Twisted tape insert having ribs in flow direction

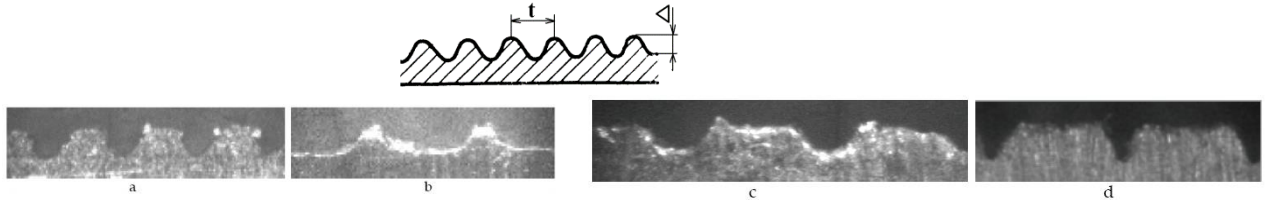


Twisted tape insert having ribs against flow direction

HEAT TRANSFER AND HYDRAULIC RESISTANCE IN ROUGH TUBES INCLUDING TUBES WITH TWISTED TAPE INSERTS

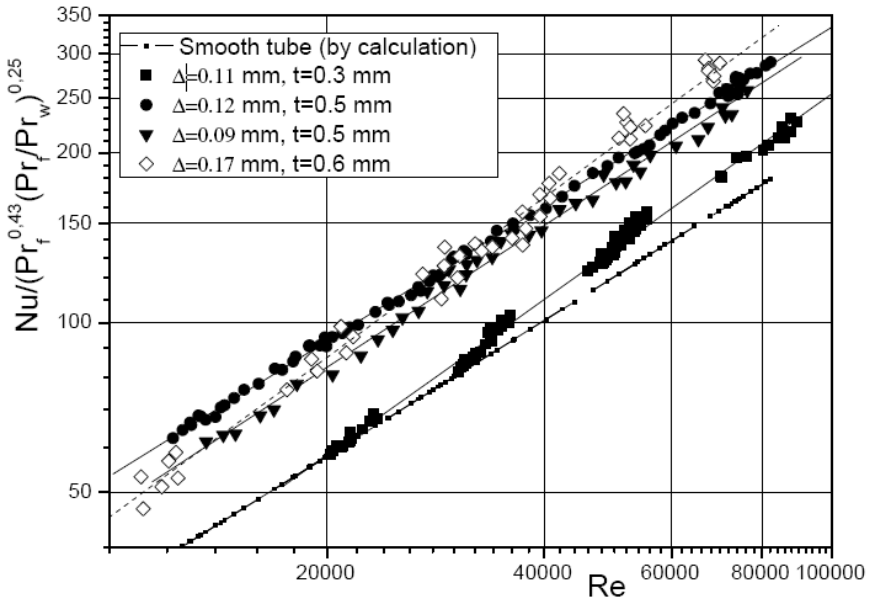
Photo of a tube internal surface with thread roughness (view in cross section)

Photos of the profiles of thread roughness (ledges up)

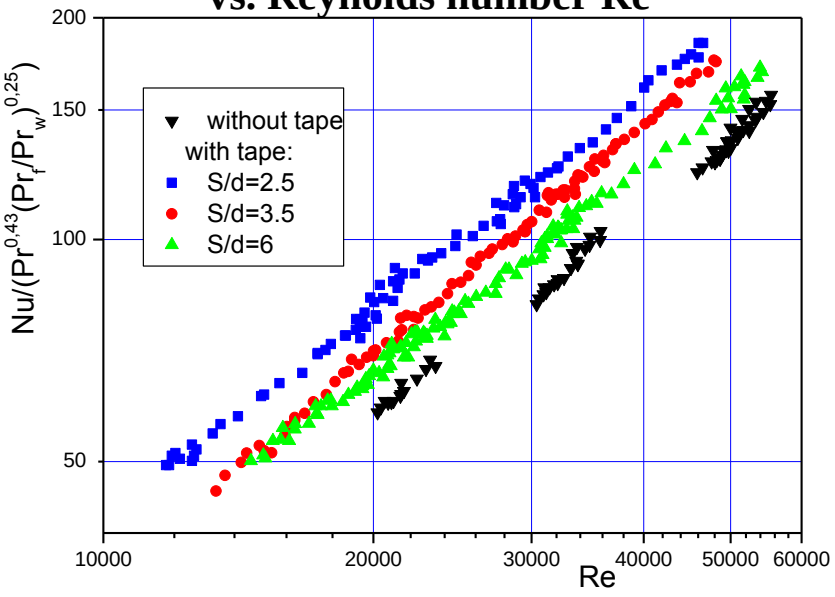


a) Δ=0,11 mm, t=0,3 mm; b) Δ=0,12 mm, t=0,5 mm; c) Δ=0,09 mm, t=0,5 mm; d) Δ=0,17 mm, t=0,6 mm

Nusselt number Nu of rough tubes vs. Reynolds number Re



Nusselt number Nu of rough tubes with twisted tape insert vs. Reynolds number Re



Roughness - variant "a"

Working processes of hydrodynamics and heat transfer in tribotechnical and cooling systems of turbomachines and power plants

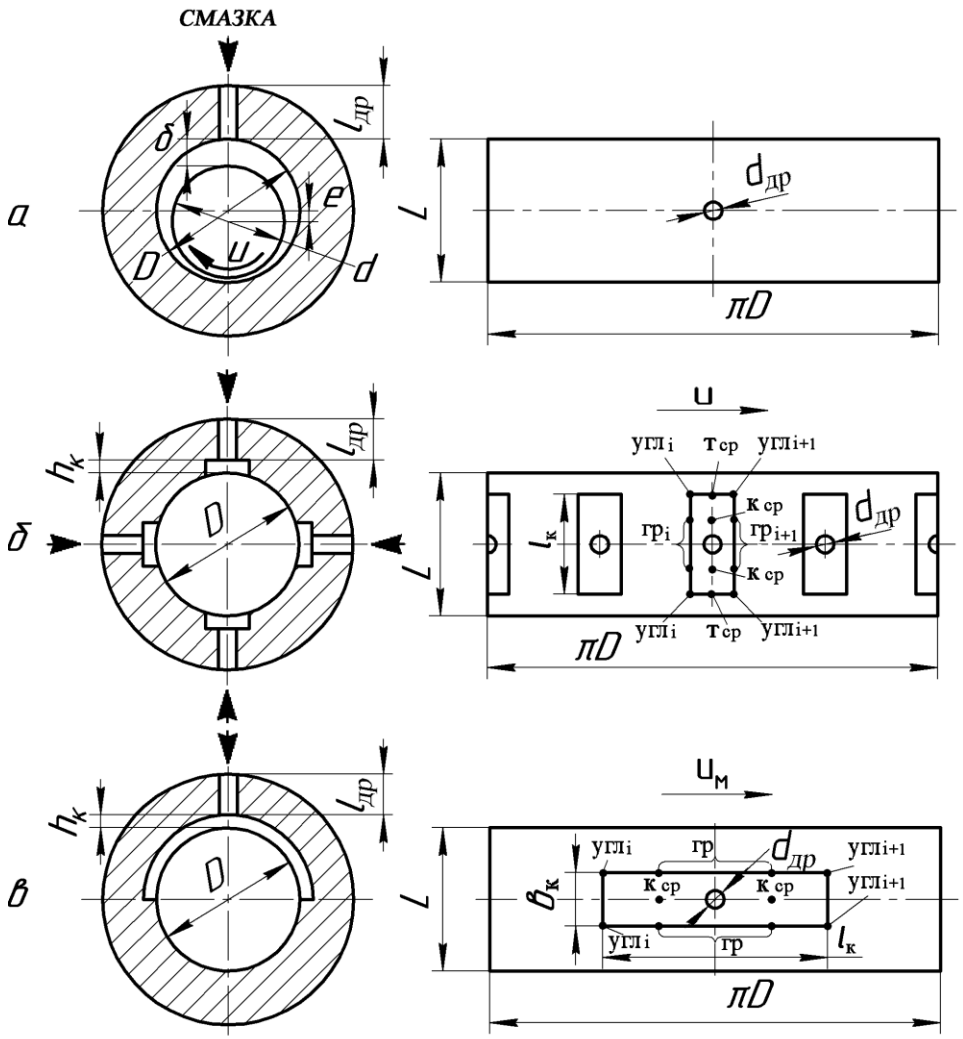
Main Scientific Interest:

- Research of hydrodynamic processes in journal bearings of rotors

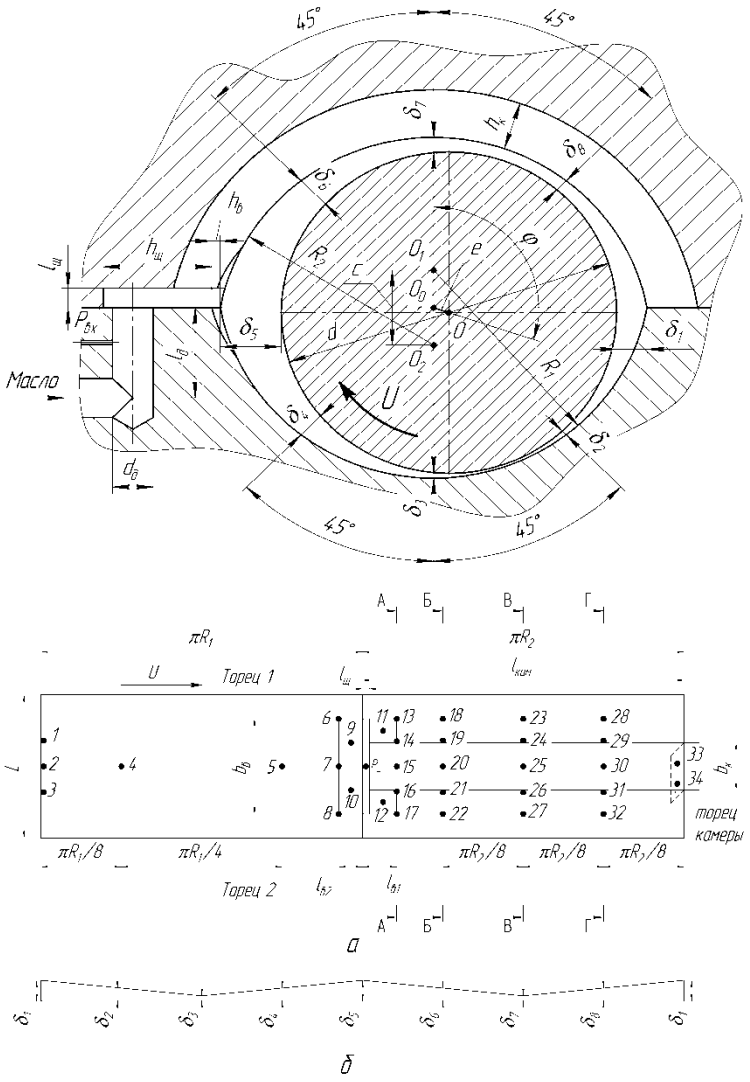
  Aim of the work: to obtain generalized experimental data on processes of lubricant flow in channel of complex shape of various types of journal bearings.

  Application: tribotechnical systems of rotors of turbomacines and power plants

Objects of study



Radial journal bearings



lemon bore bearing

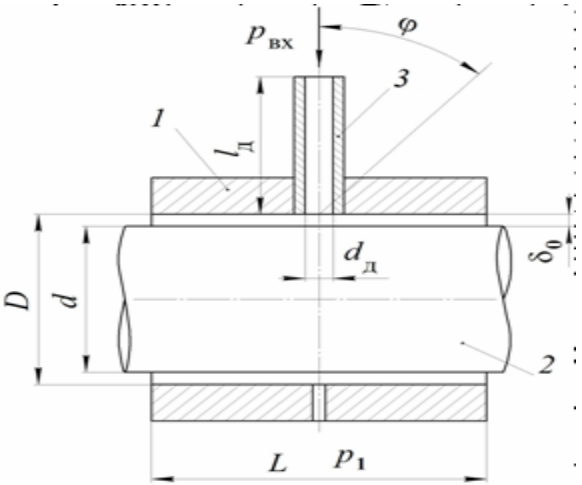
Radial journal bearing

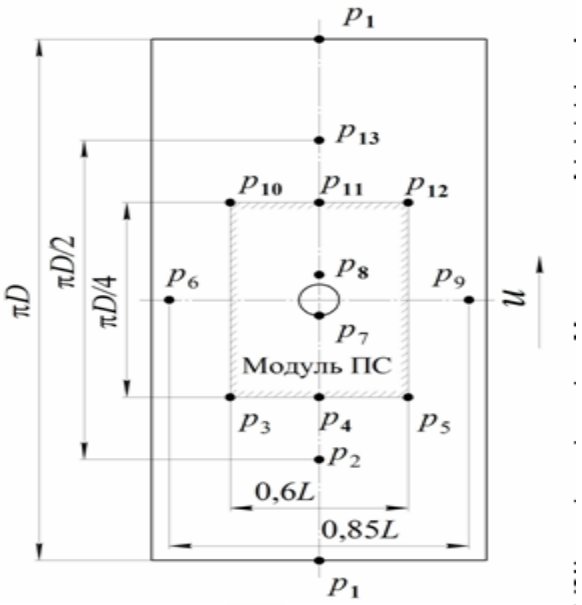
Advanteges:

1) Longer lifetime
2) Vibration stability
3) Low noise level
4) High rotation velocity, loads and temperatures
5) High damping capacity
6) Provide shaft self-centering

Disadvantages:

1) Increased wear at starting/stopping
2) High oil consumption for oil circulation





Prototype – bearing of KamAZ engine crankshaft

Pressure fields and flow rate characteristics of lemon bore bearing