SUPPORTING CAVITY PRODUCTION USING AN ENGINEERING DATA MANAGEMENT SYSTEM

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Abstract

The reliable production of superconducting cavities is a critical success factor for any future accelerator applying the "cold" technology. At DESY the complex manufacturing process is supported by an engineering data management system (EDMS). Presently the EDMS supports the quality management during the manufacturing of the cavities and controls the subsequent conditioning process. The paper presents the structural approach for the documentation using a commercially available EDMS. Supporting the lifecycle by electronic workflow techniques is described.

INTRODUCTION

Producing superconducting cavities with the anticipated high gradient in big quantities for future accelerators implies well understood production processes at a very detailed level. This asks for a complete documentation from design to commissioning.

At DESY the production of super conducting cavities is practiced for more than ten years. Thus as early as in the late 90th electronic support of the documentation tasks was requested. At the same time powerful software tools for product information management became available. These tools, now commonly known as "product data management (PDM)" or "product life cycle management (PLM)" systems, were focussed on big plant construction and on aeroplane and automotive industry.

Building accelerators is comparable to large scale plant construction (e.g. oil drilling platforms). Thus the idea came up to use industrial tools to support the construction of future accelerators at DESY. In 2001 a commercially available PLM System was introduced and adopted for DESY's needs. It was rolled out under the label "EDMS" (**E**ngineering **D**ata **M**anagement **S**ystem"). In the context of superconducting cavity production the tool is used for supporting two processes, namely the mechanical production of the cavity from niobium sheets and the subsequent surface conditioning.

EDMS BASICS

The main issue of an EDMS is to support the full product development process from the first sketch to installation (and even further). The EDMS is thus supporting business processes during the life cycle of a product. This is done by storing all relevant information during the product life cycle and to automate the processes. EDMS users have access to this information and can inspect the process history.

Object information is stored in different views, namely in the "*manufacturing view*" and the "*design view*".

The *manufacturing view* describes the world of tangible objects, e.g. a (manufactured) cavity. The *design view* describes the world of models; this comprises plans for manufacturing, e.g. a design model of a cavity. Furthermore one has to deal with *documentation* as a third category, which *describes* both tangible objects and design models, e.g. a drawing (fig. 1).

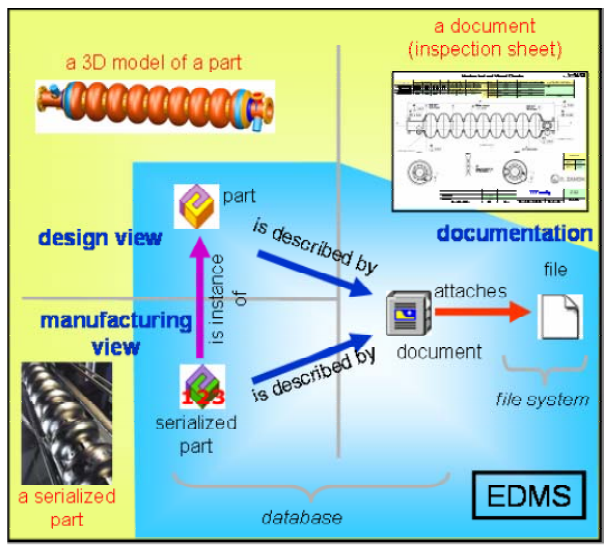

Figure 1: Objects and relations in EDMS.

Models, which have been created (and modified) during a *design process,* are represented in the EDMS as "*parts*". A tangible object, which has been created during a *manufacturing process* according to a (designed) part, is represented as "*serialized part*". Serialized parts have typically a serial number. Both, parts and serialized parts can be described by "*documents"*.

The EDMS stores information about the objects in form of attributes (also called metadata). Hence an object is described by a set of attributes. Different classes of objects may have different sets of attributes.

The system allows setting relations between objects. Different classes of relations can be defined: A "part" may have the relation "*is described by*" to a "document". Serialized parts are related to the (designed) parts by the relationship "*is instance of*" (fig. 1). Using the relation "*uses*" between parts allows defining part breakdown structures. E.g. a cavity *uses* a end group as substructure.

Files, containing the information electronically, can be related to the describing document by a relation "*is attached*" (fig. 1).

During their life cycle the objects can have different life cycle states (e.g. *working*, *released* …). A workflow engine, which is part of the EDMS, provides means to change the life cycle state and to perform operations on

these objects automatically. An operation can be e.g. demanding an EDMS user to release an object by an electronic signature.

Technically the EDMS is a software system built in a client-server architecture around a database, the files are stored in a file system, which can be exclusively accessed by the system. The commercial available software system, on which the EDMS bases, has been customized to the requirements of the users at DESY.

SUPPORTED PROCESSES

Mechanical Production of the Cavity

The present production process of cavities for the TTF is characterised by many quality assurance steps: after each production step mechanical and frequency measurements are performed and documented. The requirements for the EDMS are the following:

- Provide easy access to the quality assurance documents.
- Store them in a structured way.
- Allow navigation from a given cell in a given cavity to the primary niobium sheet and vice versa.
- Provide access to the technical drawing and other technical information in the same structure.
- Allow to give a specific life cycle status to any produced assembly and / or subassembly and provide an automatic workflow to promote from one state to the other.

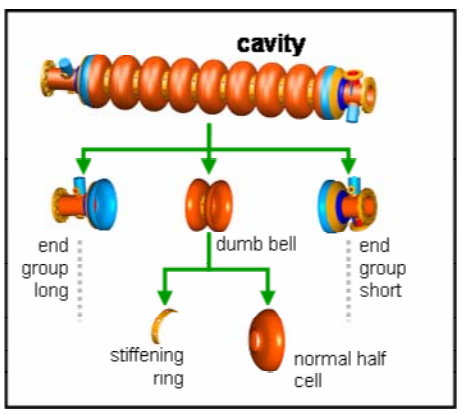

Figure 2: Design view (part breakdown structure).

These requirements demand implicitly for two views on the cavity: (1) the "design view" (fig. 2) as it is represented by 3D models and technical drawings and (2) the "manufacturing view" (fig. 3) as described by the quality management documents.

The design view refers to the product breakdown structure (fig. 2), which is represented in the EDMS by parts and the relationship "uses".

Each of these parts can be described by documents as shown in fig 4 (left). The product structure is automatically created by the 3D CAD system, which is fully integrated into the EDMS. All documents including 3D model files, visualisation files and drawings are automatically stored with the necessary relations in the EDMS.

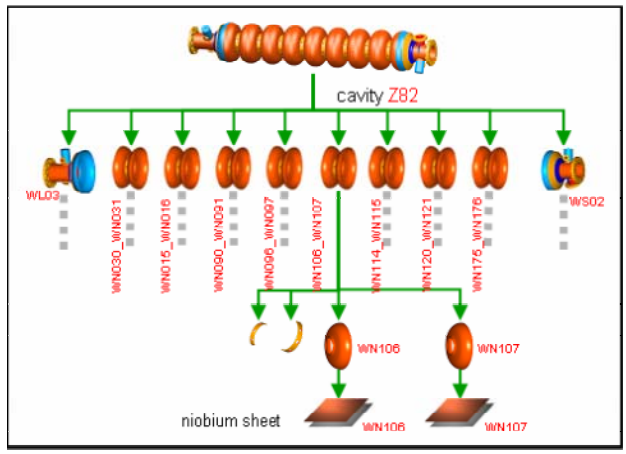

Figure 3: Serialized parts with serial numbers (manufacturing view) .

The manufacturing view refers to the manufactured real world objects (fig 3) including the niobium sheet. Serialized parts have individual properties (e.g. a result of a mechanical measurement) and are represented in the EDMS by serialized parts which have part numbers. In this use case the serialized parts are described by documents of the class "quality management document" which have inspection sheets as files (fig. 4 right). An inspection sheet is completed and then released during the production process.

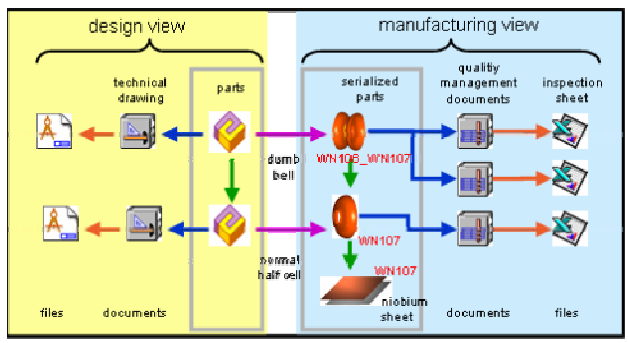

Figure 4: Documents and files for parts and serial parts.

The objects of both views are subject to workflows, which are controlled by the system. A drawing can be in the life cycle state "working". It is checked out by a draftsperson for modification and checked in. This can be repeated until it is decided to review this object and to release it e.g. for production. This life cycle is controlled by the EDMS: persons are allocated to the roles of reviewer, releaser, etc. E-mails inform these people about their tasks, which they find in the system's inbox. They can sign off the required action electronically in the system. Afterwards the object has the status "reviewed" or "released". People retrieving for this object in the system can easily find the latest (released) version of an object, e.g. a drawing.

Similar workflows are used for serialized parts and the associated quality management documents. E.g. a document describing the cavity under production contains a description, which serialized part (dumb bells, endgroups,

...) has to be positioned at what place. This document is compiled at DESY and sent by the system to the manufacturer as work instruction. The manufacturer welds the cavity and performs the measurements as required in a further document. The later is sent back by the system to the engineer surveying the production process remotely. He decides by an electronic signature, whether the cavity is released for the next step or whether further manufacturing steps are necessary.

At present, the production of 30 cavities for TTF at an Italian manufacturing company is documented in the EDMS. About 1650 serial parts with 3300 quality management documents are stored and managed in the EDMS.

Cavity Conditioning Process

After the delivery to the DESY site, the cavities undergo a complex process of different treatments. Controlling and documentation of this process is supported by the EDMS. To this end a special class of documents has been created, the so called "work packages". A work package (WP) describes the tasks one or more teams have to perform with a given cavity. For different tasks templates are available.

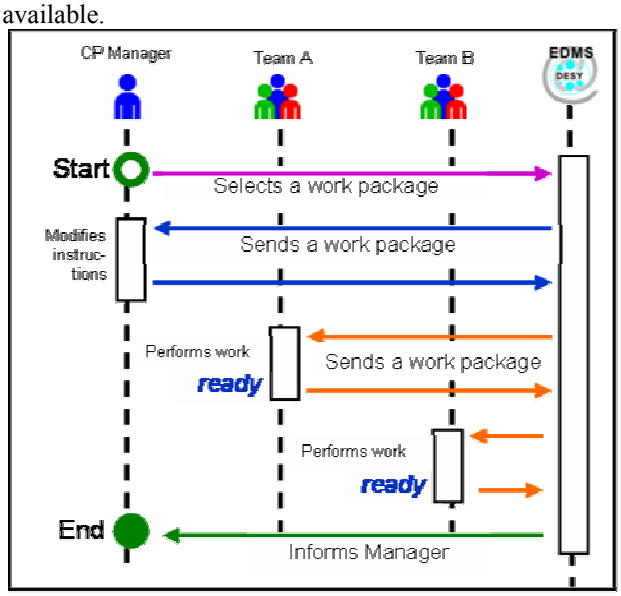

Figure 5: Workflow for work packages as supported by EDMS.

The cavity process manager (CP manager) selects a WP template, edits the tasks, and determines which teams have to do the work. Next he issues a workflow from the system (fig. 5), which sends the task to the first team; a member of the team claims this WP, performs the tasks, enters data as required into the system and fills out a form. Signing off the WP by a team member tells the system that the task has been finished. The system sends the WP – if required – to the next team or back to the CP manager. The persons involved in the process get informed via e-mail and their system's inbox.

The WPs are related to the cavity, which is an object of the class "serialised part". Further comments, notes etc. are also related to this object, hence easy navigation to all information is possible. Also navigation to the quality management documents described above is easily possible. At present several thousands of WPs are stored in the System describing the conditioning operations with the cavities since 2001.

EXPERIENCE AND OUTLOOK

The EDMS as customized at DESY supports well the needs of the present production of cavities for the TTF.

The EDMS is used at DESY beyond the described use cases as general purpose document management system and for special applications (e.g. to support the planning of the XFEL [1]).

Although some users consider putting information to the system as additional work, they consider it as a benefit that they can find all documents at a single point of access. Navigation and traceability though the system are also acknowledged.

In future the EDMS is supposed to extend its support in the context of this paper along two lines:

- The subsequent assembly of several cavities to a so called cryo-module shall be supported.
- The supported processes will be revised for series production for the XFEL. They shall be further automated by workflows. The quality management of external manufacturers shall be completely integrated into the workflow in order to allow an easy controlling and documenting of the manufacturing process remotely at DESY.

One of the lessons learned was that process control supported by a EDMS system has to be introduced in an early stage of a project. An introduction of a system like EDMS when production has already started causes losses in time and efficiency; documentation is often done twice: in the traditional way and in the EDMS.

In summary the EDMS has become an essential tool to support quality management for the serial production of superconducting cavities.

REFERENCES

[1] J. Bürger *et al.*, "Establishing a Collaborative Planning Procedure for the European XFEL", PAC'05 (these proceedings), Knoxville, May 2005.