Case Study – Rehabilitation of a 600 MW thermal power plant

CPS with its sister company Advanced Technology Company assumed the responsibility of rehabilitating a 2X300 MW thermal power station that runs using natural gas and heavy fuel oil as fuel sources. The work done in the station included the following:

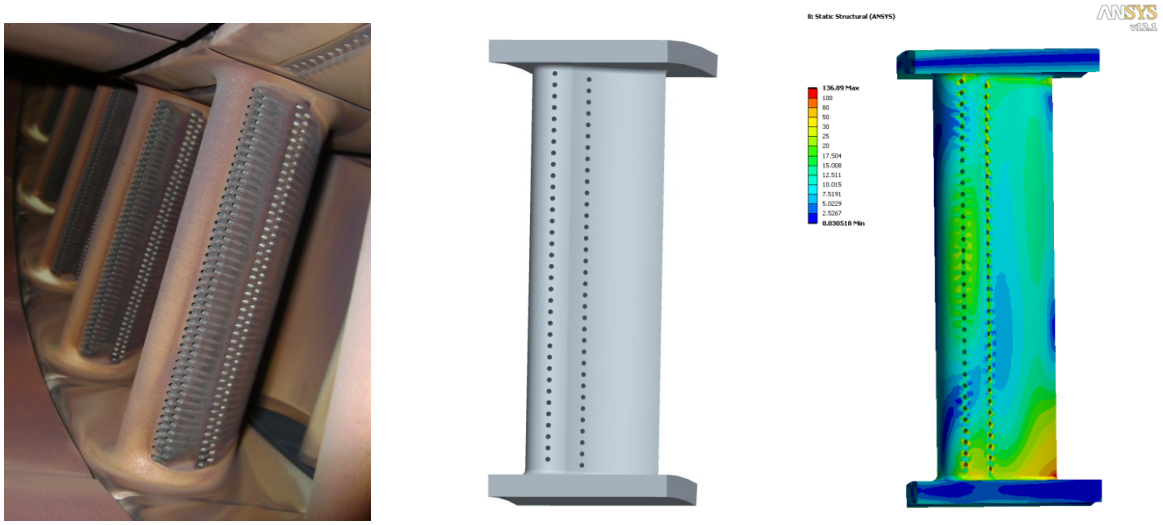
- Rehabilitation of the two 300 MW steam turbines
- Rehabilitation of both 300MW boilers; a wall fired boiler and a tangentially fired boiler. The work included partial replacement of the water walls, furnace bottom and superheater and reheater tubes
- Replacement/repair of the condenser tubes of both units
- Reverse engineering and manufacturing of steam and electrical feed water pumps internals as well as condenser vacuum pumps internals
- Rebuilding the firing system that improved the efficiency of the boilers by more than 3%
- Supplying a new very high efficiency fuel atomization system
- Replacement of parts and repair of the soot blowing system of both units
- Repair and tube replacement of the high-pressure feed water heaters
- Repair and replacement of the heating element baskets of the air preheaters in both units
- Reverse engineering and manufacturing of superheater and reheaters tubes of one of the 300 MW boilers
- Reverse engineering and manufacturing of air preheater baskets



Case Study – Gas turbine vane redesign

A major original equipment-manufacturing client wanted to reduce costs and improve the performance of a gas turbine engine by modifying the turbine design. CPS was asked to provide a concept that would meet the cost, performance and life requirements of the client:

- CPS inspected the hot gas path and proposed a re-design of the first stage vane to lower the manufacturing cost of the turbine and to reduce the amount of cooling air for improved engine performance.
- Based on the extensive experience in mechanical design and integrity as well as cooling and heat transfer CPS could propose a design suitable for an implementation into the engine.
- The vane re-design was created with the aid of advanced engineering analysis tools such as Computational Fluid Dynamics (CFD) and 3D Finite Element Modeling (FEM).

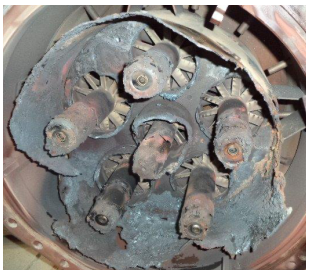
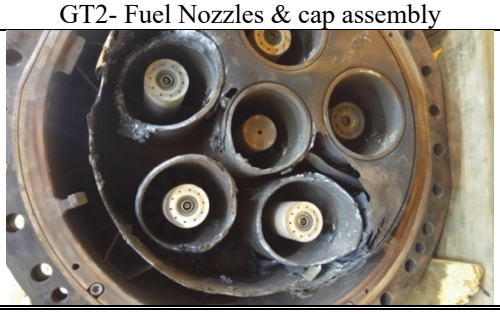


Turbine vane component and new design FEM model simulation results.

Case Study - Gas Turbine Inspection – failure analysis

CPS Creative Power Solutions (CPS) was awarded a contract to perform a Root Cause Analysis (RCA) on the damages that occurred in a combined cycle gas turbine power plant. Eight GTs were inspected given the available design and operational data. Findings:

- Inspections on all eight GTs have revealed overheated areas in the hot gas path (HGP) with thermal barrier coating (TBC) spallation and oxidation of the bare metal surfaces in all GT on site.
- Severe damage on one combustor each in two GTs as a consequence of flashback was found
- Severe damage was found in the first stage nozzles of some of the turbines
- Particle's ingestion in the machines was also present across all eight GTs.

GT1 - Fuel Nozzles & cap assembly	GT1– Liner
	
GT2- Fuel Nozzles & cap assembly	GT2 – Liner
	
GT2 – 1st Stage Nozzle	GT2 – Liner
	

Case Study - Gas turbine reliability

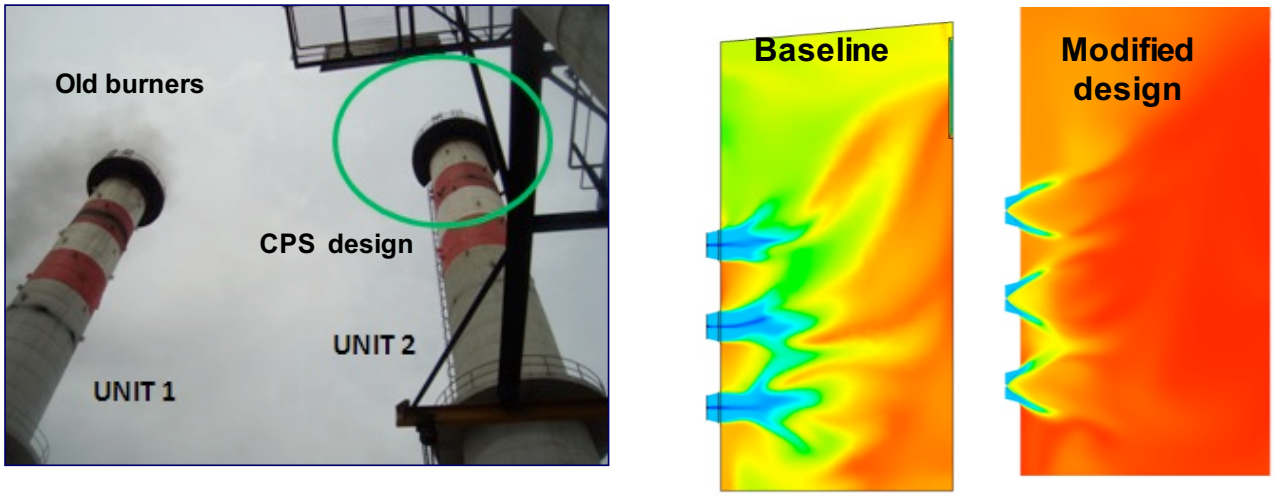
A large utility client experienced reliability issues and start-up problems of a gas turbine plant that prohibited scheduled operation. The start-up phase was frequently interrupted by a number of errors and warnings: failed ignition, flame-out, large turbine outlet temperature spread and more. Several teams from the OEM were sent to the site without being able to provide a reliable solution.

- CPS proposed a systematic and in-depth root-cause analysis including evaluation of the ignition system and ignition fuel (propane), the main fuel (light diesel oil), fuel distribution system, operation conditions, engine settings and more.
- The outcome of the analysis pointed towards a need for optimizing the ignition system based on the particular conditions of the engine. A short test campaign was made to confirm the results of a detailed flame analysis (ignition flame strength, momentum and temperature as well as main fuel evaporation rate).
- After validating the results the solution was finally implemented into the engines. All engines successfully started on the first attempt and the plant has since then increased its start-up reliability to 100%.

Case Study - Boiler firing system retrofit

An oil fired steam plant with severe emission problems called for an urgent solution. The utility client had been recommended a complete combustion system replacement by several OEMs. With CPS a route towards a much more cost effective solution has been made possible:

- By advanced simulations and engineering analysis the original combustion system was examined to identify the reason behind the poor performance of the combustion process.
- CPS was able to determine the aerodynamic mechanisms associated with the original burner system responsible for the high emissions. CPS proposed a cost-effective and elegant modification of the burners.
- With the burner modification the emission targets were achieved and black stack from plant was completely eliminated. The implementation was made at a fraction of the cost proposed by the OEMs.

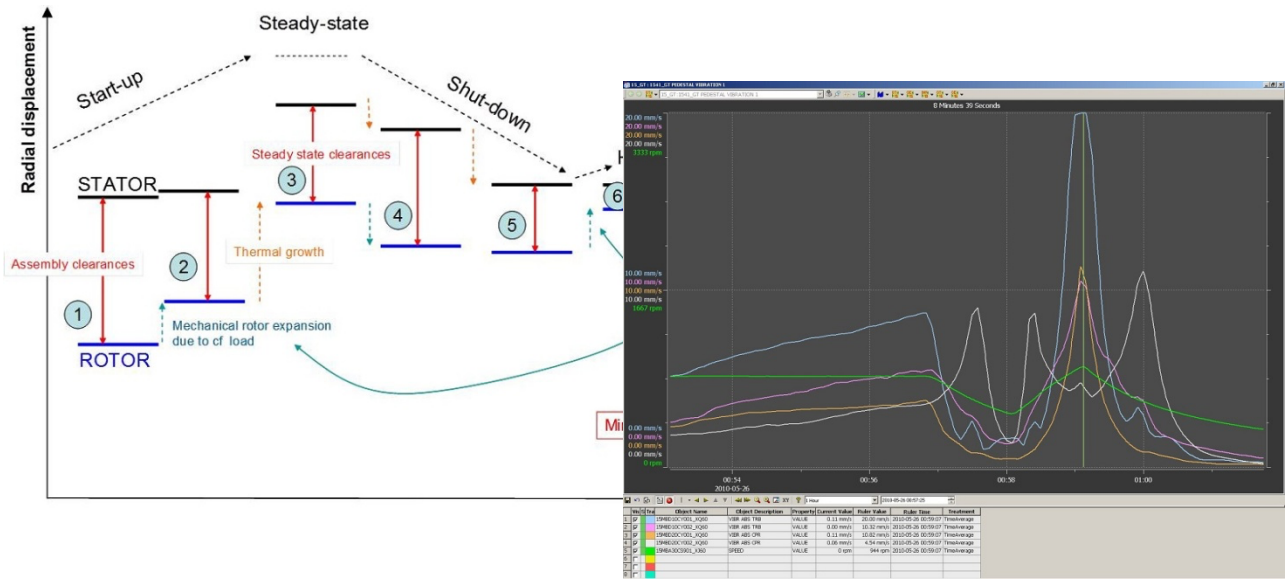


Steam power plant and comparison of burner system design.

Case Study - Gas turbine rotor vibrations

A gas turbine combined cycle plant was experiencing a severe reliability issue during start-up where a restart of the engine was prohibited due to excessive bearing pedestal vibrations. The problem occurred after a trip and the engine start-up procedure was involving a HRSG purge cycle. CPS was contacted for a root cause analysis and quick solution:

- Based on the root cause analysis CPS concluded that due to the minimum clearances after the purge cycle local rubbing occurred during the hot restart which subsequently resulted in a thermally bent rotor.
- The CPS recommendation was to cool down the rotor under turning gear operation prior to the next start attempt in order to straighten it.
- The subsequent engine start was successful without any significant pedestal vibrations.

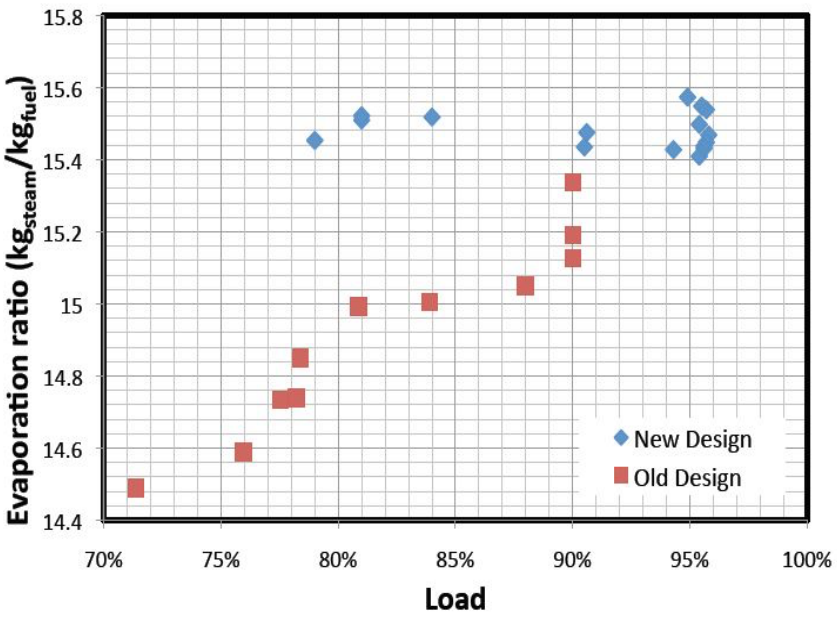


Rotor vibrations root cause analysis results.

Case Study – Improvement of Boiler performance

A desalination plant with steam boilers running on heavy fuel oil experienced frequent problems to achieve maximum rated capacity due to excessive smoke and particle formation. CPS proposed an in-depth analysis to identify the root cause behind the operational problems:

- CPS concluded that the firing system delivered by a major OEM was not able to cope with the varying fuel compositions of the plant due to the boiler design parameters applied.
- Based on detailed simulations of the combustion process CPS could propose burner modifications that significantly improved the combustion efficiency as well as the flame stability in the boilers.
- After implementation the emission problem was eliminated allowing the plant to increase its capacity and also to reduce fuel consumption by 4% at a relative load of 80%.



Elimination of emission problem and performance improvement.

Case Study - Gas turbine reliability improvement

The availability of a large gas turbine combined cycle plant was deteriorating during the winter months. Despite intense efforts of the operation team of the plant to resolve the problem the engine continued to exhibit recurring and intermittent trips. After receiving a costly proposal from the OEM the client asked CPS for an alternative route to solve the problem.

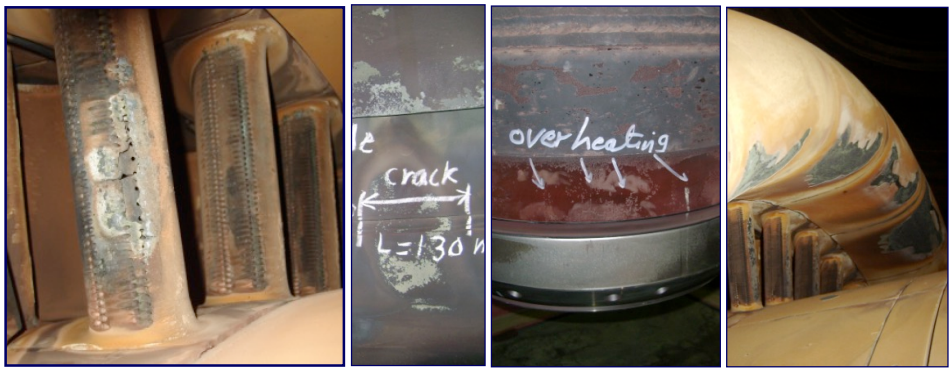
- CPS performed a thorough root-cause analysis to identify the underlying cause of the problem.
- For mitigation CPS designed and installed a customized fuel pre-heating system including filters and scrubbers meeting the fuel specifications for the engine.
- The system designed by CPS successfully could be realized at a significantly lower cost compared to the OEM offering and restored availability of the plant.

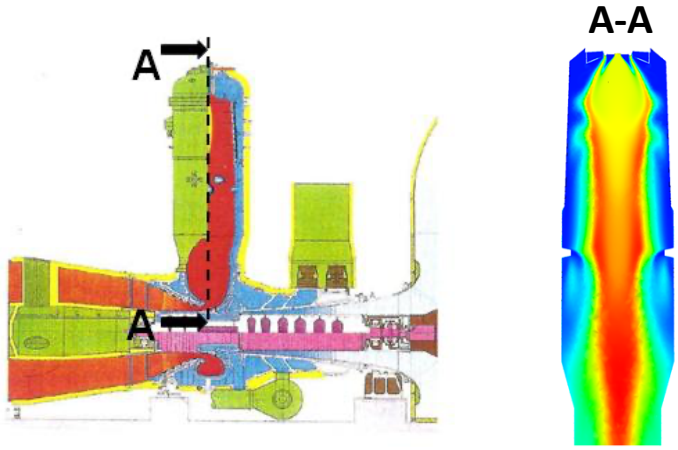
Gas turbine plant and gas fuel pre-heating system.

Case Study - Gas turbine performance & life

The gas turbine fleet operating on fuel oil had a long record of high O&M costs due to performance degradation and a shortfall in component life. The client hired CPS to do an engineering analysis as to develop a strategy for a solution to the problems:

- CPS carried out a detailed analysis including simulations of the combustion system to identify the root cause of the overheating problems and eventual part failure.
- The analysis showed that the existing combustion process produces a inhomogeneous turbine inlet temperature pattern which is the main driver behind the engine failure.





Gas turbine engine combustion system and simulation model.

Case Study – Recovering nameplate capacity of a Coal-fired boiler

The utility company operating a pulverized coal steam plant was having difficulties with a 170 MW unit. Due to heavy slagging and deposits the unit had to be ramped down frequently and was also not able to operate at full load due to excessive steam temperatures. CPS was hired to come up with a solution where several OEM companies had failed:

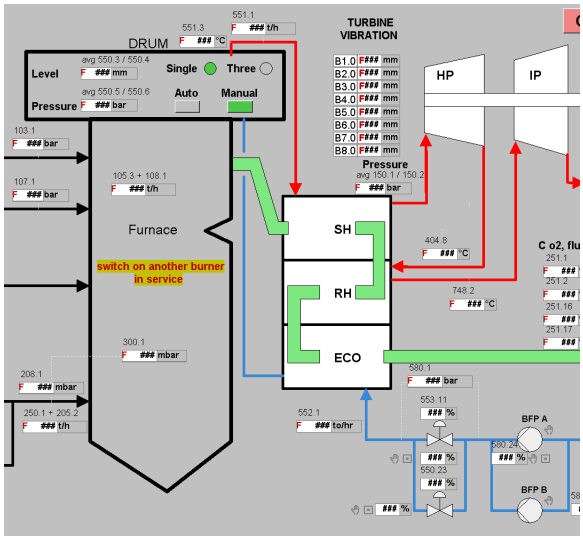
- CPS conducted a root cause analysis which identified several weaknesses related to the burner design and its operation conditions.
- The in-depth analysis with detailed simulations of the aerodynamics gave insight into the mechanisms causing uneven temperature and oxygen levels at the furnace exit.
- A straightforward and inexpensive burner redesign was proposed that stabilizes the combustion process aerodynamics resulting in significantly more uniform furnace exit conditions and reduced slagging.

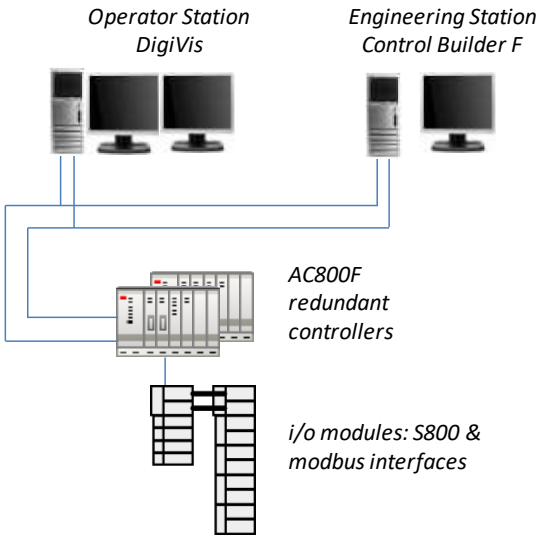
Coal fired steam plant furnace and simulation results.

Case Study – Fit for purpose steam boiler controls

A utility with an aged steam boiler plant was struggling with the availability due to a malfunctioning controls system. Due to the significant age of the plant the management was reluctant to replacing the system with a new OEM system for a high cost. CPS was asked to provide a customized solution.

- CPS evaluated the functionality of the existing plant controls system and quickly identified the critical issues.
- The CPS team generated a plan for retrofitting the existing controls system including addition of new functionalities and improved human-machine interface design for easier operation for the plant.
- The customized CPS controls system is associated with a significantly lower cost as compared to replacing the existing design with a new OEM application.

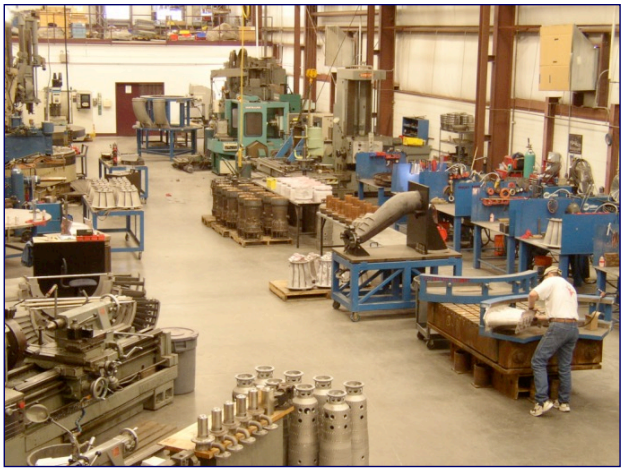




Case Study - Gas turbine fleet O&M

A large company in power generation wanted to reduce the operation and maintenance expenditures for its gas turbine fleet. CPS was consulted to provide a suitable strategy for cutting the O&M spending and strengthening the company in negotiations with the OEM companies.

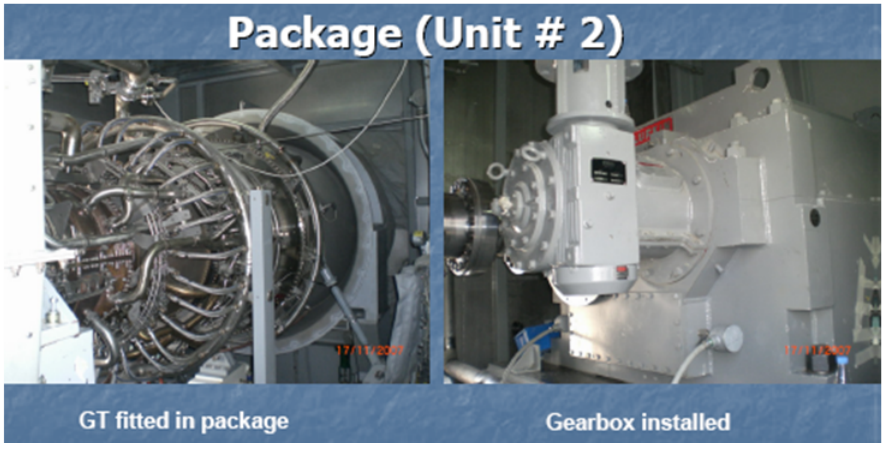
- CPS carried out a benchmark analysis of the clients' O&M expenditures to set the cost reduction targets of the project.
- CPS could identify a significant cost reduction potential in the procedures for replacement of hot gas parts as well as refurbishment of the same.
- The evaluation by CPS included a set of recommendations on how to strengthen the position of the client in the O&M contract negotiations in a short as well as a long term perspective.



Case Study - Gas turbine plant design

A utility company had planned for a 200 MW expansion of its power generation capacity during a period of very high market prices for OEM equipment. In order to minimize the capital investment cost CPS was consulted.

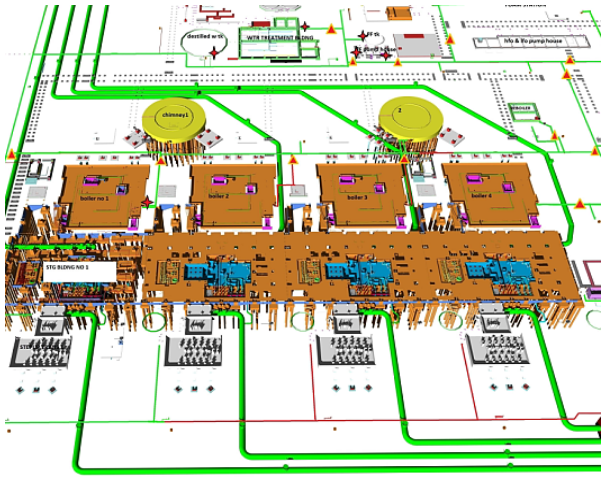
- CPS was able to engineer, procure and install a customized solution based on a conversion of 60 Hz engines to the 50 Hz electricity grid.
- The conversion of the machines and subsequent adaption of the plant allowed to client to achieve significant first cost savings.
- CPS engineering scope comprised the entire Balance of Plant (BOP) system:
  - Primary and secondary fuel systems design (liquid and gaseous).
  - Gas conditioning and pre-treatment systems (including filtering, scrubbing and compression).
  - Cooling systems for lubrication oil and other applications.
  - Water conditioning systems (demineralization).



Case Study – Plant construction

A leading global architect engineering company was looking for a local partner for a new 1’500 MW steam power plant project in the MENA region. The choice fell on CPS to act as the extended arm of the company and to lead the construction project on site.

- The CPS was handed the task of subcontractor supervision and activity co-ordination as well as on-site inspections.
- CPS provided the client with an on-site team of 10 experienced project management professionals and 20 highly qualified engineers.
- The CPS team integrated fully with the back-office of the client through a well defined work process and advanced IT-system.
- The extremely efficient CPS reporting and communication process with the client involved 3D modelling of the work progress.
- The CPS task of contractor supervision and co-ordination as well as on-site inspections has exceeded the high expectations of the client.

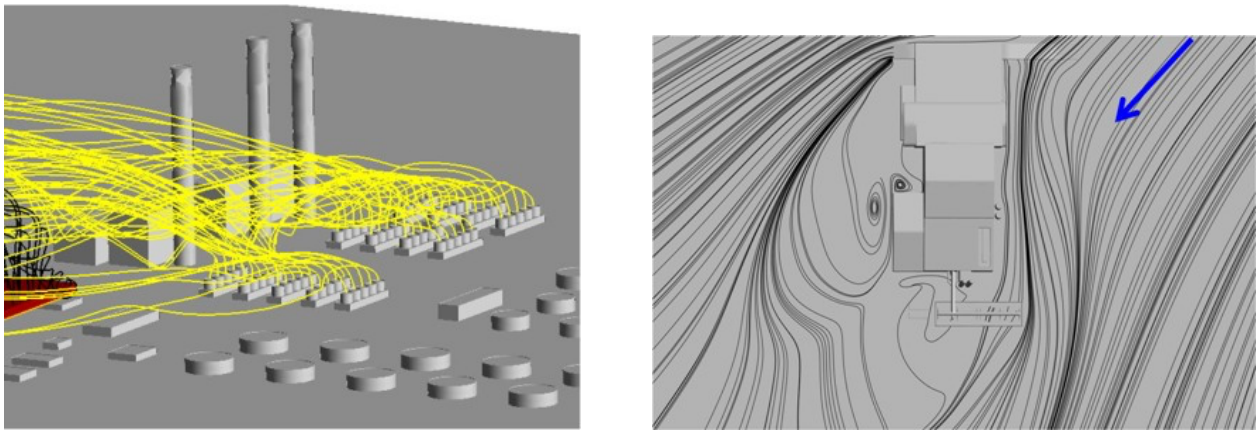


Steam plant construction and 3D CAD model.

Case Study – Enhanced ACC performance

A utility company planned a new layout for the placement of the air cooled condensers (ACC) in their power plant. The influence that upstream cooling tower exhaust could potentially play on the ACC performance was a concern of the utility. CPS was hired to perform an analysis to evaluate the proposed location with regards to the performance.

- CPS conducted simulations with varying crosswinds to determine the overall affect of the cooling tower exhaust on the ACC units.
- An in-depth analysis was performed on the wind interaction with surrounding structures and the recirculation zones created throughout the plant.
- CPS was able to advice the client on an optimized location and improved overall site layout with regards to the performance of the ACC units.



Power plant site model and simulation results.

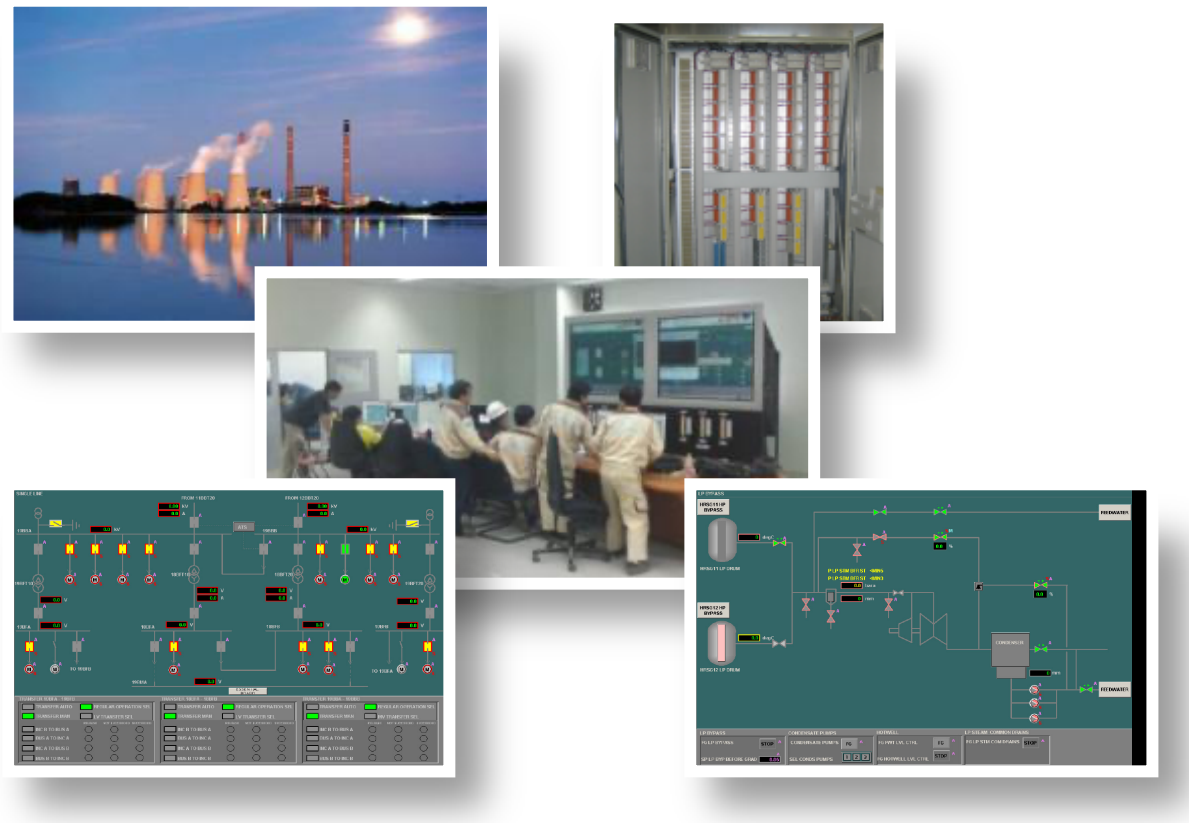
Case Study – Plant control systems

760 MW Combined Cycle GT Power Plant

The project scope comprised supply of a complete plant DCS system:

The control system, realised with ABB 800xA, comprises 9 Servers, 7 Operator Workplaces, 4 Process-stations with 2’700 hardwired I/O's (including SIL 2 applications).

With roughly 2’000 signals via miscellaneous interfaces to the three Turbines (via redundant MB300 connection), to the HV substation (via redundant IEC 60870-5-104 interface) and various other subsystems. The turbines (with redundant AC450 and AC160 controllers, supplied by ABB CH) were fully integrated into the DCS (i.e. full operation, monitoring and archive functionality from DCS).

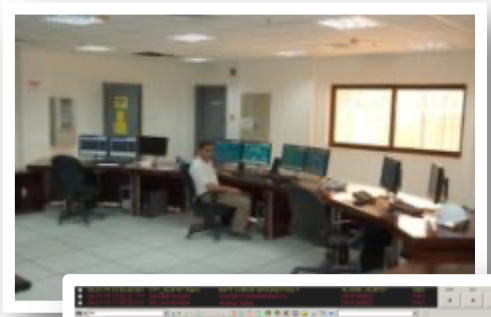


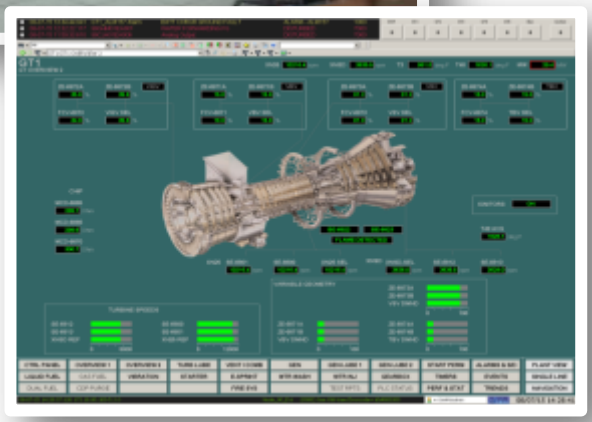
Case Study – Plant control systems

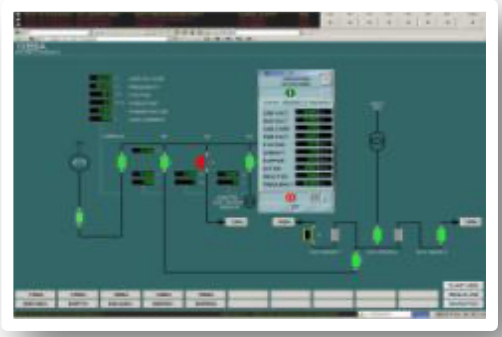
200 MW Simple Cycle GT Power Plant

The project scope included supply of a complete DCS for a power plant with five GE LM6000 gas turbines. Within three months, a fully functional system was demonstrated to the customer in our test laboratories.

The project (realized with ABB 800xA and AC800 controllers) was later expanded and comprises now 6 servers, 7 operator stations, 3 CPUs with 700 hardwired I/O's and 6’000 signals via Ethernet & Modbus connections to the GT's of LM6000 type (via EGD-OPC server), to the switchgears and various subsystems.







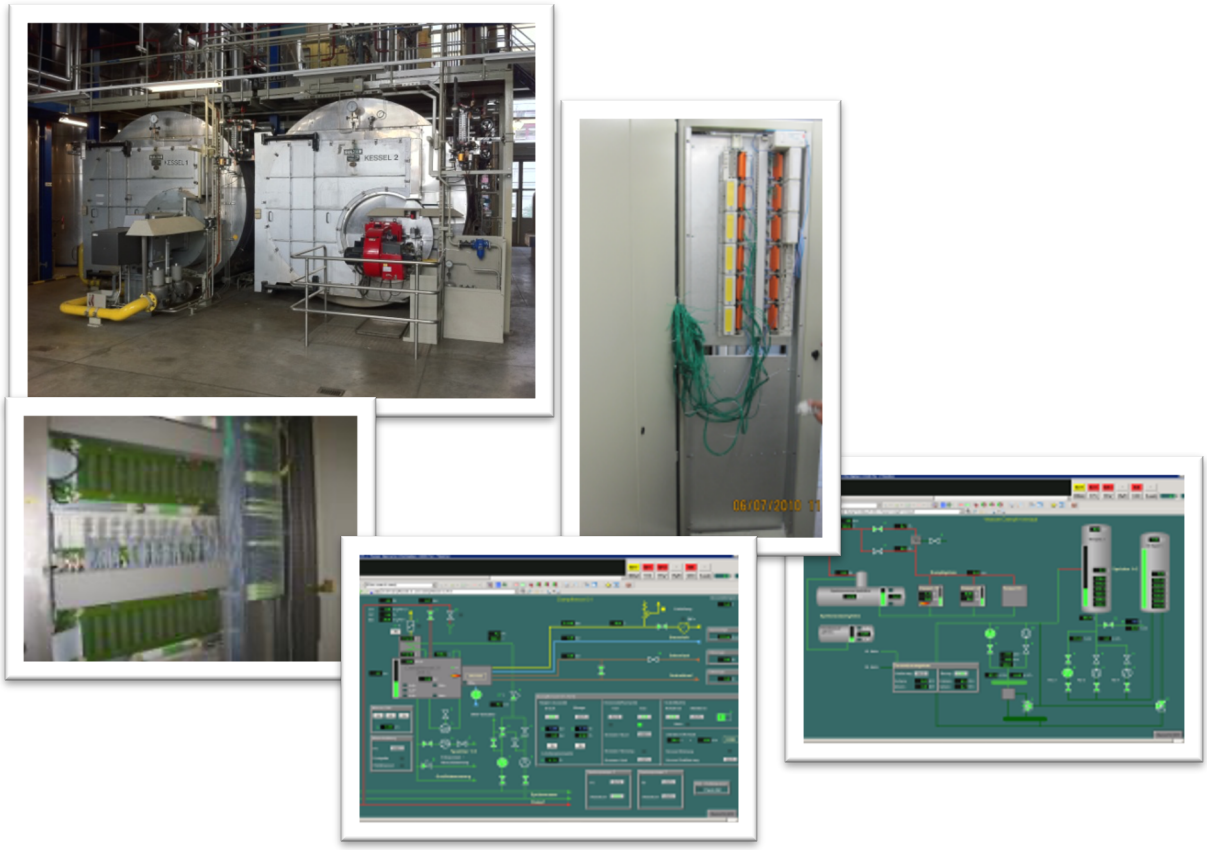
Case Study – Plant control systems

District Heating Plant

The project scope comprised replacement of the existing Siemens Controls with new ABB AC800M Controls for two Boilers and Subsystems.

Integration of the new controls into existing client-server network for the city wide ABB 800xA System was also required.

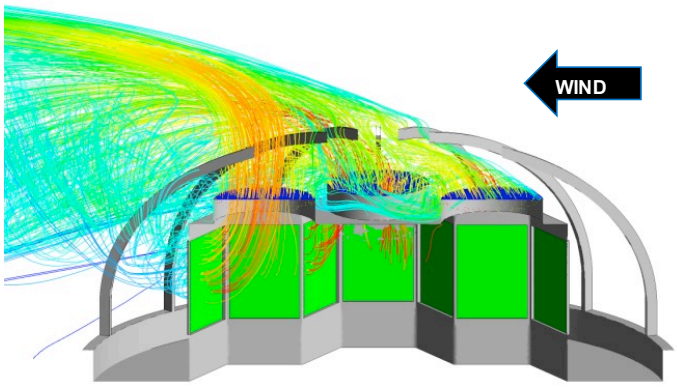
Scope of hardware supply was 2 servers, 4 Controllers with 2000 IO's including SIL2 applications as well as interfaces to burner controller.

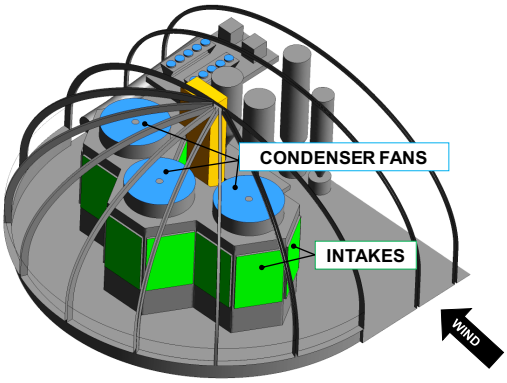


Case Study – Air-cooled condensers

A power producing incinerator plant had problems with the performance of its steam based power plant. The design power output was not achieved under conditions of strong winds. In order to solve the problem CPS was asked to perform a root-cause analysis.

- CPS generated a detailed CFD simulation model of the plant and its surroundings as to analyze the impact of strong winds. Several wind scenarios were investigated and evaluated.
- Based on the simulations it was concluded that the plant steam condensers are severely disturbed by strong cross-winds. A particular deficiency observed was recirculation of condenser exhaust air into the intake screens.
- As to mitigate the problem CPS analyzed a number of aerodynamic modifications that prevent the loss of condenser performance.

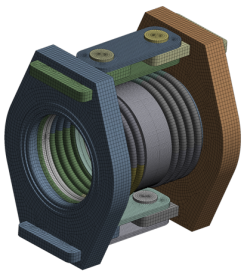


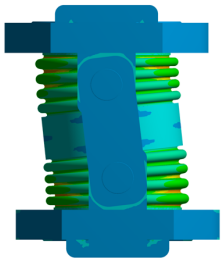


Case Study – Compensator life

An operator of a nickel mine was experiencing unplanned shut-downs of the plant due to a failing slurry pipe system. The system expansion joints that compensate the thermal growth of the pipework were repeatedly failing after only a short period of operation. Due to the high impact of these failures in terms of production downtimes the Nickel plant was looking for a new design for these expansion joints. In order to minimize the risk of further failures the customer requested a detailed strength and lifetime assessment. This task was given to CPS.

- CPS performed several 3D FEM analysis of the expansion joint including the fittings and the bolted connection flange. The complete expansion joint was analyzed under design conditions and proof test conditions.
- Based on the initial analysis, shape optimizations for the highly loaded fittings of the expansion joint have been designed in order to reduce the stress in these components.
- A static strength assessment and a detailed lifetime assessment for the expansion joint have been carried out to demonstrate the safety and longevity of the new design.
- All analyses have been performed according to EN 13445-3. Conformity of the design with PED 97/23 / EC has been certified by a notified body.
- The final report was reviewed and accepted by the end client and the contract to supply the new expansion joints has been awarded.

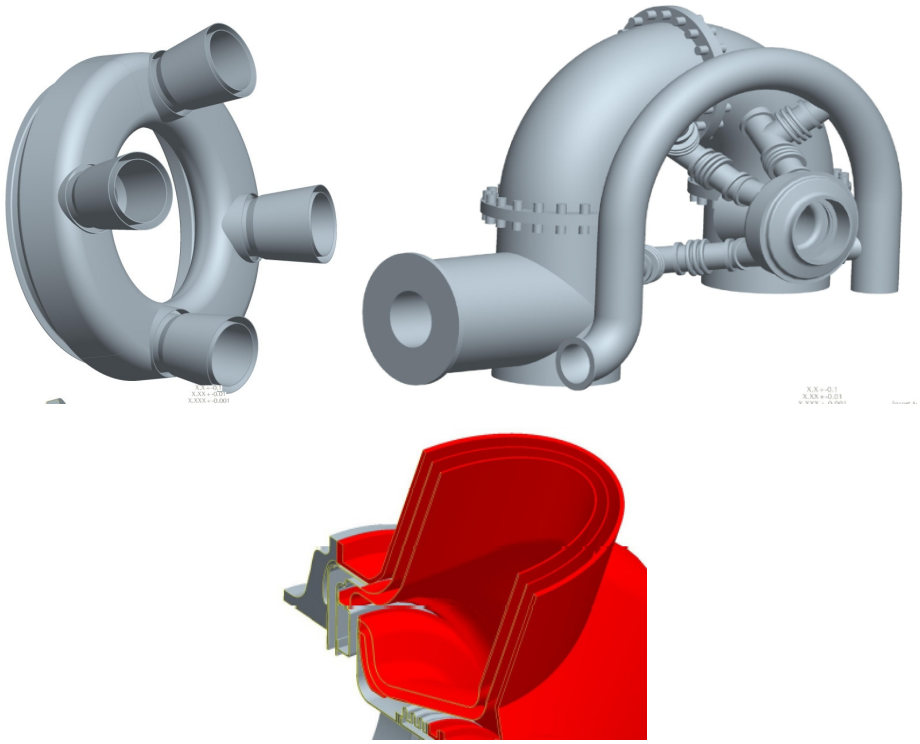




Case Study- Gas turbine conversion to external firing

A manufacturer of small gas turbines wanted to convert an existing engine design into an externally fired turbine generator. CPS was contacted to develop a conceptual design in competition with other engineering firms.

- With the delivery of a compelling design CPS was chosen to develop the concept into a detailed design for the engine.
- The detailed design included a redesign of the engine casing and implementation of a hot air delivery system.
- In addition to the new hardware the scope included development of operation as well as controls concepts for the engine.

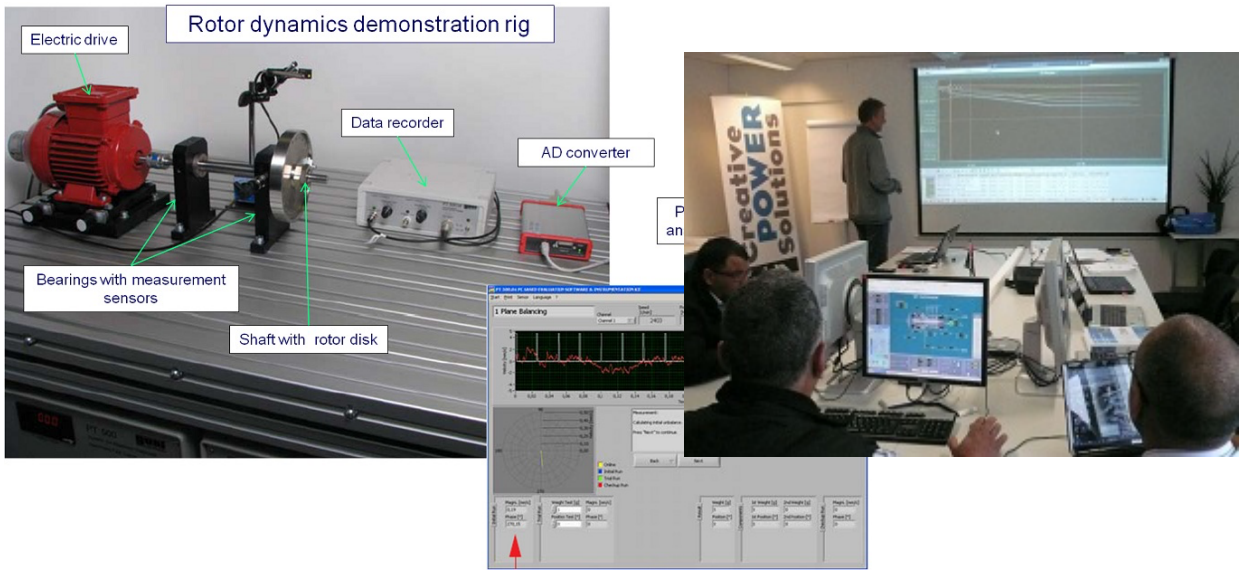


Conceptual design proposals for externally fired gas turbine.

Case Study – Technical training

A major utility company saw the need for additional technical competence in order to improve its ability to resolve technical problems and increase the production fleet reliability and availability. CPS was asked to provide a tailor-made technical training on gas turbines for 30 engineers:

- CPS launched a training program comprising technical know-how at an advanced engineering level in three areas:
  - Gas turbine controls & operation (incl. simulator)
  - Gas turbine combustion technology
  - Rotor vibrations and dynamics (incl. test rig)
- The training program included a methodology for problem solving and troubleshooting with emphasis on root-cause analysis.
- The trainee learning process was based on case study exercises with the use of a systematic approach for problem solving and application of technical skills on actual problems.



Training experimental equipment & simulator sessions.