Quality assurance for power plant simulation

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Abstract: - Quality is a relative concept that depends on different criteria, some objective and some subjective. For the simulation of the process in power plants, the Total Quality Management (TQM) and the ISO 9001-3 guidelines are useful instruments. These are of help in achieving satisfaction and confidence with a minimum effort, in a short time and with low costs. The paper presents a quality assurance flow-chart for the power plant simulation models. Some simulation philosophy elements used for a 50 MW thermal power plant are given as example.

Key-Words: - quality assurance, total quality management, power plant, simulation

1 Introduction

The quality of a power plant simulation model is a relative concept that depends on the reference point: on whose point of view is defined, the requirements (expectations) for the final product etc. Quality doesn’t have the same meaning for the developer and for the customer, as the developer’s expectations are different from the customer’s ones. Moreover, the expectations may be different from one customer to another and from one developer to another, depending on his objective and subjective reasons. Thus, quality is a complex concept, on which a quality philosophy is developed [1].

The complexity of power plants simulation modelling requires a total quality approach. The Total Quality Management (TQM) focuses both on quality and management, using specific techniques. The key issues of TQM are: customer satisfaction, continuous improvement, teamwork [2]. Other elements of TQM include cost reduction, leadership and top management, training and education, organizational culture [1].

Recommendations on how to assure and control quality are given by the International Organization of Standardization through the ISO 9000 series standards. The specific standard applicable for software applications is ISO 9001-3 and it contains guidelines to the development, supply and maintenance of software [3].

By developing a quality plan, the compliance to the customer requirements can be easily tracked during the development of the simulation model phases and also easy to control. This increases the confidence of the customer and of the developer at the same time [4].

The paper presents the quality assurance flow chart for the development of power plant simulation models. It was used for the simulation of a 50 MW thermal power plant.

2 Quality assurance flow-chart

The modelling and the simulation teams need to have both scientific knowledge (of mathematics, physics, engineering and computing) and natural/educated qualities (talent, experience, inspiration, innovation etc.). Scientific knowledge about the different physical processes that occur in a power plant is a task that can be accomplished by studying and learning. The qualitative component of the team represents the delicate part, making a difference in the final products quality. Good planning is a good way in handling activities in which is involved a high percentage of qualitative work, hard to quantify and to manage [6]. Building a sound quality control plan is one of the keys of TQM.

According to ISO 9001 2008 [5] quality assurance must establish SMART quality objectives. The letters of the “SMART” word emphasize the main characteristics of the objectives: specific (S), measurable (M), achievable (A), realistic (R) and time bound (T).

Following the concepts of quality assurance, fig. 1 shows a quality assurance flow-chart for power plant simulation models. The first two phases are very important for the future hardware and software
2.1 Project definition
From the very beginning, there is defined the input and the output of the project. The functional criteria are very clearly and accurately defined:
- the scope of simulation: if simulation is used for training, process control, optimization or for another scope,
- the customer requirements regarding the software and hardware of the simulation: reliability, acceptable tolerance, performance requirements etc.,
- the input data: the detailed physical system description, the way of operation, known parameters, measurements etc.,
- the normal and abnormal operation conditions, with data resulted from such situations
- the limits / boundary conditions of the future simulation model,
- the comparison data (from measurements, other experiments etc.), used for testing, verification and validation of the model.

2.2 Simulation philosophy
In this phase the principles of simulation are defined. The criteria that are used for power plant modelling might include:
- MODULARITY. Complex problems are split into several modules and sub-modules. A library of modules is developed, the simulation model being assembled by accessing different modules/sub-modules and by matching their input and output variables.
- MODELING PRINCIPLE. The modelling principle is preferably based on the laws of physics (laws of conservation, heat transfer etc). Other principles may be used, like artificial intelligence or black-box techniques, separately or mixed.
- SIMULATION CODE. For developing the software, a programming language or other specialized soft may be used.

The following phases - of design (3), testing & verification (4) and revision (5) - are addressed separately for each module/sub-module.

Fig.1. Quality assurance flow chart.
2.3 Design of modules

During the phase of design, the criteria defined in the first two phases are used to SMART develop the simulation program modules. This phase includes [7]:

- **Mathematical modelling.** The physical phenomenon is described by using the laws of physics (laws of conservation, heat transfer etc) and/or other mathematical relations.

- **Algorithm developing.** The mathematical model is written as a sequence of mathematical algebraic and logical operations. Special attention is taken to consider all possible situations and to set up the initial and boundary conditions.

- **Simulation code writing.** Based on the algorithm, the source code is written, according to the simulation philosophy adopted.

2.4 Modules testing and verification

The simulation program is run in different situations to check that it satisfies the input requirements, defined in the first phase [4].

A discrepancy between the simulated data and the comparison data may appear because of the assumptions, approximations and simplifications made during design [7]. A confidence and precision level of 90/10 is usually accepted, based on the observation that simulation can be in the optimistic case as good as the input data (which has commonly a 90/10 confidence/precision level) [8].

2.5 Modules testing and verification

Depending on the testing & verification results, the simulation model may need to be revised. In this case, errors occurred during the prior phases (mathematical modelling, algorithm developing, simulation code writing or simulation philosophy definition) are identified and eliminated.

2.6 Modules assembling, testing and verification, revision

After obtaining acceptable results at testing & verification of all the modules and sub-modules, they are assembled by matching their input and output variables. Testing & verification are again pursued, this time for the assembled simulation model. A revision is made if needed.

2.7 Validation

During validation, the simulation model is checked for meeting the customer’s requirements (according to the project definition phase) and for executing the expected tasks [9].

3 The simulation philosophy of a 50 MW thermal power plant

Some simulation philosophy elements used for a 50 MW thermal power plant are given as example.

The modules are defined using two levels of modularization:

- process equipments: the mechanical equipments of the power plant which are responsible for the process,
- automation equipments: the automation equipments that control the operation of the mechanical equipments
- additional applications: other supplementary applications that command the automation and the mechanical equipments.

![Fig. 2. First level of modularization.](image)

The second level of modularization states the modules that are included in each group defined at the first level [10].

The modules of the mechanical equipments’ group contain: the boiler, the turbine, pumps, condenser, cooling tower, heat exchangers, deaerators, steam reducing valves, valves, pipes, nodes etc. By linking the modules of mechanical equipments, the scheme of the power plant is determined (fig. 3).

The modules of the automation equipments’ group contain control modules: transducers, actuators, controllers etc.

In the third group, additional applications for the operation of the power plant are included: optimization, for the support of decisions, management of data etc., depending on the simulation requirements.

The mathematical models are based on the laws of physics: laws of conservation, heat transfer etc.

The code used for developing the simulation program is Turbo Pascal.
Such a simulation philosophy was used for developing a training simulator [11] and for an expert system for the analysis, economical management and operation of a thermal power plant [12].

4 Conclusion

In developing simulation models for power plants, it is recommended to use the Total Quality Management (TQM) concept and the quality assurance guidelines, so as they are given through the ISO 9000 standards. These help to achieve and to sustain the quality of the simulation models, giving also confidence to the customer and management.

The quality plan is a good instrument to ensure and assure the customer’s satisfaction within a shorter time and with lower costs. A quality assurance flow-chart for power plant simulation modelling is given.

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