"Capacity Building for a New Generation of Scientists in Energy Security and Climate Neutrality"
Advanced Study Institute. Budapest, October 8-16, 2024

Monitoring and diagnosing power equipment to improve reliability and energy efficiency

Igor Sikorsky Kyiv Polytechnic Institute National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute"
Prof. Stefan Zaichenko

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Agenda

1. Introduction/General information about "Igor Sikorsky Kyiv Polytechnic Institute"
2. Main areas of Monitoring and diagnosing
3. The main tasks of technical diagnostics power equipment to improve reliability and energy efficiency
4. The structure of technical diagnostics

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General information

Kyiv Polytechnic Institute (since 2016 - Igor Sikorsky Kyiv Polytechnic Institute) was founded in 1898. Today it ranks 4% of the best universities of the world according to the international rating QS and Webometrics. University annually holds the highest positions among the best higher educational establishments of Ukraine (national rankings "Compass" and "TOP-200 Ukraine").

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University has powerful institutional capability for international cooperation

Currently the University is taking part in 1 EMFAF project, 1 EIT project, 1 NATO SPS, 4 Horizon Europe projects and 1 ERASMUS+

International Collaboration Department of Igor Sikorsky Kyiv Polytechnic Institute

icd.kpi.ua

Igor Sikorsky KPI
Center for International Education

istudent.kpi.ua

Academic Mobility Office

European Commission

СПІЛЬНИЙ УКРАЇНСЬКО-НІМЕЦЬКИЙ ЦЕНТР
GEMEINSAMES UKRAINISCH-DEUTSCHES ZENTRUM

… and wide experience of cooperation with different international organizations and programs

UNDP

Erasmus+

UNIDO

DAAD Deutscher Akademischer Austausch Dienst
German Academic Exchange Service

BRITISH COUNCIL

HORIZON 2020

SIU

FULBRIGHT UKRAINE

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Educational and Scientific Institute of Energy Saving and Energy Management

The Educational and Scientific Institute of Energy Saving and Energy Management was established based on the basis of the Mining and Technical Faculty in 1997 as a result of the implementation of the "Comprehensive State Program on Energy Saving". Today, the departments of NN IEE train highly qualified specialists. Today, 455 students' study at ES IEE. The teaching staff of the institute ensures a high level of the educational process, considering the requirements of today, preparing a worthy young change with great professional and moral potential, preserving the traditions and specifics of the institute, which have been formed for decades! Total number of employees - 136.

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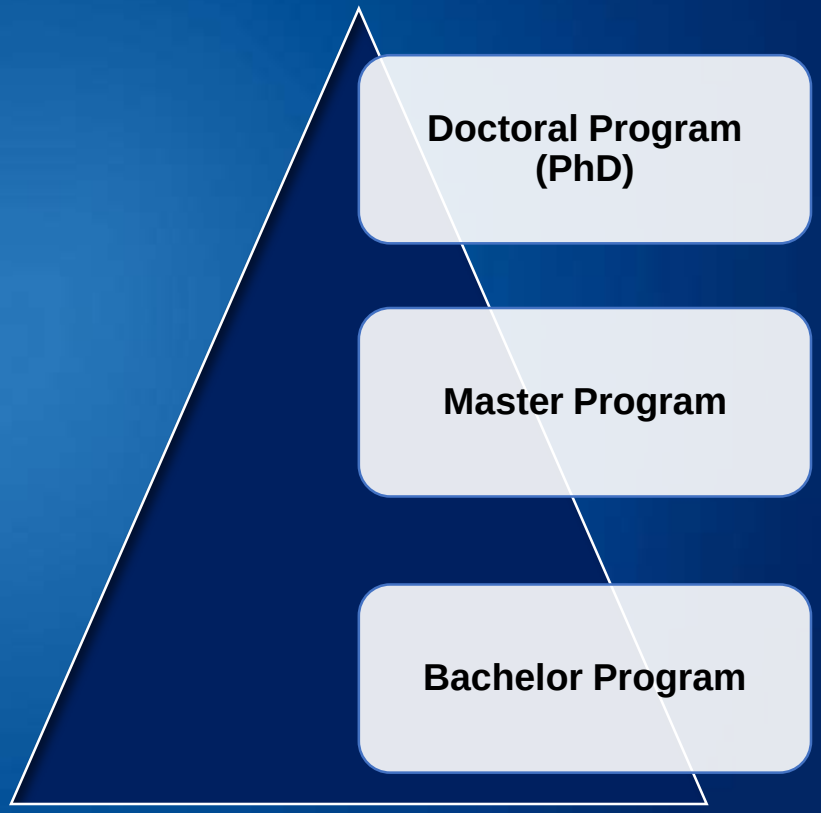
ES IEE educational programs

Educational programs:

- Electrical Energetics, Electrical Engineering and Electromechanics
- Electric Power Distribution Systems Engineering
- Energy Management and Energy Efficient Technologies
- Engineering of Intelligent Electrical and Mechatronic Complexes



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Areas in which specialist training and scientific work are carried out

Departments of ES IEE today specialists in the following specialties:

141 Electric power engineering, electrotechnics and electromechanics

183 Environmental protection technologies ***184*** Mining

The educational and scientific institute focuses on advancing knowledge and methods for energy conservation and effective energy management. It enhances professional development and technological innovation in intelligent electrotechnical and mechatronic systems, integrated power supplies, Smart Grid-based energy management for industrial and municipal facilities, and underground space utilization in megacities. Additionally, it addresses decarbonization technologies in the industrial sector.

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Research tasks of the Department of Automation of Electrotechnical and Mechatronic Complexes

- Complex analysis of design, development and functioning of hybrid electric power systems on the basis of low power RES and Energy storage.
- Development, approbation and implementation of daily generation forecasting methods for hybrid low power generation systems with Energy storage.
- Determining methods of demand management for hybrid power systems
- Development of implementation models for generation, accumulation and consumption management for power industry subjects with low power hybrid systems

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Research tasks of the Department of Automation of Electrotechnical and Mechatronic Complexes

- Identification of energy saving potential and optimization of control systems of electrotechnical and electromechanical complexes
- Development of methods for diagnosing the energy efficiency of technological installations and assessment of the possibilities of using energy-saving technologies using energy management systems
- Development of systems for technical diagnostics of automated and mechatronic complexes

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INNOVATIVE TECHNOLOGIES IN HUMANITARIAN DEMINING

Around 30% of Ukraine's territory is contaminated with mines and unexploded ordnance. In 2023, 18,000 square kilometers were cleared, over 10% of the total area needing to be surveyed. The number of mine action operators has grown, with over 30 certified operators and 52 more organizations in the process of certification. UN Under-Secretary-General Martin Griffiths stressed that demining Ukraine is a humanitarian priority, and significant resources are needed to address the dangers of mines and explosives.

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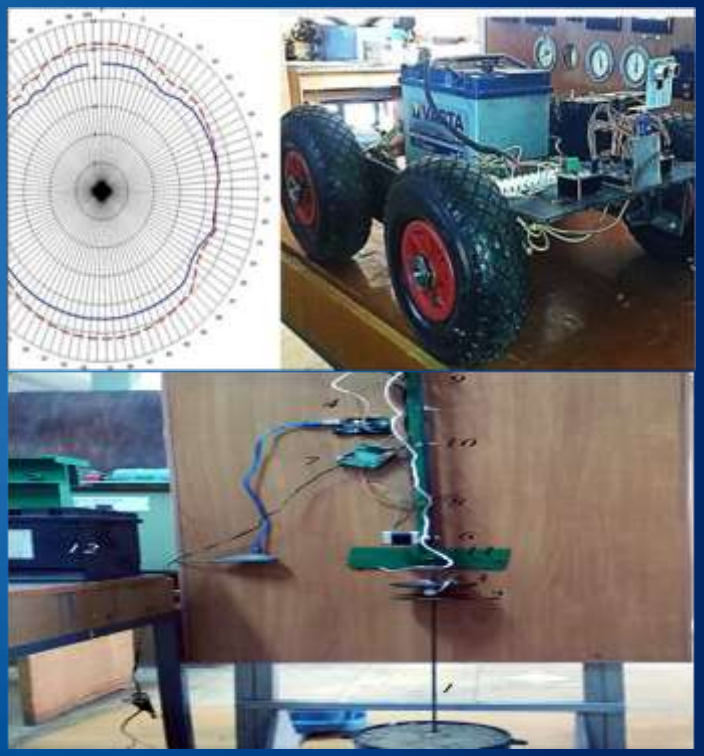
CENTER FOR HUMANITARIAN DEMINING

The Center was founded at Ukraine's largest technical university, Igor Sikorsky Kyiv Polytechnic Institute. It has skilled technical staff with practical experience, a diverse material and technical base, and well-equipped laboratories. A qualification center for the profession of "Deminer" has also been established. The Center conducts its own research in the defense sector, participates in government working groups, and studies best practices in humanitarian demining.



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Ukraine towards Carbon Neutrality

Project 'U_CAN Towards Carbon Neutrality of Ukrainian Cities' is to seamlessly integrate Ukrainian cities into the collective vision of the EGD(**European Green Deal**) by bonding them with best-practice European counterparts – namely selected CNSC mission cities – through the usage of advanced tools and methods for institutional networking, knowledge transfer and innovation management.

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Ukraine towards Carbon Neutrality

<u>The mission has five main objectives:</u>

- Support Ukrainian cities in developing tailored climate strategies for transitioning to climate neutrality.
- Identify key sectors for climate transition, including industrial decarbonization, energy transition, and nature-based solutions.
- Foster exchange of best practices through CNSC twinning activities, connecting pioneering cities as mentors for others aiming for climate neutrality.
- Facilitate local pilot projects to demonstrate the feasibility and benefits of climate-neutral measures.
- Raise awareness among a broader group of Ukrainian cities about climate action.

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Monitoring and Technical diagnostics

Technical diagnostics is a field focused on determining the current technical condition of an object and how it changes over time. It involves studying how the object's condition manifests and developing diagnostic systems. The technical state (TS) refers to the properties of an object, which can change due to external factors. These changes are measured by diagnostic indicators at specific times and conditions.

The object of diagnosis can be any technical product or component. The goal of technical diagnostics (TD) is to provide information about the object's technical condition, summarized in a conclusion called a technical diagnosis.

Key principles of technical diagnostics include:

- Causality
- Maximizing diagnostic information with minimal data
- Using non-destructive methods that do not affect the object's condition

TD assesses properties like reliability, fail-safety, durability, maintainability, and controllability. Reliability refers to the object's ability to perform its functions under specified conditions, while durability is its capacity to remain operational until it reaches its limit state.

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Main areas of technical diagnostics

- The term "diagnosis" comes from the Greek word meaning "recognition" or "definition." In diagnosis, the condition of a patient (medical diagnosis) or a technical system (technical diagnosis) is identified.
- **Technical diagnostics** is the science of identifying the condition of technical systems. Its goal is to improve the reliability and lifespan of these systems by studying methods to gather and evaluate diagnostic information, and by creating models and decision-making processes.
- The main goal is to prevent failures, which can have serious consequences, such as engine failures during flight or power plant malfunctions under load. Early detection of defects allows for maintenance to prevent such failures, improving reliability and efficiency. In practice, the lifespan of systems is based on their weakest parts, and maintenance based on their condition can save up to 30% of the total fleet cost.

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The main tasks of technical diagnostics

- Technical diagnostics focuses on determining the condition of a system with limited information, often without disassembly. It relies on statistical methods and pattern recognition to classify systems as working or faulty. This involves the risk of false alarms or missed issues, and uses decision-making methods from statistical theory.
- Another key task is predicting system reliability until the next maintenance, based on failure models.
- **Controllability theory** is another major area, ensuring systems can assess their condition and detect malfunctions early. It involves designing diagnostic systems, automated control, and fault detection.
- Though initially developed for radio-electronics, technical diagnostics applies to a wide range of systems.

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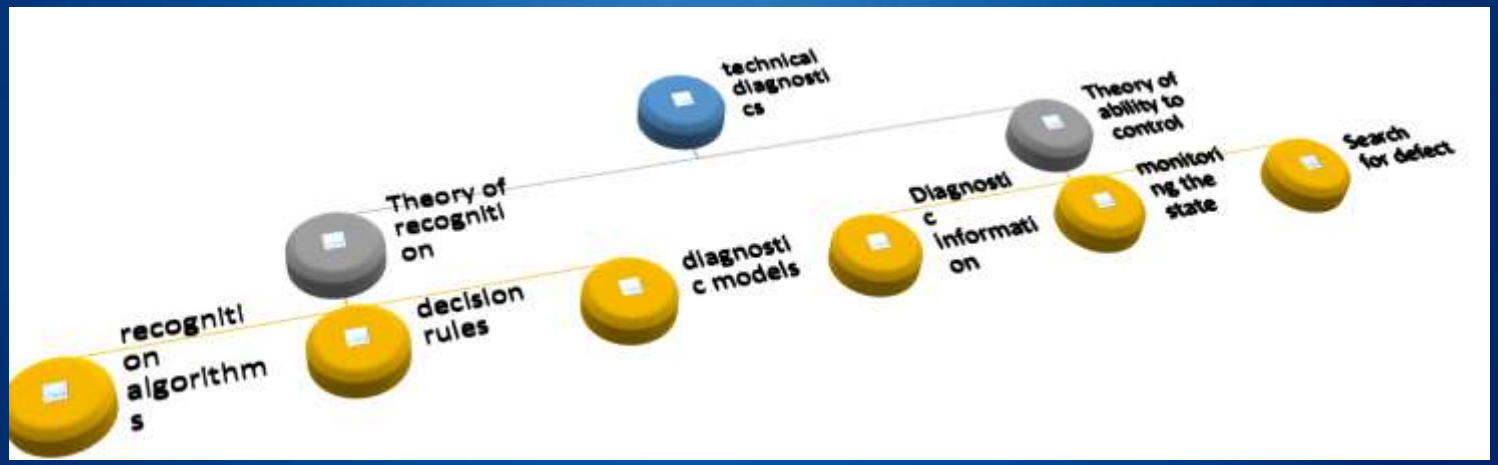
The structure of technical diagnostics

In fig. the structure of technical diagnostics is shown. It is characterized by two interpenetrating and interrelated directions: recognition theory and controllability theory. Recognition theory includes sections related to the construction of recognition algorithms, decision rules, and diagnostic models. The theory of capacity control includes the development of means and methods of obtaining diagnostic information, automated control and fault finding. Technical diagnostics follows as a section of the general theory of reliability



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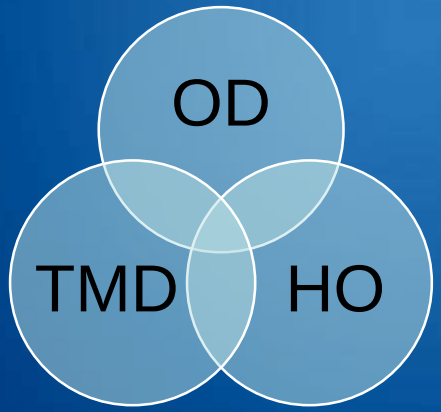
Structural diagram of the production process

Diagnosis of the technical condition of any object is carried out by those or other means of diagnosis. Means and object of diagnostics, interacting with each other, will form a system of diagnostics.

The diagnosis process involves, as a rule, the object of diagnosis (OD), technical means of diagnosis (TMD), that is, means designed to determine the state of OD, and the human operator (HO)



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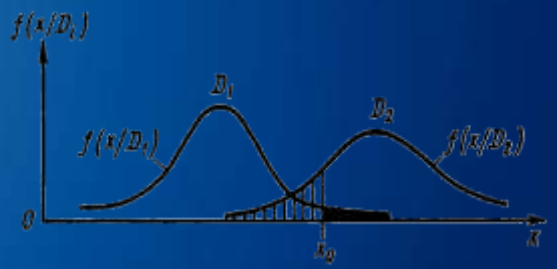
Test and functional diagnostics systems

In test diagnostic systems, special tests are applied to the object, while in functional diagnostics, the object operates under normal conditions without extra tests. Both systems analyze the object's response to determine if it is functional or defective.

Test diagnostic systems check for defects affecting the object's operability, while functional diagnostics focus on ensuring proper operation and detecting functional issues.

Diagnosis involves running algorithms that include basic checks (test or functional) and analyzing their results. Models of objects, either functional or structural, help in diagnosing functionality or finding defects. These models can be deterministic or probabilistic, with probabilistic models used when exact behavior can't be described.



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Connection of technical diagnostics with reliability and quality

Product quality is defined by its properties that determine how well it meets specific needs, with reliability indicators like failure rate, durability, and maintainability being crucial. Defects can occur at any stage and negatively impact quality and reliability.

- Reliability involves three main aspects:

1. **Physical**: Focuses on selecting and improving materials and technologies to minimize defects during production and use.
2. **Hardware**: Uses redundancy methods (like duplication) to prevent defects from causing incorrect operation.
3. **Informational**: Ensures reliable data handling through redundant information, error-correcting codes, and secure processing.
4. **The diagnostic aspect of reliability is crucial for detecting defects during production and operation, ensuring that systems remain functional and effective. This involves checking the technical condition of objects and finding any issues that may affect their performance.**

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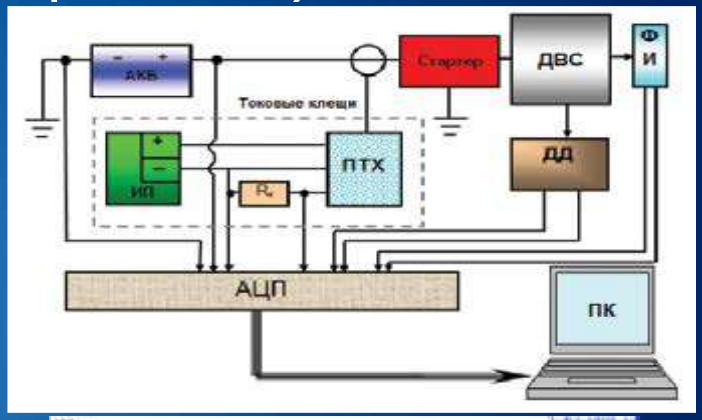
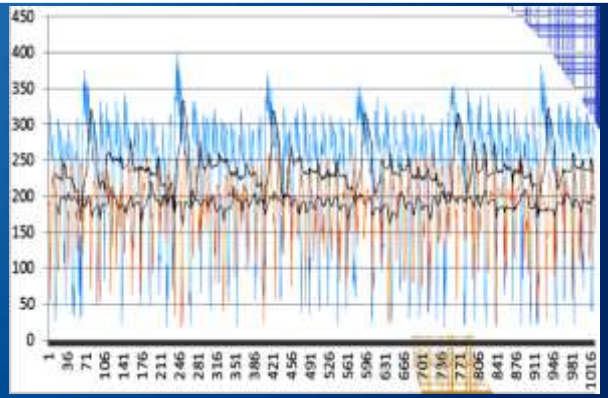
Systems for technical diagnostics of autonomous power supply apparatus (petrol-powered)

- A stand-alone power generator should have a greater degree of reliability.
- The main element of an electric autonomous generator is an internal combustion engine.
- For reliable and efficient operation of the internal combustion engine, the condition of its cylinder-piston group must be good.
- A method has been created for a simple method for diagnosing the standing of a cylinder-piston group.
- The essence of the method lies in the compresor diagnosis of the generator.





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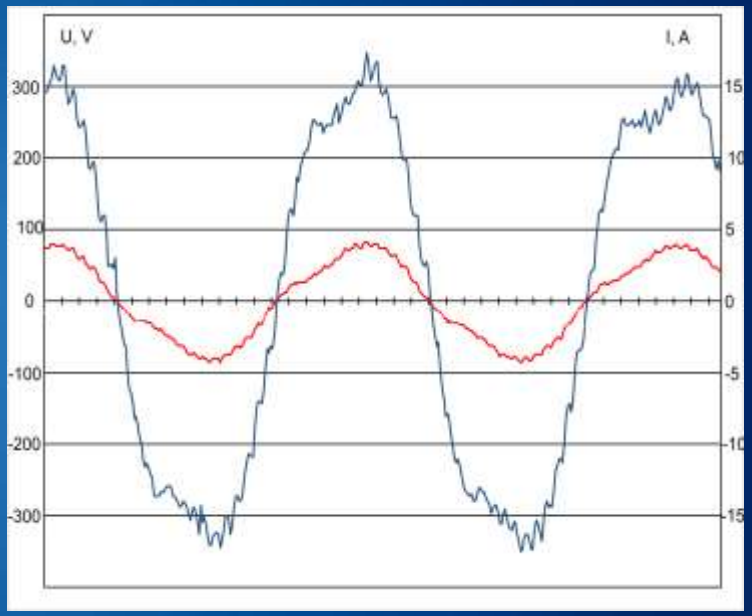
Systems for technical diagnostics of autonomous power supply apparatus (petrol-powered)

$$\dot{BSFC} = \frac{m}{\Delta P} = \frac{\rho \Delta V}{\Delta P} = \frac{\rho \Delta V}{\int_0^{\Delta t} I(t)U(t)dt}$$

$$\eta = \frac{\Delta P}{\Delta Q} = \frac{\int_0^{\Delta t} I(t)U(t)dt}{q\rho\Delta V}$$



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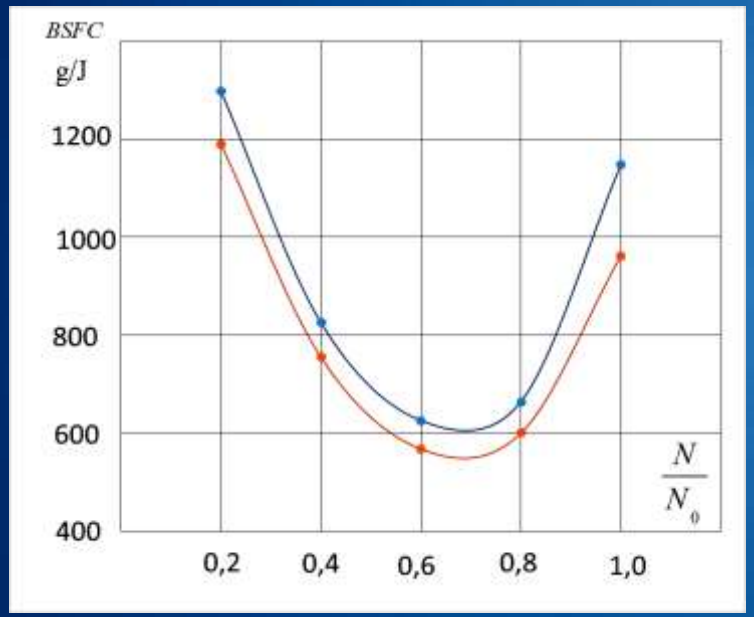
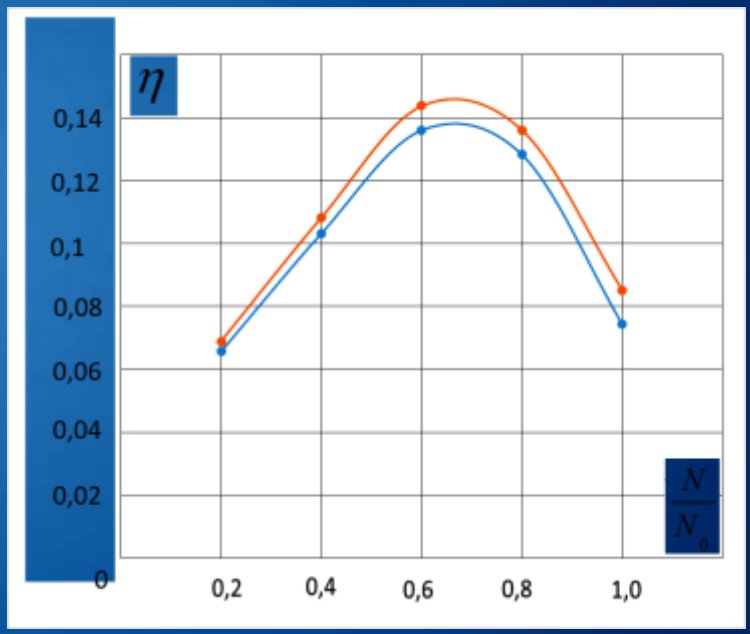
Diagrams of changes in specific fuel consumption (a) and efficiency (b) when using different types of fuels:

———- gasoline automobile A-95 - Euro5; ——— - gasoline automobile A-95 - Euro5 - E7





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Conclusions

Diagnosis plays a crucial role in assessing whether a system or product is functional or defective, ensuring quality and reliability. There are two main types of diagnostic systems:

Test Diagnostic Systems, which identify defects through specific tests, and Functional Diagnostic Systems, which monitor normal operations without additional testing.

Effective diagnosis and monitoring are essential for enhancing reliability by detecting potential issues before they lead to failures.

Key aspects of reliability include improving materials, using hardware redundancy, and managing data effectively. Continuous monitoring allows for real-time assessments, while integrating diagnostic tools with monitoring systems fosters effective maintenance and operational efficiency.

A proactive approach in diagnosis and monitoring helps identify issues early, thereby reducing unexpected failures and enhancing overall safety and performance, highlighting the critical role of these processes across various fields.

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Thank you for your attention

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