DSS Scheme for Operation Optimization Problem on Power Plants

Jiang Hao* Xu Zhigao

(Department of Power Engineering, Southeast University, Nanjing 210096, China)

Abstract: Based on the target analysis of the operation optimization for power plants, a novel system scheme called operation optimization decision support system (OODSS) is brought forward. According to the structure and design thinking of decision support system (DSS), the overall structure of the OODSS is studied, and the scheme of the sub-systems in the OODSS such as the user interface system, the problem processing system, the database system, the model base system, the expert system (ES) and the data mining system are put forward.

Key words: power plant, operation optimization, DSS, database system, model base system, data mining, expert system

According to the developing status of the electric power industry, the economical operating of power plants is a very important problem to study. The operation optimization is a powerful method for the economical operating management. In this paper, a novel operation optimization system scheme called operation optimization DSS (OODSS) based on the DSS architecture is studied.

1 Background

The operation optimization system for power plants (PPOOS) is a software packet whose main object is to make an evaluation or a decision on the operating status of the power unit with some defined target value, and to make guidance on the unit adjustment[1]. These include 4 contents:

1) Provide the operators the performance value to reflect the real-time operating status with the online performance calculation.

2) Provide the operators the optimization target value to reflect the optimized operating status with the online optimization value analysis.

3) Provide the operators the online diagnosis and the adjustment decision support with the deviation analysis.

4) Provide the managers the statistical report about the operating status examination and the equipment adjustment decision support.

The study and the application of the operation optimization are very active now, but there are also some problems in this field:

1) On the object orientation, they always orient to the monitoring, but not the decision.

2) On the designing orientation, they can process only structured problems, but not semi-structured problems or non-structured problems.

3) On the instruction aspect, they are short of the ability to process operation instruction based on artificial intelligence (AI).

The power plants operation optimization management is an operator-manager oriented, semi-structured problem type decision problem, and should be designed and implemented with the DSS architecture.

The operation optimization DSS (OODSS) makes use of the data processing, model processing and analysis ability of the computer system, and helps the operators and the managers to make efficiency decision with a powerful user interface system. Using the DSS architecture, the OODSS can process the semistructured problems successfully.

2 Overall Structure

2.1 Basic structure

The basic structure of the OODSS is shown in Fig.1[2]. It consists of 3 parts: an integrated component, which includes a user interface (UI) system and a problem processing (PP) system, a model base (MB) system and a data base (DB) system. The basic problems of the PPOOS are processed by the problem processing system together with the user interface system, the MB system and the DB system.

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* Born in 1976, male, graduate.

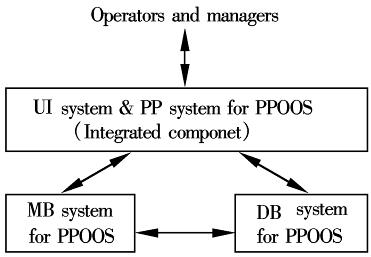

Fig.1 Basic structure of OODSS

2.2 Synthetic structure

The data warehouse (DW), the online analysis processing (OLAP), and the data mining (DM) are new techniques on DSS. They can provide novel schemes for some difficult problems on PPOOS, such as the optimization value problem.

The expert system (ES) is used to construct the intelligent decision support system (IDSS). ES can help the DSS to process the operation instruction problem.

The synthetic structure of OODSS shown in Fig.2[2] is made up of DW, OLAP, DM, ES and the components in the basic structure. This structure consists of 3 sub-systems: the 1st sub-system is made up of the MB system and the DB system, the 2nd is made up of the ES and the DM system, and the 3rd is made up of the DW system and the OLAP.

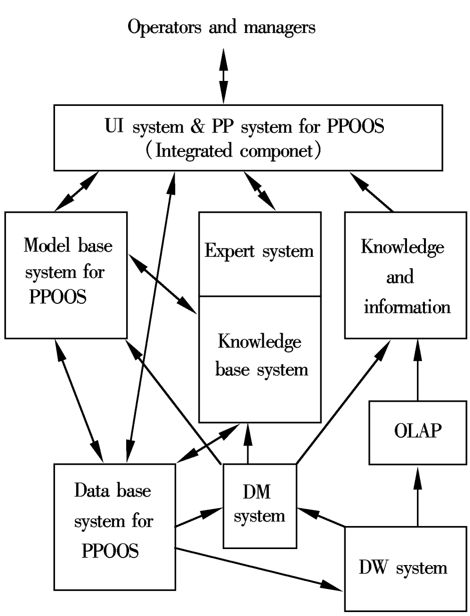

Fig.2 Synthetic structure of OODSS

Not all of the 3 sub-systems of the synthetic structure are needed to make OODSS. Each sub-system is independent, and can be integrated. The OODSS, which will be referred subsequently, is made up of the 1st and 2nd sub-system, and it is an IDSS in fact.

3 Particular Structure

In the OODSS now used, there are several components, such as the UI system, the PP system, the MB system, the DB system, the DM system and the expert system. Each component has its own structure.

3.1 MB system

The MB system should provide model support to all of the problems of PPOOS. As we have discussed, the operation optimization system has its own problem structure; the model system organization structure is something like it. The structure is shown in Fig.3, and it is made up of many sub-models. The model system structure has several layers, and some parts of them are shown.

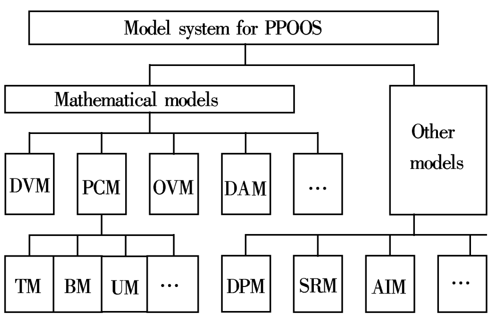

Fig.3 Model system organization structure

Abbreviation in Fig.3:

DVM: data validation model;

PCM: performance calculation model;

OVM: optimization value model;

DAM: deviation analysis model;

DPM: data process model;

SRM: statistic report model;

AIM: artificial intelligence model;

TM: turbine calculation model;

BM: boiler calculation model;

UM: unit calculation model.

The MB system is made up of the model base (MB) and the model base management system (MBMS), and its structure is shown in Fig.4.

The MB consists of the model system shown in Fig.3 and the model index (also called model dictionary) providing the index for the model caller. The MBMS has 2 main functions called static managing and dynamic managing. The static managing function includes sub-functions such as model creating, model deleting, model querying, and model maintaining. The dynamic managing-module performs the models' running managing and provides models' combination

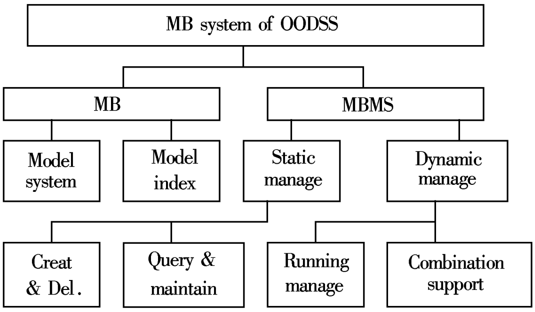

Fig.4 MB system organization structure

support as well.

For example, during the unit performance calculation, the MB system will provide running model support to the performance calculation module in the problem processing system; the running managing module in the MBMS calls the appointed model (such as the turbine calculation model, the boiler calculation model, etc.) with the model index to realize this support function.

3.2 DB system

The DB system should provide structured data support to all of the problems of PPOOS. The real-time data is obtained from DCS data highway or plant real-time database, and then stored[3]; the manual data is inputted by user and then stored; the output data of the OODSS needs to be stored as well. All of these are included in the database of the OODSS. The OODSS DB system is made up of the database and the database management system (DBMS), and the DBMS is a bridge between the OODSS database and the processing modules in the problem processing system.

3.3 DM system

The DM system discovers knowledge needed by OODSS from the database with the given method or technique. On the one hand, it can provide knowledge to the ES through the knowledge base (KB) system, and on the other hand, it links the MB system, and provides support to the DVM and OVM in Fig.3.

Take the OV module for example: with the statistical analysis on the database of the OODSS, the DM system can obtain the optimal value of each performance targets and operating parameters with the relationship to the load of the unit. In this way, the DM system can help the OV module to fulfill the optimization value analysis. An example of optimization value analysis result based on the DM method is listed in Tab.1.

Tab.1 OV analysis result of a 200 MW power unit

Item	Load		
	200 MW	180 MW	150 MW
	Reference/Optimal	Reference/Optimal	Reference/Optimal
p_0/MPa	12.90/12.96	12.70/13.06	12.60/12.93
t_0/℃	535.00/538.98	535.00/538.47	535.00/536.15
t_r/℃	535.00/538.76	535.00/537.64	535.00/532.39
p_c/kPa	5.20/5.44	4.80/4.84	4.20/4.19
t_{fw}/℃	243.00/238.06	234.60/234.61	220.40/225.96
t_{eg}/℃	129.60/129.31	126.00/125.69	120.10/122.32

In Tab.1 p_0 is the pressure of main steam; t_0 is the temperature of main steam; t_r is the temperature of reheated steam; p_c is the pressure of turbine exhaust steam; t_{fw} is the temperature of feed water; t_r is the temperature of boiler exhaust gas.

The optimal value based on the DM method and the reference value based on the traditional method are both listed, and with a compare of them, it can be concluded that the DM based OV analysis is efficient and useful.

Since the optimal value and reference value can both provide the optimization target value reference to reflect the optimized operating status, certainty factor or weight for each of them must be determined to get the universal target value. It is a multiple model based, semi-structured problem in fact; OODSS can connect together with users through the UI system to process this type of problems, and the users can give the system some extra information about the certainty factor or weight for each of these value series.

3.4 Expert system

The expert system (ES) helps the DSS to process the operation instruction (OI) problem. The deviation of controllable operating parameter between its physical value and its optimization value in a running unit is caused by some factors of the operation level, the unit status, and the automatic control system. The operation instruction system should have the ability to determine the cause and the effect of the deviation, and give the guidance and the assistance to the operators. In the ES, the deviation cause and its settling scheme can be stored in the knowledge base, and then the inference engine can make an online diagnosis while the unit is operating and give operators the online guidance or the assistance.

3.5 Integrated component

The integrated component including the UI system and the PP system is the head component in the OODSS. It works under the monitoring of the users, and communicates with the other components of the OODSS to process all of the problems of PPOOS. The running logic structure of this component is shown in Fig.5[4] (the sub-systems called by the modules are marked in the brackets), and it is also the main running logic of the whole OODSS.

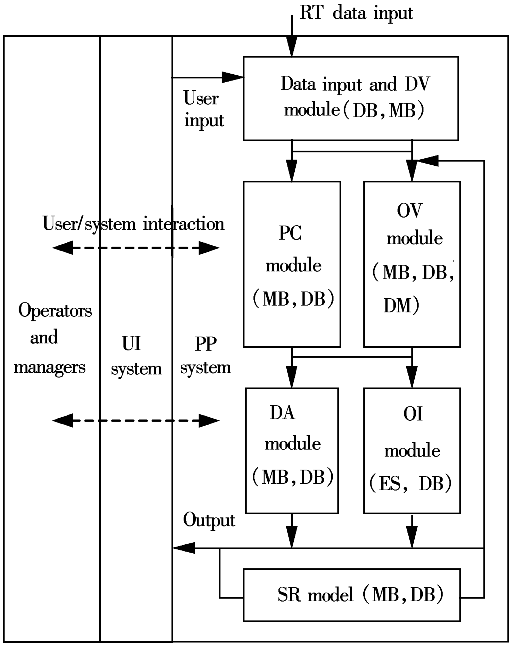

Fig.5 Logic structure of integrated component

Abbreviation in Fig.5:

DV is the data validation; PC is the performance calculation; OV is the optimization value analysis; DA is the deviation analysis; OI is the operation instruction; SR is the statistic report.

The real-time data and manual input data is obtained by the "data input and DV module" and then shared by all of the modules in the problem processing (PP) system. The "PC module" fulfills the performance calculation function while the "OV module" performs the optimization value analysis. The result of these two modules is then put to the "DA module" and the "OI module", which perform the deviation analysis and the operation instruction. The "SR module" fulfills the statistic report function. All the results of the modules are fed back to the users through the UI system.

Take the "PC module" for an example, when the module is called, it gets the input data from the DB system, and gets the running model support from the MB system, and then performs the calculation, and puts the calculation result to the DB system in the end.

4 Conclusion

In this paper, the overall structure of the OODSS and the design scheme of its sub-systems such as the integrated component, the MB system, the DB system, the DM system and the expert system are put forward.

This novel scheme for the power plants' operation optimization system can resolve the problems in the PPOOS field discussed in part 1, and it is proved to be efficient, preponderant and recommendable.

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电站运行优化问题的决策支持系统方案

江 浩 徐治皋

(东南大学动力工程系,南京 210096)

摘 要 基于电站运行优化问题的目标分析,提出新颖的电站运行优化决策支持系统(OODSS)解决方案.依照决策支持系统(DSS)的结构及其设计思想,对 OODSS 的总体结构进行了研究,并对其主干子系统:包括人机交互系统、问题处理系统、数据库系统、模型库系统、专家系统(ES)与数据开采系统等的设计提出合理的方案.

关键词 发电厂; 运行优化; 决策支持系统; 数据库系统; 模型库系统; 数据开采; 专家系统

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