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MECHANICAL LOSSES IN INTERNAL COMBUSTION ENGINES: ANALYSIS, DIAGNOSTICS AND EXPERIMENTAL ASSESSMENT METHODS

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Abstract. This paper explores the origin, classification, and quantitative evaluation of mechanical losses in internal combustion engines (ICEs). These losses are responsible for a significant portion of the fuel consumption and influence the engine's performance, efficiency, and durability. Both theoretical and experimental methods are reviewed, with special emphasis on practical diagnostic techniques applicable to modern automotive and tractor engines.
Keywords: mechanical losses, internal combustion engine, experimental methods, fuel efficiency, tribology, diagnostics, modeling.

Introduction. Mechanical losses in ICEs arise from friction between interacting components, energy consumption of auxiliary components, pumping resistance, and aerodynamic drag. These losses can account for up to 40% of the fuel energy, especially in high-load or transient conditions. Given their impact on fuel economy and emissions, understanding and reducing these losses are vital objectives in engine research and development.

The *object* of this study is mechanical losses in ICEs. The *subject* involves diagnostic and experimental methods used to evaluate these losses. The *goal* is to review, compare, and assess existing theoretical and experimental approaches, highlighting their advantages, limitations, and applicability. The *novelty* of this work lies in its synthesis of multiple research perspectives and in emphasizing practical diagnostics based on empirical data and test bench validation.

1. Theoretical Background of Mechanical Losses

Mechanical losses include: (1) friction in tribological pairs (piston-ring-cylinder, bearings, cams), (2) power consumed by auxiliaries (oil pump, fuel pump, cooling system, generator), (3) pumping losses due to gas exchange processes, and (4) aerodynamic losses. A breakdown of these losses reveals that piston assembly friction can contribute up to 60%, bearing friction up to 20%, and pumping and auxiliary components up to 25%.

Mathematically, losses are often expressed through the mean mechanical loss pressure (P_{ml}), which can be estimated using empirical relationships based on piston speed, cylinder diameter, stroke length, and crankshaft rotational frequency. Various researchers have proposed such formulae for specific engine types, but universal applicability remains limited.

2. Experimental Methods of Evaluation

Numerous experimental methods have been developed to assess mechanical losses. These include:

1. Indicator-Effective Power Comparison Method – calculates losses by subtracting effective power from indicator power. This method is simple but may be affected by measurement noise

2. Sequential Cylinder Disconnection – estimates losses by analyzing changes in torque output when individual cylinders are deactivated.

3. Electric Motor Crankshaft Drive – uses an external motor to rotate the crankshaft and measures the power required to overcome resistance.

4. Coast-Down Method and Double Coast-Down – analyzes the deceleration rate of the engine crankshaft rotation after fuel cut-off.

5. Fuel Consumption at Idle – estimates losses based on the amount of fuel consumed with zero effective load.

6. Test Bench Load Variation – employs indicator diagrams at various loads and RPMs to construct a full loss profile.

Each method has trade-offs. For example, the coast-down method is convenient in field conditions but requires accurate data on the engine's inertial characteristics and thermal state.

3. Simulation and Modeling Approaches

Advanced numerical modeling tools like ANSYS allow for the simulation of contact mechanics, deformation, and wear. In this study, piston models with modified side surfaces and plasma coatings were tested. The simulations showed clear shifts in stress concentration and friction zones, indicating the significant impact of surface engineering on performance.

The study also applied nodal-point statistical methods to explore multifactorial dependencies, such as crankshaft speed, oil viscosity, and thermal conditions. This allowed for the formation of generalized models to forecast loss behavior under variable conditions.

Conclusions. Mechanical losses in ICEs play a crucial role in overall engine efficiency and durability. Despite a range of theoretical and empirical tools available for their evaluation, a universal methodology is lacking. The most reliable results come from hybrid approaches that combine modeling and physical experimentation. The findings of this paper can be instrumental in future projects aimed at reducing losses in automotive and agricultural power units, especially through advanced tribological design and real-time diagnostics.

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ARTIFICIAL NEURAL NETWORKS FOR HYBRID INERTIAL-SATELLITE NAVIGATION SYSTEMS: CHALLENGES, TASKS AND RECENT RESEARCH

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Abstract. This paper addresses the problem of unreliable or falsified GNSS signals and presents advanced methodologies for their detection. The focus has been made on the integration of machine learning techniques, particularly Artificial Neural Networks (ANNs) into hybrid navigation systems to model temporal and spatial anomalies in GNSS data, enabling the system to distinguish between authentic and corrupted signals.
Keywords: GNSS; inertial navigation; artificial neural networks.

Introduction. In recent years, Artificial Intelligence (AI) has emerged as a powerful tool for addressing various challenges associated with hybrid Inertial Navigation Systems (INS) and Global Navigation Satellite Systems (GNSS). However, their vulnerability to signal degradation, jamming, and spoofing poses significant challenges to the reliability and security of navigation solutions.