From Concept to Manufacture - Optimising the design and implementation of Process Plant.

The pressure of international competition is being felt in the field of plant engineering with a demand for shorter development times and reduced project costs. A consistent and efficient approach to plant design can help to dramatically save both time and money. The challenge of work-flow in the engineering of process plants remains with high numbers of people and departments involved in the passing of different data formats and media, often resulting in duplication of effort, inconsistency of data and disparate systems resulting in lost time and higher costs. Integrated and consistent design data can be a decisive factor for competitive success. 3D-CAD programmes alongside the deployment of standardised interfaces and central data management is already making a continuous work progress for the individual stages of procedural planning possible today. The next step towards increased efficiency is the smooth merging of process planning and control technology through an integrated planning approach. Simon Ellam from Siemens Industry Automation explains more.

Before a process plant can be taken into operation, a variety of individual, independent planning stages is necessary, in which the most varied of specialist disciplines (so-called trades) are involved. These range from process technology through mechanical engineering and electro measurement and control technology to software-programming. The specific know-how of all those involved must be integrated into the overall project.
Each of the disciplines has recourse to specific methods and tools; the element combining them is the utilisation of computer applications to support the planning. Computer Aided Engineering (CAE) is an important component in the handling of the respective tasks. The spectrum of software deployed in this ranges from self-programmed developments of one’s own and established applications that are used at specific stages of the development, through to trade-spanning tools that have come to define quasi-international standards.

The process of engineering is strongly dependent upon the division of labour, i.e. the planning of automated industrial plants is a very complicated structure that those handling the individual stages can only survey in its entirety with difficulty, if at all. Mutual dependencies are indeed known, but are often not seen as a problem. Those involved processing the planning data in the format necessary for their own work and then passing them on. Data consistency is at its most important at the time of transmission. This leads to a multitude of discontinuities in the entire process with data transmitted in the form appropriate to the respective tools.

With regard to the three important key factors in an engineering project: quality, costs and adherence to delivery dates, it is imperative that multiple data entries, different levels of information and lack of transparency in the documentation should be avoided. There have been approaches developed during the past years regarding the planning and realisation of plants, in particular around control technology project management, the potential for rationalisation from which plant operators can already profit today, and future developments that are conceivable.

An increase in engineering efficiency may be achieved in various ways. For example, software manufacturers attempt to guarantee them by expanding functionalities or by creating inter-disciplinary tools. Standardised interfaces that allow exchange to take place between the various trades also afford the possibility of minimising the transaction expenditure along the value-creating
change. A number of international organisations concern themselves with the improvement potential that is latent in engineering and give, in part, concrete recommendations for actions to both software manufacturers and users. These include GMA 6.12; VDI/VDE 3695, DIN EN 62424 and NE 100.

Three basic principles guide an approach to plant engineering projects.

- **Computer Aided Engineering (CAE)**
  The most important of the trades involved in plant engineering – process planning, plant planning and process control planning – all have recourse to CAE-software. On the basis of the computer-supported engineering, all trades attempt, during the planning phase, to portray the correct construction of the plant with the aid of models long before they are actually constructed. In the engineering field, tools provide assistance with regard to the organisation, project management and purchasing departments. The pieces of information received from the various trades do not exist independently of one another, however and the redundant storage of data in individual tools has been recognised as a problem.

- **Process flow**
  The description of the process is the beginning of the plant planning. The engineering systems of the individual trades are supplied with basic information on the basis of these verbal descriptions. Procedural and pipeline technicians as well as automation specialists begin their work on the basis of this information. Manufacturing instructions, apparatus designs, quantity and volume flows are established. At each stage of the process, equipment will be allocated and requirements defined. Subsequently, the appropriate functional components will be selected for the automation system. On the basis of the description of the procedural flow, the automation engineer is able to compile a functional design specification for software development purposes. The software engineer incorporates this information in the configuration and takes care of the creation of the software in the automation process. At a number of
the stages questions arise: the entire process is iterative and passes through several cycles.

- **Lifecycle**

The general planning process described is a very important phase in the overall lifecycle of a plant. During this phase the technical, organisational and economic basis for the plant is developed.

A more detailed view of the abstracted lifecycle of process engineering plants provides a better understanding of the planning and installation phase. If a company wishes to base its view of the workflow upon a more exact procedural flow it runs up against limits; the demands in the field of plant engineering are too different and companies follow their respective individual workflows. The ability to model the lifecycle of a plant and the product it will produce simplifies the identification of the number of sequential procedural steps and corresponding transition points required.

The examples below highlight how the planning phase can be approached in a multi-disciplinary manner and the transition from the planning phase to the start of operations benefit from an integrated focus.

**The Planning Phase**

The subdivisions within the planning phase of the life-cycle model reflect the fact that a number of trades are involved in the total planning process. The plant planners for the Front End Engineering and Design (FEED) often work for completely different companies than those who are responsible for the Detail Engineering or the purchasing and construction planning. The tasks to be carried out at each phase of the project require the expert knowledge of specialists.

- **Front End Engineering and Design (FEED)**
Here, a rough plan is undertaken which is decisive for the following tasks. The production process is drafted and simulated. Process specifications and procedural flowcharts are compiled in order to describe the plant.

- **Basic Engineering**

The results of the FEED are refined, the tender for the plant drafted and documents for the approval process compiled. Planning engineers decide upon the deployment of equipment, machines and pre-fabricated components, so-called "Package Units". Specialist engineers and process technicians develop the flowcharts for the pipe lines and instrumentation. These form the schematic basis for the plant: apparatuses, engines, pumps are depicted symbolically and joined together. Measuring points are indicated for the measurement and regulatory technology and the foundation for the control technology concept along with the measuring principles are developed. Furthermore, consumers of electricity are identified and circuit diagrams conceived.

- **Detailed Engineering**

Before the plant can be built, an exact specification is required. This is the phase during which the equipment, machines and other pieces of equipment are ordered. A 2D- or 3D-installation diagram makes the locations of these parts of the plant visible in a 'virtual environment'. In the Detail Engineering phase, the functional plans, the field planning and the documentation of low-to-medium voltage applications and the automation (on the basis of comprehensive plans such as circuit, cable and cabinet arrangement plans etc.) are compiled.

In this phase, the plant planning (up to this point neutral with regard to the target system) is bound to a particular system, i.e. the decision is taken in favour of a specific type and manufacturer control system technology – generally a Distributed Control System (DCS). In this regard, the libraries for the types of measuring points and hardware are designed in accordance with the specifications for automation during the detailed planning stage.

**The Path to more Efficiency**
This brief outline makes clear the number of inter-disciplinary tasks that require the deployment of the widest variety of tools. The consistency of the tool chain is decisive for an efficient engineering workflow. The VDI/VDE-guideline 3695 “Evaluation and optimisation of plant engineering” demonstrates this in more detail. The category “auxiliary materials” says the consistency of the tool chain may be achieved via four attainable target statuses. Reflected in the software developments of major manufacturers this results in the following picture:

- **Target status A**: Electronic documentation from planning

- **Target status B**: Deployment of computer-supported planning software with data formats that can be evaluated on computers → heterogeneous planning

- **Target status C**: Data exchange between tools via corresponding interfaces → homogenous planning

- **Target status D**: Automatic electronic data exchange within integrated systems → integrated planning

Target **status A** has today already been realised in the majority of cases, in particular with regard to larger-scale plans the documentation is prepared in electronic form and no longer only on paper. The special characteristics of target statuses B to D are set out below.

**Heterogeneous Planning**
A plethora of participants, tools and data formats is often the reality of planning projects. Even admitting that a comprehensive list of the tools is deployed, naming their areas of deployment and data formats, cannot be reproduced. However, the heterogeneous form of plant planning can be equated to the target **status B** defined in VDI/VDE 3695. The planning data from the various tools is available in the form of data that may be evaluated by
computers, either in a proprietary file format or as XML- or CSV-files. These files are on principle reusable and valid for various trades. However, information is either lost during the exchange between two kinds of tools or it has to be improved manually afterwards.

**Homogeneous Planning**

More tool manufacturers are offering a comprehensive portfolio of task-oriented tools from a single source. Proprietary interfaces often ensure the exchange of data but the use of standardised interfaces would be preferable. The import or export is initiated manually by the user and target **status C** is attained and electronic data exchange between tools in accordance with work procedures. This exchange can also function between software applications made by different manufacturers, assuming there is a standardisation of interchange format and interfaces.

**Integrated Planning**

The target **status D** quoted in VDI/VDE 3695, which describes an automatic electronic data exchange with independent consistency review, and data-linkage can only take place in completely integrated tool packages. The strict honouring of this status would mean data consistency throughout all trades including DCS-engineering and has to this day not yet been attained. Only the deployment of one single data basis would enable this exchange of data without any transformations. A centralised or completely consistent storage of data in appropriate databases is essential for this.

So far this approach has only been pursued by a limited number of companies in the field of process technology planning. These software suites provide application modules for specialist applications on a single platform and the exchange between the applications is done automatically. In the course of the planning objects are furbished with an increasing volume of information that is added to the individual trades. In their turn the trades have at their disposal a specific view of the object and information irrelevant to their own tasks is shut out.
These objects can be provided with substructures and relationships so that a model of the plant may be developed. The graphic and alphanumerical characteristics of an object form a common unit within the database. A smooth merging of procedural technological planning and control technology project work can only succeed on the basis of rigorous cooperation between the providers of planning tools and manufacturers of process control technologies.

**The Operational Phase**

The handing over of the plant to its operator marks the end of the planning and construction phase. In the context of the start-up, “As-Built” data, in particular, is frequently subject to changes. Plant-wide access to up-to-date project data and an intelligent system of revision management are the keys to a smooth start-up of operations. To this end, a smooth exchange of data between planning tools and DCS-engineering is required and consistent documentation can only be provided if the systems, at the time of change, are on the same level of information. This is very important in plants for which qualifications are mandatory, for example pharmaceutical industry plants.

Upon the transmission to the operational phase the tools also change with operations-accompanying systems for repair and maintenance work or Enterprise Resource Planning (ERP) systems crucial for this stage of the plant’s life cycle. These systems also require information that has already been collected during the planning phase, for example maintenance requirements, inspection plans, device characteristics. These should be taken over directly from the CAE-tools.

A further important component of efficient engineering is the planning and documentation during on-going operations. During the life time of a plant, alterations, expansions and optimisations are everyday occurrences. These alternations are made under enormous time pressures and it is necessary to waive the advance procedural documentation. This changes the workflow and a company must be in a position to restore the alternations carried out on the
plant during operations in the planning “as-built” – another argument that speaks for homogeneous and/or integrated planning.

This way of proceeding constantly keeps the documentation up-to-date and ensures data consistency from the request via the draft version through to realisation. On the basis of up-to-date planning data, planned expansions can be reviewed to establish feasibility. Thanks to the standardisation of interfaces and/or integrated data storage on a life-cycle-oriented platform, information remains intact throughout the operational phase. Data formats independent of manufacturers lead to a greater degree of independence of the plant operators in the choice of their providers. Even changes to the controlling system can be realised with far less expenditure on the basis of up-to-date and complete planning data.

Summary

The optimisation potential in plant planning is far from exhaustive. Nothing much is likely to change regarding the multi-disciplinary nature of engineering, but for the tools it is a very different story. In order to shorten project times, offer task-specific support and guarantee consistent documentation, the planning tools of the future need to be optimised even further. Integrative approaches using planning suites on consistent data platforms will become more effective when DCS-manufacturers are able to place their tools directly upon it. Closer cooperation between planning software suppliers and control technology manufacturers will make a decisive contribution in the future to the development towards an integrated plan across trade boundaries. Major automation and infrastructure companies like Siemens are helping to pioneer this integrated approach and have already made huge strides in breaking down the data barriers between engineering disciplines. As this development continues, process manufacturers with the ambition to reduce their time to market are opening their eyes to the major untapped efficiencies and cost savings that streamlined plant engineering can offer.
Notes to editors:

About Siemens Industry Automation & Drive Technologies

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