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APPLICATION OF EES SOFTWARE AND AI TOOLS FOR CONCEPTUAL SYNTHESIS OF CHP SYSTEMS

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ABSTRACT

It is commonly accepted that inside the whole European Union within immediate 15 years some significant investments are expected in both the electricity production as well as in energy transfers. Such investments will need the precise decision-making processes, supported with versatile engineering tools. To make of any analysis required by a designing process fairly general, type and structure of the power plant has to be decided. This absolutely fundamental decision, fraught with consequences, is equally essential for huge system power stations as well as for small units of distributed electricity generation. All decisions made have to take into account demands for energy of all kinds as well as the local natural resources with special emphasis on the fuels. Coupling element of those two is just a power plant (*i.e.* electric power station, CHP, tri-generation unit *etc.*). Its detailed project always refers to the type and structure of the plant and to series of assumptions regarding technical data like level of pressures and temperatures within cycle and so on.

The major objective of this paper is to discuss an application of a new methodology applicable to automatic synthesis of a power systems taking into account a combined cycle power plant as an example. This methodology follows an idea published by Melli and Sciubba [1, 2] and utilises the current artificial intelligence tools like selection algorithm, artificial neural networks, expert systems, genetic algorithm etc..

It is currently assumed that structure of the power plant is composed from basic energy devices like compressor, expander, steam turbine, combustion chamber, heat exchanger, fluidised bed, mixer, etc. Connections of those devices are specified in so-called connectivity matrix. This is rectangular matrix in which its rows represent all input flows while its columns represent all output flows associated with particular devices. Entry of a representative coefficient c_{ij} can take only value 1 (meaning input number i is the same as output number j) or 0 (meaning there is no connection between input number i and output number j). Changing those coefficients one can easily modify the structure of the plant. Simplicity of such modifications create favourable conditions for systematic search for a new structure.

Genetic algorithm searches for the best solution (individual) among feasible structures

of the power plant (i.e. chromosomes). This is done by means of proposing successive structures of the power plant defining the connectivity matrices made of binary elements. Considered elements and structure itself are also verified according to previously defined knowledge base system (by means of such logical operations as: deduction, induction, decision tree scanning, etc.). This knowledge base system contains logical information (of procedural and declarative type). The exemplary entries of such expert system can take value of:

if one of the inputs/outputs of device is used, then all remaining must also be used,

if there is electricity demand, then the electricity generator is needed,

if the generator exists, then the mechanical power is needed,

if the expander exists, then there is mechanical power,

if the steam turbine exists, then mechanical power is available,

if the steam turbine exists, then the steam generator is needed,

possible steam generator is waste-heat boiler, and many other similar constrains.

Decision making process is based on genetic algorithm which requires the fitness function evaluation. At this stage of the analyses as a fitness function the energy efficiency of the cycle is used. It should be noted that in order to determine energy efficiency an appropriate thermodynamic models of the considered cycle need to be build and solve. In-house Fortran code was developed and is currently used to generate a text file containing the full description of the set of equations which reflect all mass and energy balances within considered structure. Such text file is then read by the Engineering Equation Solver [3] which searches automatically for a solution of the above defined equation set.

This paper is devoted mainly to the methodology, although some preliminary numerical tests are also included. Following works will essentially present computational aspects of the proposed approach as well as results of the computer simulations.

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