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DOCTORAL THESIS

SUMMARY

„OPTIMIZATION OF THE OUTCOME OBTAINED IN THE PETROLEUM PRODUCTS TRANSPORT MANAGEMENT BY IMPLEMENTING CERTAIN HIGH-PERFORMANCE INFORMATION SYSTEMS”

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The paper ,,OPTIMIZATION OF THE OUTCOME OBTAINED IN THE PETROLEUM PRODUCTS TRANSPORT MANAGEMENT BY IMPLEMENTING CERTAIN HIGH-PERFORMANCE INFORMATION SYSTEMS" represents the result of my scientific preoccupations in the period 2017-2020, as a student of the Doctoral School within University of Petroșani, having as purpose the obtaining of the PhD title in the field of Mining, Oil and Gas.

This paper represents an analysis of the implementation methods of high-performance information systems used, in order to optimize the performance obtained in the management of the petroleum products transport and technologies used to achieve this goal. In addition to the theoretical aspects indispensable in performing the analysis, current engineering practice has imposed new approaches correlated with the technological evolution of topo-geodetic equipment, as well as equipment used to modernize the vibration and temperature monitoring system for pumping equipment.

The importance and topicality of the topic addressed in the thesis, implemented in an energy company (transport of petroleum products through pipelines) is related to the spatial information managed by such a company and maximizing the benefits that can be obtained by integrating information and their availability to the level of certain companies in the field, which leads to an integration of workflows and, by this, to a reduction of data redundancy and optimization of information exchange. The practical result of the paper, expressed by case studies, is materialized by identifying the implementation of high-performance information systems in order to find solutions for the management of geospatial infrastructures. Geospatial infrastructure provides many benefits, such as increasing the efficiency of internal processes by rapid access to data and real-time collaboration, anticipating problems and reducing operating incident costs, thus increasing efficiency and reducing overall infrastructure operation and maintenance costs.

In order to improve the technological performance of the oil and petroleum products transport system, predictive maintenance was used in the work, which allows the early detection, localization and identification of defects or used parts, as well as the operation time of the equipment in conditions of safety. Predictive maintenance is a superior qualitative leap in a modern maintenance system, regardless of industry or production specificity, because it provides all the necessary information for: early detection of faults, their location, fault diagnosis and identification of operating time in safety conditions of the equipment.

Keywords: information systems, vibration and temperature monitoring system, geospatial infrastructure management, transport system management, technological performance optimization.

Chapter I - ”Overview of the National Transport System for Crude Oil and Petroleum Products” describes the concerns of the Doctoral Research Report 2 and beyond, being structured so as to present relevant data on the composition of the transport system of petroleum products as well as the technologies used in the operational technological flow.

In Chapter II of the thesis, named ”Implementation of the GIS System within the National Transport System for Crude Oil and Petroleum Products”, I aimed to present the existing IT systems within the company operating the oil transport system, by a thorough documentation, exposing also the applicability of interconnection with other systems.

Chapter III of the paper that has as goal to optimize the national transport system by the use of predictive maintenance was intended for the theoretical framework regarding the applicability of predictive maintenance and experimental research on vibration and temperature monitoring in equipment related to the national transport system.

In Chapter IV, for personal contributions, the essential ideas resulting from the case studies and from the theoretical aspects stated, the final results obtained and the original contribution of the author were presented.

The operating condition of any static or dynamic machine is the main concern of designers and users. One of the characteristics of this state is the vibratory movement. When this vibratory movement has an amplitude that exceeds the permissible limit, the machine can become a source of disturbance, damage or fault to other machines, becoming a potential hazard in operation. In order to avoid such unpleasant and expensive situations, it is necessary to know the permissible limits of the machine vibrations and to follow the vibration evolution, using hardware/software components.

The practical result of the paper expressed by the case study is materialized by identifying how to implement high-performance information systems (predictive maintenance) in order to identify solutions for geospatial infrastructure management and thus increase the degree of technical and economic efficiency.

This implementation of high-performance information systems is based on the existence of a predictive maintenance system, respectively a database containing the necessary information on the evolution of the status of each machine over time, and periodic analysis of the causes that led to machine failure, so they should be removed before creating the conditions for a new failure.

In order to improve the technological performance of the crude oil and petroleum products transport system, I used, in the thesis, predictive maintenance that allows early detection, location and identification of failure or worn part, as well as safe operation time of dynamic equipment.

During the treatment and solution of this topic of the doctoral thesis, I made the following personal contributions:

- ✓ Critical analysis, systematization and synthesis of information regarding the general description of the National Transport System for Crude Oil and Petroleum Products
- ✓ Analysis of the situations regarding the failures of the National Transport System for Crude Oil and Petroleum Products by a case study carried out over a period of 40 months, starting with January 2016 until April 2019.
- ✓ By the study, I identified two types of failure: technical failure and caused failure. The graphical distribution of the failures was made for each year and, comparatively, for the four years of study.
- ✓ I have made a critical presentation of the need to modernize the National Transport System and emphasized the aspects regarding the modernization of pumping stations for the safe operation of the transport of petroleum products through pipelines.
- ✓ Following the analysis of the specialized literature, I made both a presentation of the SCADA system and a critical analysis of the current automated structure within the company CONPET S.A.
- ✓ Synthesizing information on the effective implementation of the GIS system by interconnecting with existing systems (SCADA, SpectraPro database) within the company.
- ✓ Accurate and deep identification of the elements necessary to develop an IT architecture specific to data integration and visualization platforms by a GIS system.

- ✓ Selection of maintenance technologies that can be applied to remedy incipient defects caused by vibrations during the operation of dynamic equipment.
- ✓ Presentation of the equipment that is part of the Lucăceşti pumping station, a station located within the company CONPET S.A.
- ✓ Systematization of technical information regarding the equipment necessary to be implemented within the Lucăceşti station in order to monitor the vibrations at the pumping equipment.
- ✓ Monitoring and interpretation of measurements performed with the vibration transducer at both booster pumps and main pumps, recorded for 30 days, with Viber X5 analyzer, vibrations in horizontal, vertical and axial direction for pump motor fans, for motor-pump coupling and for discharge pump.
- ✓ I have created a database integrated with the SpectraPro system that provides the evolution of the measured/monitored parameters.
- ✓ The SpectraPro system is connected to the SCADA system and, remotely, depending on the values recorded for vibrations in the three directions, I tried (and succeeded!) to reduce the pump speed so that it could work until the arrival of the maintenance team. The correlation of the information (alarm) within the SCADA system with the Spectra Pro database, respectively the analysis of the vibration amplitudes led to the avoidance of an accidental stop and the intervention of the maintenance team in a timely manner.
- ✓ A 10% reduction in pump speed led to the maintenance of the equipment in operation for another 7-10 days. Even if the operation occurred within the limits of the warning parameters, the machines kept constant values of vibrations, so as not to endanger the functional integrity of the pumping station or the volume of crude oil transported.
- ✓ Following the evolution of the parameters, I have tried a new speed reduction by another 10%, but this time, the values recorded in all situations remained at a very high level, maintaining an upward trend, which led to the shutdown of the machine.
- ✓ I have conducted a case study on the reliable maintenance of centrifugal pumps.
- ✓ I have applied the methods of analyzing the reliability of PHA, AMDEA/FMEA and HAZOP identifying the risks and problems in operation.

Based on the identified risks and problems, I have found that:

- the component subassemblies of a pump can fail in different ways;

- each mode of failure has one or more causes;
- the causes of failure originate inside or outside the working environment, as well as in the quality of the fluid conveyed;
- each failure mode can cause deviations of the pump parameters from the constructive values.

✓ I have carried out a case study regarding the evaluation of the technical condition of a Ø6 in. pipe, collector pipe located in the area of the Lucăceşti pumping station.

✓ I have performed manual excavations in three points and measured the wall thickness of the pipe in 10 measuring points distributed according to the circumferential direction at a distance of 45°, and after the longitudinal direction at a distance of 150 mm.

✓ I have determined the level of risk related to the measured wall thicknesses and I have represented its percentage variation depending on the wall thickness, at the working pressure, both according to the circumferential direction and according to the longitudinal direction.

✓ Following the calculations, a corrosion addition of 3.441 mm resulted, which would be equivalent to another 34 years of operation at an operating pressure of 25 bar.

✓ Following the investigation of the metal pipeline route in length of 809.09 m, the following resulted:

- the pipeline has no cathodic protection;
- the pipeline has no potential outlets;
- the pipeline has direction change terminals;
- the pipeline does not have electrical insulating joints mounted at either end or if it has, in buried installation, they are not functional;
- all the valves - the outflows existing on the pipeline route present the metal in direct contact with the ground behaving as insulation defects by putting the pipe on the ground;
- the pipeline has various wall thicknesses, these being presented at the control pits;
- the pipeline has relatively satisfactory insulation, alternating with defects priority 1,2 and 3 in the average number;
- the pipeline has at both control pits the outer diameter of 168.3 mm;
- the natural potential of the pipeline is between - 465 mV and - 492 mV

The outcome obtained as a result of the investigations has led to the conclusion that the existing insulation of the pipeline is in a relatively satisfactory condition requiring only the repair of insulation defects with intervention priority 1, 2 or 3 and maintaining a wear pressure related to the degree of wear specified in the pipeline technical book.

The possibility of increasing the speed of the machine (respectively the pumping pressure) in order to eliminate the amplitude of vibrations could not be realized due to the degree of wear of the collecting pipe or the operating pipe.

The correlation of GIS, SpectraPro, SCADA information systems will lead to the optimization of the transport system of petroleum products by reducing costs, intervention times and increasing operational safety.