Software Package for Optimization of Energy Resource Efficient Layout of Complex Process Pipeline Heat Systems

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***Abstract*— To meet the challenge of the optimized energy resource efficient layout of complex process pipeline heat systems, a software package allowing for minimization of reduced costs for process pipeline systems and increase of efficiency of utilization of petrochemical industry facilities operating area with due account for the heat exchange process simulation models, engineering, structural, process, geometry, flow dynamic, physical and chemical restrictions of pipeline layout, was developed. The software package is implemented in the PML utilizing tools of DABACON object-oriented database, AVEVA Engineering design data control system and AVEVA PDMS computer-aided design system.**

Key words*— convection, heating; heat insulation; heat exchange; heat system; pipeline; layout

Enhancement and increase of petrochemical industry (PCI) performance, utilization of deep cold, high temperatures and pressures in chemical technology processes (CTP) stipulate the requirement for utilization of combination of heat insulation and supplementary vapor or hot water flow trace heating of complex pipeline systems transporting products to long distances at prescribed temperature or products with viscosity unacceptably increasing while getting cool ensuring increase of indicators of chemical process system energy resource efficiency due to reduction of heat losses and fuel and energy consumption rate [1–5].

PCI process pipelines are generally long amounting to hundreds of kilometers, hence, have high material consumption. The scope of work related to design of heat insulation structures for heat traced process pipelines makes not less than 10% of the overall scope of heat insulating operations at the petrochemical facilities.

Operation and design of the complex heat systems pose one of the critical research tasks and require utilization of the present-day mathematical techniques and tools of computer-aided design of the optimized energy resource efficient chemical plants for its handling. The primary tasks of operation and design of the complex heat systems include the tasks of flow dynamic and heat analysis, as well as layout tasks with due account for the heat exchange process simulation models, engineering, structural, process, geometry, flow dynamic, physical and chemical restrictions of pipeline layout allowing for minimization of reduced costs for process pipeline systems and increase of efficiency of utilization of PCI facilities operating area.

To meet the challenge of the optimized energy resource efficient layout of complex process pipeline (CPP) heat systems, a software package allowing for minimization of reduced costs for process pipeline systems and increase of efficiency of utilization of petrochemical industry facilities operating area with due account for the heat exchange process simulation models, engineering, structural, process, geometry, flow dynamic, physical and chemical restrictions of pipeline layout, was developed. The software package is implemented in the PML utilizing tools of DABACON object-oriented database, AVEVA Engineering design data control system and AVEVA PDMS computer-aided design system [1–7].

The authors stated the input engineering task related to the optimized energy resource efficient layout of CPP heat system. With due account for the requirements of PCI facilities design standards related to arrangement of CPP structures and maintenance areas, prescribed physical and chemical parameters of process flows of chemical process system and data of handling the task of the optimized arrangement of main process equipment [1, 8, 9], it shall be required to select such optimized option of heat system layout for the prescribed optimized chemical plant process flow chart, when reduced costs for heat systems are minimum with due account for

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mandatory adherence to chemical plant (CP) operation conditions related to output of the required products of required quality and in required quantity [1–3].

As part of the software package, de-compositional topological-heuristic (DTH) algorithm allowing for selection of optimized energy resource efficient routes for 3D laying the complex process pipeline heat systems developed by the authors is implemented in the macro-PML.

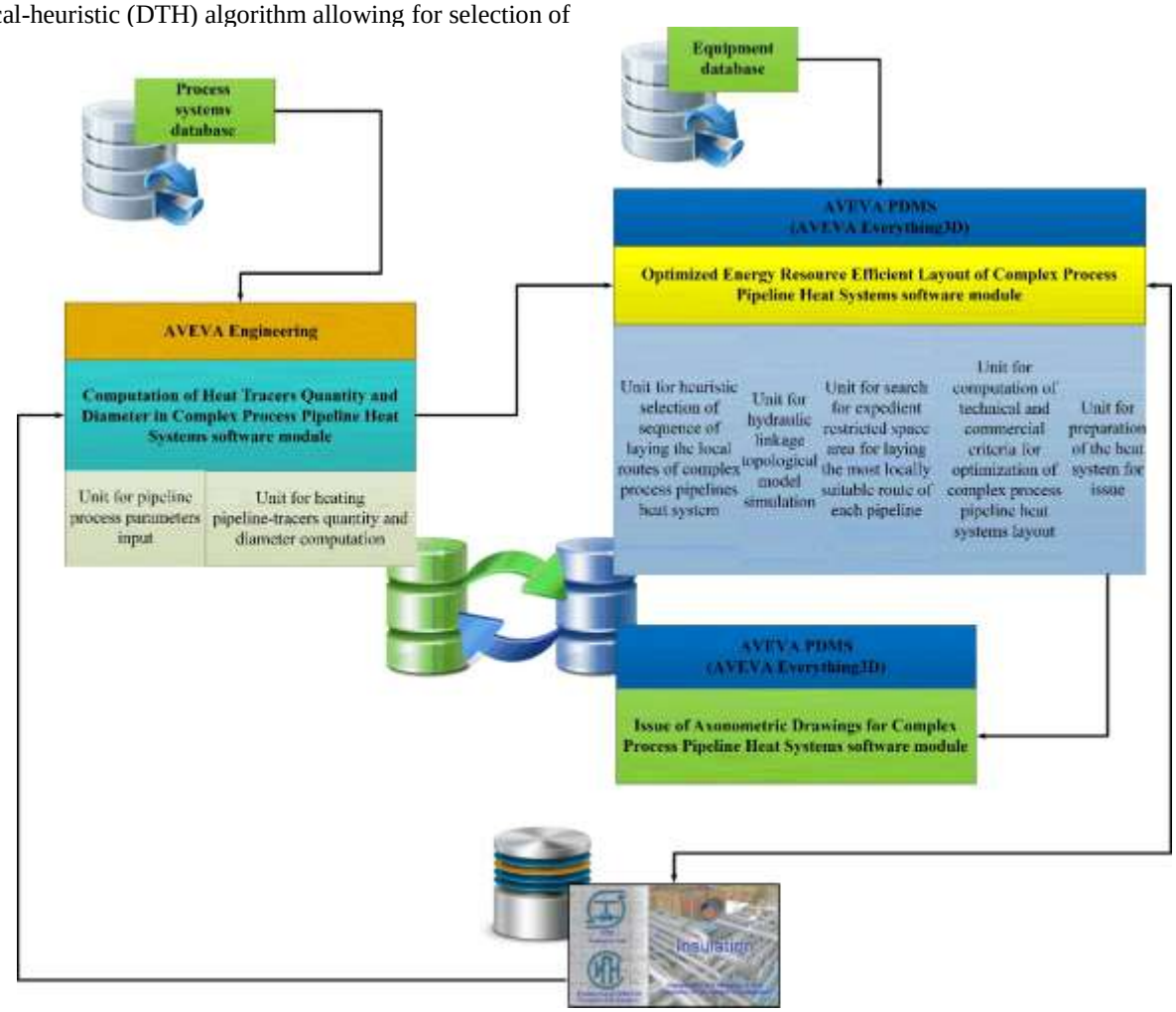

Fig. 1. Architecture of Software Package Key Modules Interface.

De-compositional topological-heuristic algorithm includes the following five stages:

Stage 1. Hydraulic analysis of the complex process pipeline heat systems with the use of standard topological algorithms for hydraulic linkage (HL) analysis.

Stage 2. The procedure for heuristic selection of sequence of laying the local routes of each pipeline (PL).

Stage 3. Simulation of a hydraulic linkage topological model as a hydraulic structure graph with due account for the set of heuristic rules.

Stage 4. Topological and heuristic search for expedient restricted space area for laying the most locally suitable route of each PL.

Stage 5. Computation of the corrected diameter of each PL laid within a passageway or area.

Application of the developed DTH-algorithm of optimized energy resource efficient layout of complex process pipeline heat systems has allowed for 10%-reduction of material and energy costs due to optimization of PL network design, operating costs and capital investments for re-designing the chemical plant.

The software package architecture shall include three basic modules and is shown in Fig. 1. Developed program and algorithm support of the software package shall allow for computation of heating pipe (tracer) quantity and diameters based upon the process parameters estimated at the design stage; 3D layout of the optimized energy resource efficient routes of the complex process pipeline heat systems at the final design stage; automated issuing the final axonometric drawings for optimized energy resource efficient routes of heat systems; transmission of the obtained data for optimization of heat insulation structures of the CPP heat systems to Insulation computation program developed by NTP Truboprovod.

The proposed software package is applied in practice for handling the engineering tasks related to laying the optimized energy resource efficient routes of complex process pipeline heat systems of elementary sulphur plants at refineries (Refer to Fig. 2).

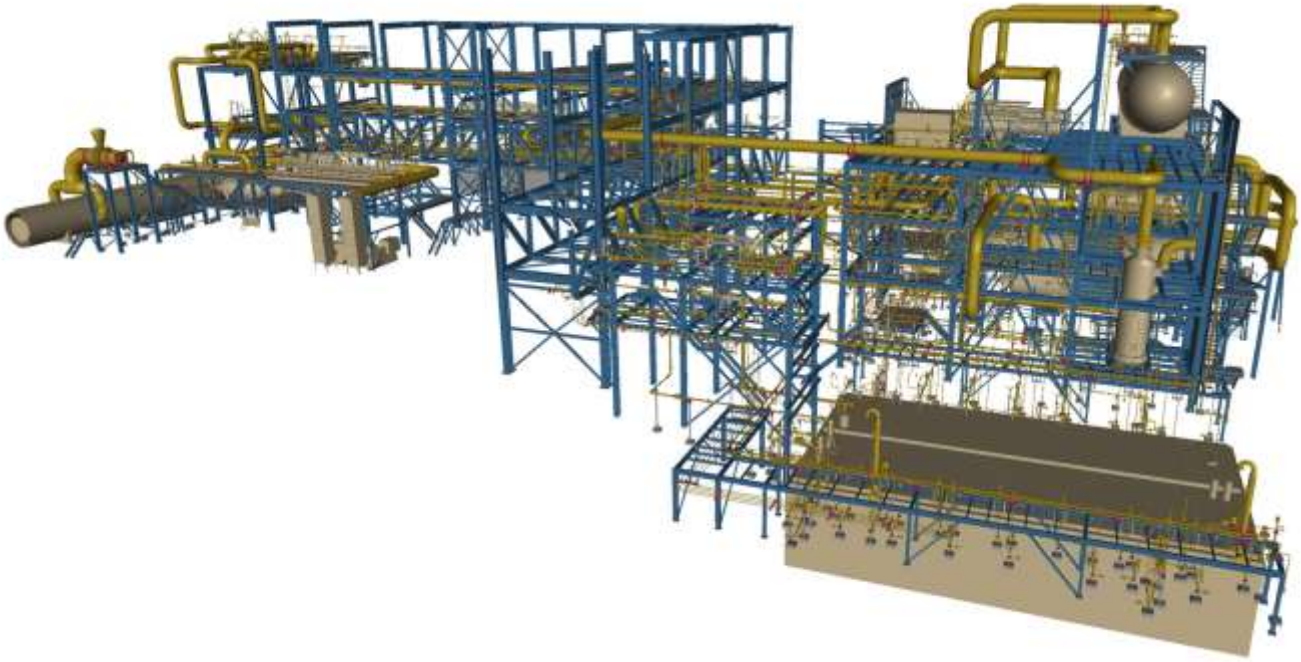

Fig. 2. Detail of the Optimized Energy Resource Efficient Layout of Elementary Sulphur Plant Complex Process Pipeline Heat System

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