EXTENDED USE OF SPECIAL OPTION 6

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ABSTRACT

Special Option 6 (SO 6) has been designed for the automatic turbine acceptance test data correction to standard operating conditions, as specified to the turbine vendor.

The computerized archives of the actual power plants keep record of measurements made usually under operating conditions different from the standard ones and with a poorer measurement quality.

Israel Electric Corporation has put up a computerized procedure based on the PEPSE-PC program. A highly flexible model combined with SO 6 can boost the use of the archived data for monitoring and maintenance purposes.

INTRODUCTION

The last twenty years have been marked by the accelerated pace of "computerizing" the power plants, old and new alike. The high benefits of fast decision - taking and monitoring have strongly advertised for this action.

The latest efforts have been made mainly to provide the "control room"personnel with" on-line "data processing softwares with extended "learning" and "what-if" capabilities. Still, there are other decision - taking groups that need a broader time span to collect data and analyze them.

Huge computerized archives for logic and analogic descriptors of the events that took place in the power plants have been set-up. Dedicated "off-line" softwares, like PEPSE-PC, might process these data and give answers to the questions of the power plant management aimed at long-term processes.

Standard turbine tests require high measurement quality and special actions to be taken (power limitation, cycle isolation, steady operation of the unit for a prescribed time span a.s.o.). I.E.C.'s goal has been to widen the use of the archived data, to try to use lower quality measurements and less restrictive operating conditions to obtain information about the main cycle components. This information should be comparable to the one obtained from the standard tests.

A highly flexible and up-to-date design model can produce the benchmark data required for the correction of the calculated heat rate and generated electric power resulting from the archived data .

HEAT RATE AND GENERATED POWER CORRECTION TO STANDARD OPERATING CONDITIONS

The steam/water cycle is a very complex function of a high number of parameters, some independent and some dependent of each other. There is no question about the necessity of correcting the calculated heat rate and the generated power to standard operating conditions by means of a full heat balance re-calculation (with the same throttle valve opening). Both the U. S. standard [1] and the International Electrotechnical Commission standard [2] express the same view.

However, the lack of means (fast calculation, sufficient vendors' data, detailed test data a. s. o.) has produced an alternative method: the correction by means of parametric curves. Usually, these curves are built by the turbine vendor, before the Acceptance Tests. The curves are built for a small number of parameters, loads, for the "design" configuration of the plant. These curves cannot be used even after a short working time since the efficiencies of the turbine stages can differ substantially from the designed ones. Even if new curves are built after the Acceptance Tests, the sequential correction, although accepted by the above-mentioned standards, can produce significantly different results [3].

Our experience has shown that a strong design model can be built with PEPSE-PC . Based on the Acceptance Tests of the main components (steam turbine, heaters , pumps a. s. o.) this model can be finely tuned. The results obtained with such a model , based on "as-built" data, can be used as a reliable benchmark for a full heat balance re-calculation.

A STRONG DESIGN MODEL

Theoretically, there are no preferential reference points for power plant equipment monitoring.

For the Acceptance Tests, the reference points are usually those supplied by the turbine Vendor. In most of the cases these points are also valve "best" points (easy to attain and reproduce).

For routine monitoring , the reference data are collected either in the "new and clean" status of the plant or after some major equipment changes (retubing, reblading, a.s.o.). The operating points are, understandably, the valve "best" points!

It is obvious that the number of tests for reference is also economically limited to a small number. In order to have reliable reference points other than the few "best" points the PEPSE model can be successfully used. This model has to be highly flexible, detailed and thoroughly checked.

The first step taken by I.E.C. was to build an "as-designed" model. This model included all the relevant data supplied by the vendors (schedules, performance data sheets, drawings, operating set points a.s.o.). Some of the solutions we found suitable for a PEPSE model are mentioned hereafter: The boiler feed pump had variable speed. The vendor supplied a family of curves for the total developed head vs. volumetric flow and speed and another family of curves for the efficiency vs. volumetric flow and speed. I.E.C. developed a combined control - operations - schedules algorithm that yields the correct T.D.H., volumetric flow, pump efficiency and rotational speed for the operating conditions required by the heat balance.

The horizontal heaters with U-tubes have been modeled with a split steam path in order to allow for a correct water level influence.

--For the main steam lines (extractions, cold and hot reheat, main steam) and for the superheater and reheater components the pressure drops and heat losses are calculated for all the operating conditions based on isometry or vendor reference data.

In addition, a fairly large number of by-pass, emergency drain lines and some of the associated valves have also been included in the model. These elements allow calculations for unusual operating configurations.

The next step in the build-up of the model has been to check and correct most of these data according to the Acceptance Tests. Since the measurements are made, corrected , stored a.s.o. with the utmost care during these tests, the collected data have to be considered as ... "best possible". The result of this step was an "as-built" model of the turbine cycle.

The last step was to confront the "as-built" model with some unusual operating conditions and to check its ability to produce reliable results. Most of these conditions are well known "break-down" situations:

-- one turbine driven boiler feed pump is replaced by an electric driven one;
-- one feedwater heater is out of service,
-- a heater by - pass line is partially opened.

As expected , the calculated data agreed fairly well with the measured ones and the model has been " qualified " for benchmark data calculations. Earnestly, it should be mentioned that this step has also given us the opportunity to ... debug the model.

It is also worthwhile mentioning that, despite the large number of components, streams, controls, operations and schedules in the model, it did converge steadily and fastly for all the cases.

FIELD DATA ACQUISITION FOR SO 6 CALCULATIONS

I.E.C. is using a PI archive for the long term storage of the measured data. These data are stored after calibration and transmission corrections have been made. Besides the specific PI storage procedures no other manipulation of the data is made.

In order to get correct results, PEPSE has to be used according to its fundamental concept: steady state heat and mass balance calculations. Therefore, the measured data to be used for SO 6 have to be collected over a steady state operation time span of the power plant (unit).

It might be useful too to recall to our memory the requirements of the Steam Turbine Acceptance Tests Standards (any of them) regarding the data acquisition: ...all the boundary conditions (for the turbine cycle) -- temperatures pressures, flows in and out the cycle, any valve position , a.s.o. -- have to remain unchanged for at least one and a half hour before measurements can be started.

In order to comply with the steady state condition, I.E.C. has devised a special PI application: it is meant to check that the operating point chosen for a SO 6 calculation had a time span longer than 1.5 hours. The operating point has been defined by several key - parameters and their accepted deviations (power, main steam temperature and pressure, hot reheat temperature, reheater spray flow, a.s.o.). Under the term "accepted deviation" we understand normal small fluctuations.

The building of a second application is under way too: it is meant to build a map of the PEPSE streams with the OPEN/CLOSE specification based on the PI recordings of the positions of the relevant valves. Any change in this map, detected during the chosen time span, means that the plant configuration has been altered during the data acquisition and therefore the data set is not valid for the SO 6 calculation.

Since the routine field data have a lower quality than the data collected during the Acceptance Tests , I.E.C. has decided to include in the data set some redundant data (e.g.: electric power for electric pumps, flow measurements, a.s.o.) and the appropriate operations. These data can be used instead the measured data if they are missing or clearly unreliable - instrument or data transmission fault.

EXTENDED USE OF SO 6 TO
NON-STANDARD OPERATING CONDITIONS

I.E.C. has put up a procedure which enables the performance engineer to use SO 6 for long term analyses. The procedure can be started only after the "as-built" model has been qualified for benchmark data production. This procedure has several steps:

-- Step 1: Test data selection

The user asks for a main steam flow span and eventually for a calendaristic time span (year, month, hours).

The data sets found are checked for completeness (all the required data should be present) otherwise the set is rejected.

The data sets found are checked for the steady-state condition: their time span should exceed 1.5 hour and no change should occur in the stream map otherwise the set is rejected.

One of the remaining data sets can be finally written down into a file, called "No. 1" - external file for PEPSE.

-- Step 2: Test data primary screening

Since we did not want by any means to alter the measured data, no data validation procedure has been used. Still, as recommended in ref. [6], a visual screening of the main turbine expansion lines per sections had to be performed before submitting the selected data set to SO 6. This screening can be done after the data set is input into a "performance only" model and run, eventually using SO 2, to a satisfactory convergence.

If the results of this run are deceiving - unacceptable expansion line or low convergence conditions - a new set of data has to be selected.

-- Step 3: Benchmark data production

The user ran the " as - built " model under SO 1 using the main steam flow and the stream map got from the external file "No.1".

The model is in full design mode.

A special output variable list is built in a file " no . 2 " - external for PEPSE .

-- Step 4: SO 6 analysis

The user ran the model under SO 6: - the benchmark set is in " performance mode " and gets its data from file "No. 2"; - the test set gets its data from file "No. 1".

The final result is a "standardized" complete heat balance complying with the "test" requirements with the operating conditions chosen freely (almost) by the user.

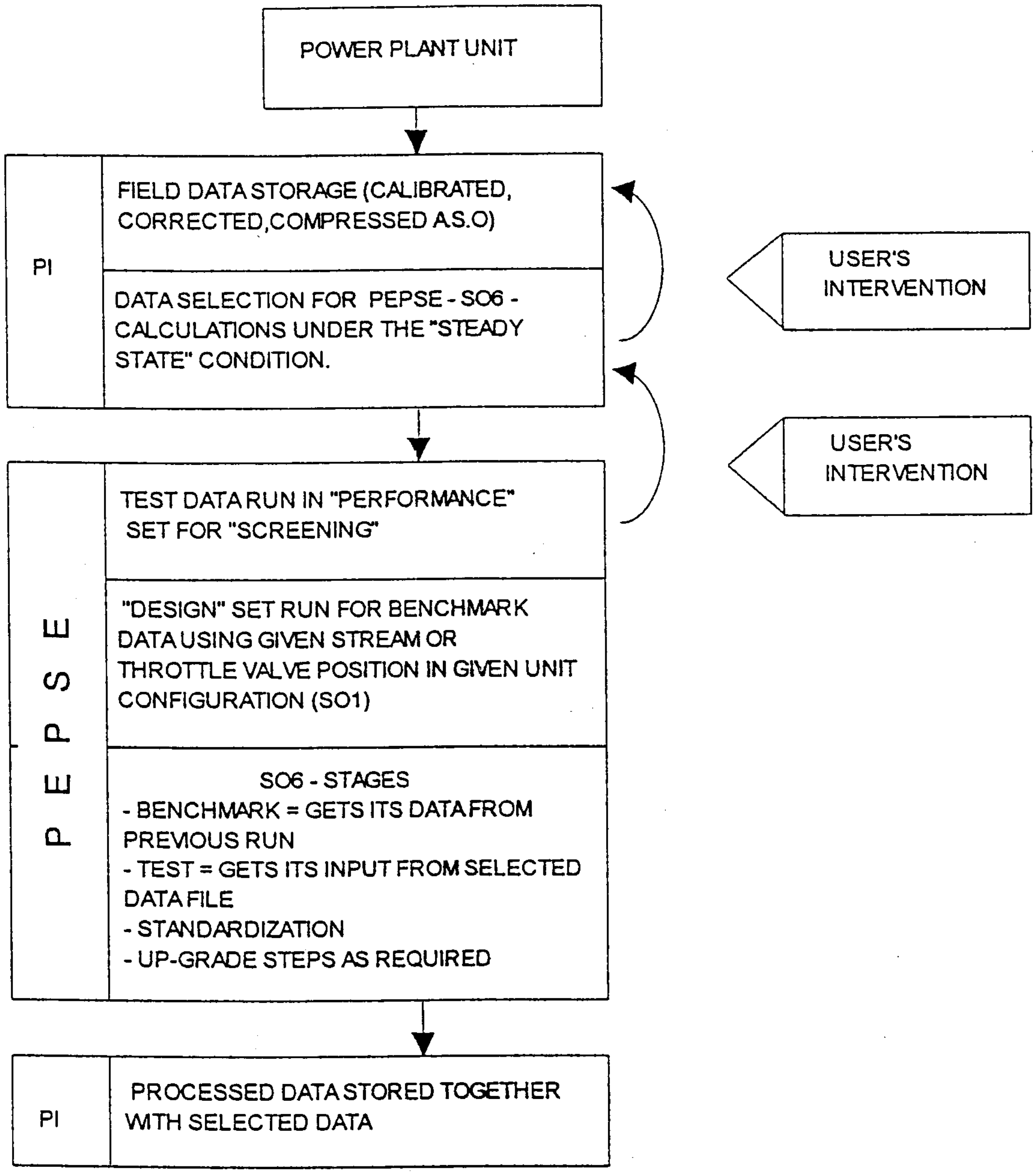

FIG.1

Flow chart for I.E.C.'S procedure for the processing of stored field data using PEPSE.

RESULTS

The individual steps of I.E.C.'s procedure have been in use for some time now. Although a lot of user intervention was necessary the final results did confirm that the archived data , properly selected and processed with PEPSE , could yield valuable data . These data could serve for monitoring or maintenance purposes together with the test results.

The procedure , as a whole package however , is still undergoing a through scrutiny in order to find acceptable answers to some still bothering questions:

- What should be the connection between the "steady state" definition for data selection and the PEPSE convergence data?

- Should this procedure be the exclusive "asset" of an advanced PEPSE user or should it be transformed into a "black box" for anyone?

CONCLUSIONS

The possibility of using PEPSE - PC for analyses of field data stored in the computerized facilities of the power plants has been investigated with positive results. The procedure presented in this paper has to be further developed in order to have a sure and smooth calculation.

REFERENCE LIST

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