3D virtual models applied in power substation projects

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***Abstract*—The present work briefly presents a methodology that has been developed and applied in a success manner to create complete 3D virtual models for power substations. This work describes the different modeling process stages for each kind of element of an installation, pointing out the mean problems that have been faced to represent real objects that can be manipulated in an easy way with common software programs. Finally, this work shows a real case application, in which the development of a 3D virtual model for a transmission substation, 230 kV and 60 MVA, worked very well as a visual support to take decisions about its expansion.**

Keywords: 3D virtual model, substation, modeling, virtual walk.

I. INTRODUCTION

Nowadays is imperative that the industries involved in the process of design and construction, including those that design new products, develop models that represent in a very realistic way the characteristics, details, operation conditions and performance of the elements or the systems that need to be manufactured or installed. This allows visualizing the results and functionality of the finished product, even before to begin the construction.

The use of 3D models in several work areas is necessary because of the need to increase the reliability and security of the installations. The electrical power systems aren't the exception.

The application of those models in power transmission projects, including power substations, has been focused principally to reach the following requirements:

- To show in a clear way and with a high degree of details, the characteristics of the projects that are going to be constructed.
- To have a support tool that permits to prepare more efficient designs and keep a better performance over the construction of the project.
- To visualize in very easy way the real extension of the projects, helping to decide over important changes on it.
- To have an instrument that permits to train the personnel involved on the planning, construction and operation of the power systems.

II. MAIN STAGES IN THE DEVELOPMENT OF 3D MODELS

The development of a complete 3D virtual model implies the execution of various stages, in each of which is imperative to establish the objectives to be achieved. This with the purpose that at the conclusion of the tasks, the designers have a model which satisfies the requirements established before.

In projects so far developed using 3D models, there have been established the following sequential steps:

i) Collecting information. To begin with the development of the 3D model it is necessary having lots of information about the mean characteristics of the substation, its equipment and systems to model all the elements in 3D. This step demands a lot of time because, normally, not all the information is in the same place. For this reason it is necessary to search in several information sources, which sometimes is difficult to access. Some items that should be collected are: catalogs, pictures, images, maps, as build plans, standards, specifications, etc.

ii) Modeling elements. Once most of the information have been collected, the next step is to model each element that integers the substation. This step is the one that takes the most of the time, because the task of modeling each particular element is a lot of time consuming and, in some cases, there are elements too much sophisticated. Since the purpose of the 3D model is to show the installation in a realistic form, it is necessary to create each model in three dimensions, which requires more effort and time. Before starting with the modeling stage, it is important choosing the adequate software that will be used to create 3D models, as well as the level of detail for modeling. This choice is essential, because it will affect the development of the subsequent steps in order to elaborate the 3D virtual model. The high level of detail demands lots of time to create every element, which is translated in greater requirements of memory and greater difficulty to handle. Therefore, we must find the adequate balance between the level of the details and ease to handle the elements with the programs that are used.

The main elements which have been modeled in projects of power substations are the following:

- Primary equipment

- Structural elements
- Structural modules
- Civil elements
- Buildings
- Other installations

Figure 1 shows an example of the equipment that has been modeled and used in a 3D virtual model of substation.

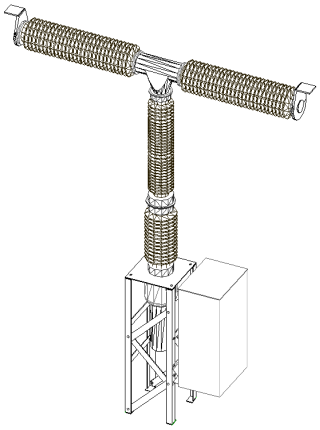

Figure 1. Model for a circuit breaker of 400 kV.

iii) Integrating the installation. Once all the elements of the substation have been modeled, the next step is to integrate all the elements in the same space, in order to generate the installation. This integration can be developed with the same program which was used to model the elements, or with other software that will be used in the next step. In this stage we can realize that the level of detail is important because when the elements are joined in a unique file, sometimes they are difficult to handle. It's important to mention that the better computer equipment is the easier and faster to manipulate the model and the result is having a greatest efficiency in the process. Figure 2 shows an example of the stage of integrating the installation.

Figure 2. Power substation model 230/115 kV.

iv) Fixed virtual tour. Once all the elements have been integrated to make up the complete substation, we continue with the virtual tour plan that involves the installation and the environment. For this, it's important to identify the adequate software with which we can create a virtual tour with a fixed path. In several virtual tours, the methodology applied has followed the next steps:

- Location into the work place.
- Assignation of materials to all the elements of the substation.
- Selection of the environment and the sort of illumination.
- Selection and allocation of the effects during the animation.
- Selection of the path that the animation will follow.
- Selection of the kind of video out file and its length.

The features and scope of each step is associated with the kind of program that is used to develop this tour.

Based on the experience in some developed projects, some approximations have been estimated about working time to develop a complete virtual model following the sequential stages mentioned above. The main figures are showed in Figure 3.

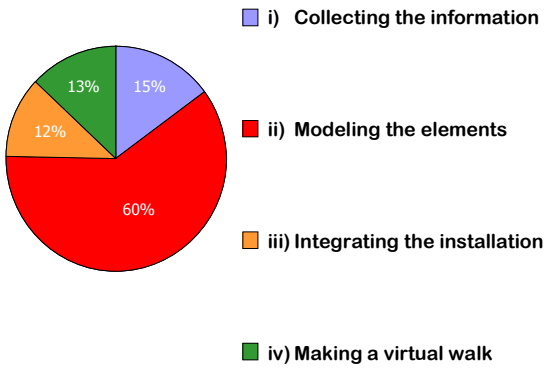

Figure 3. Working time figures in the developing of 3D virtual models.

III. PROBLEMS ABOUT MAKING 3D VIRTUAL MODELS

Although the process of elaboration virtual models deals with several problems, the most severe is when it is necessary to extend a power substation; the mean troubles about this are the next:

- In the most of the cases the existent installations are much larger than the new zone.
- The information about the existent installations normally is not available in electronic format.
- A huge time investment to model the existent zone.

Other important aspect about this is refers to have a powerful equipment to process the amount of information that is required; a computer without the necessary features could fail, or takes a lot of time to execute any necessary task.

A successful realization of the project depends on an adequate plan to develop each task and the strategy followed to solve the problems explained above.

IV. VIRTUAL MODEL OF XOCHIMILCO SUBSTATION

Xochimilco substation is located in the region of Xochimilco, part of Mexicali town in Baja California, Mexico. This substation is integrated by the next components:

- A three-phase transformer of 40 MVA with the voltage levels of 230/13,8 kV.
- Two feeders in 230 kV that link Xochimilco substation with Wisteria and Mexicali II substations.
- A metal-enclosed switchgear, voltage level of 13,8 kV, with five feeders.
- A capacitor bank of 2,4 MVAr in 13,8 kV.

The bus bar arrangement in 230 kV is principal bus + secondary bus with transference circuit breaker, while the 13,8 kV arrangement is single bus.

Due to the huge demand that has been presented in the Mexicali 2006 summer, it was decided that the capacity of the substation should be increased in 50 MVA to assist the energy requirements in the surrounding area.

To achieve this goal, two options where proposed: the first consisting of building a new substation in the surrounding area, outside the town, while the second one was about to extend the existent substation. In both cases, it was necessary to install an additional three-phase transformer of 40 MVA with double relation (230-161/13,8 kV), which was available as a spare in another power substation.

The personnel in charge to operate Xochimilco substation had some doubts about the feasibility of expand this substation, because the reduced space in the switchyard. This was the reason to prepare a 3D virtual model of Xochimilco substation, with the purpose of verify the feasibility of the demanded expansion.

Some alternatives were prepared, including one that shows the feasibility of adding a new bay in the 230 kV switchyard, which was the one that demonstrated the feasibility of the project.

The project was developed, and the new power transformer was energized in Xochimilco substation on august 2008. Figure 4 shows an aerial view of the 3D virtual model of Xochimilco substation.

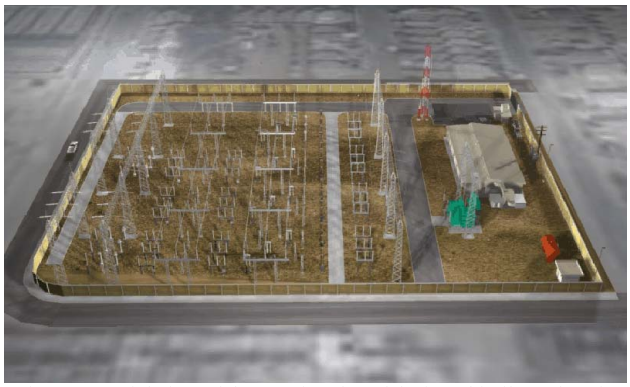

Figure 4. Aerial view of the 3D virtual model of Xochimilco substation.

V. CONCLUSIONS

Nowadays the use of 3D virtual models is very necessary to show the features, details, operation conditions and behavior of the whole elements that integrate a system, which permits to visualize the finished product before it is constructed.

The developing process of the virtual model has several steps, some of which consume large amounts of time and resources.

To elaborate a virtual model it's necessary to make a balance between the detail levels and the facilities to handle the components that integrate the 3D model.

3D virtual models is a tool that aids having a better perspective about the project before it's developed which give the chance for testing several possibilities to execute it with high realism.

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