QuEST
BORN TO ENGINEER

a cost-effective xml-based integrated design system for pipe routing

The best piping configuration is the least expensive and offers the highest efficiency throughout its life term. This requires consideration of various factors such as total cost of ownership in addition to the total installation cost.

Dr. Sharatkumar Variyar
QuEST Global

contents

Abstract

The best piping configuration is the least expensive and offers the highest efficiency throughout its life term. This requires consideration of various factors such as total cost of ownership in addition to the total installation cost. The pipe configuration should also allow for easy maintenance, design repeatability, complete flexibility in assembling the gas turbine plant accessories onsite, packaging considerations, and should also be amenable to upgrades or life-extension.

A unique integrated pipe routing design system, which allows the piping and packaging for auxiliary systems to be designed quicker and better, is the need of the hour. If this system integrates pipe-routing system design software, computer-aided drafting (CAD), and isometric visualization software to create a seamless link based on XML, it can result in a simpler pipe routing capability. This, combined with other factors such as the ability to meet market requirements for higher performance, lower design costs, and minimal impact on the production schedule, can guarantee an established power plant's competitiveness in the long run. This paper focuses on the packaging of the gas turbine engine, which encompasses piping accessories and the overall auxiliary system.

The Market Need for Better Gas Turbine Auxiliary Systems

Deeper research on materials and combustion technology is today resulting in better design, performance, and maintenance aspects in gas turbine-based power generation plants. However, the design approach to the accessories and packaging surrounding the core turbine and generator also has a significant influence on the total cost of ownership and installation. A key organizational competence factor for power generation majors is to ensure flexibility of the gas turbine plant accessories and pipe routing design process, so that it can respond to varying customer requirements.

On one side is the push for more research and better design and on the other is the capability of the organization to respond to product realization or manufacturing requirements within a reasonable time and cost limitations.

Advances in Gas Turbine Development

Developments such as high power density for a given installation size, improvement of heat rate characteristics, variable load features, higher fuel efficiency and firing temperatures, lower emissions and dual fuel capability have been achieved on the core turbine. Customizations undertaken on the baseline configurations in response to specific customer needs related to local and statutory requirements, and ease of installation or interfacing with other equipment and auxiliaries, are perennial expectations of the power plant engineering team.

Pipe Routing and Configuration Design Criteria

Gas turbines continue to be popular as important sources of power, but the changing landscape of power demands is influencing the design and build of gas turbines in newer ways. To be competitive on design, operation, and maintenance involves not only deeper research on materials and combustion technology, but also on the approach employed while designing accessories surrounding the core engine.

Auxiliary systems (including piping specifications and pipe routing) are integral elements of the design of gas turbine based power systems. Flexibility and responsiveness of the piping and the packaging design realization processes to meet diverse customer requirements has become a key organizational competence factor for established power generation bodies.

Organizations that already provide turbine design services to OEMs and with the right set of skills and in-house capabilities in pipe routing design can help accelerate the design cycles with a more coordinated approach to the design of, for instance, the entire power plant.

Accomplishing Improvements in the Gas

Turbine Auxiliary System over a period of time, designers working with the engine core-analysis teams have become more efficient at optimizing the design cost and the number of design iterations it takes to test out concepts analytically.

In order to meet the requirements of today's gas turbine engines and the configuration of their accessories, some of the options currently available include reducing the design lead times, accomplishing modularity, cross-utilizing design-variants, and applying pre-engineered configurations.

Today, the piping design process typically runs concurrently with other processes and systems including the mechanical, civil, and electrical design. An organization competitiveness and flexibility to realize better and, more importantly, concurrently develop the piping and packaging accessories will be key to reducing the design lead times of the entire gas turbine.

For example, when designing the piping routing and the associated accessories for an oil and gas company based in a hot terrain, such as Saudi Arabia or Oman, due considerations are taken into account to build the entire package. Engineering services organizations that have the optimum capabilities will be able to reuse the design in other similarly hot terrains such as Nigeria or Congo. Consequently, the design times are reduced and experience is transferred quickly, thereby shortening the time-to-market.

Another example is designing for an energy plant near a shore, because of the enriched experience of understanding what materials and configurations suit humid and rugged conditions to suit the piping design can be reused in other similar terrains and operating conditions, making the project more sustainable in the long run.

In both the cases, customizations are undertaken based on a library of baseline configurations while changes incorporating local regulations, specific customer requirements, ease of installation, and so on are incorporated to develop the new design package.

A Unique Piping Design Integration System and Process

QuEST has developed a unique piping design integration process that allows auxiliary systems to be designed in a more efficient matter. The QuEST piping design integration system integrates the following piping requirements for various gas turbine auxiliary systems:

- Fuel-gas system
- Fuel-oil system
- Lubricating-oil system (supply and return paths)
- Bleed-air system
- Instrument-air system
- Seal-air system
- Drainage system
- Cooling water system
- Compressed air system

This integration process also combines the three principal design areas that lead to the implementation of the auxiliary systems. These are:

- A schematic design for piping and instrumentation diagrams
- Design and drafting of piping systems and arrangements
- Isometric visualization

Drawbacks of Traditional Methods and Processes

Traditionally, these design activities are completed on a single platform utilizing commercially available software. However, this approach can be extremely expensive and often requires an advanced level of operator expertise. Therefore, they are both capital and labor-cost intensive.

Pipe Routing Design Using XML-based Integrated Solution

QuEST's unique pipe routing integration system offers an alternative design platform that is fully functional, yet cost effective. The QuEST design automation team, during the development of this system, leverages its cumulative experience of working with diverse piping requirements of hydro turbines, gas turbines, steam turbines and generators. This system uses pipe routing system design software, CAD software, and isometric visualization software to seamlessly integrate all three software units – resulting in a simpler and more cost-effective pipe routing solution.

The application is dependent on the piping design having already been done. The typical guideposts for piping design include:

- Maximizing pipe sizes
- Minimizing material (and costs)
- Enforcing maximum straightness and shortness
- Provisioning for adequate lengths for flow development in relation to the suction or discharge
- Enabling accessibility for maintenance and/or replacement
- Provisioning for pipe slopes
- Provisioning for hangers, supports, springs and braces considering the loads through - weights of the pipe, the medium in the pipe, pipe insulation and gauges mounted externally

It is assumed that the best practices built through cumulative experience have been followed at the design stage. For example, it is preferable to include standard pipe fittings instead of fabricated pipe fittings as this reduces cost and lead or cycle times at the design, procurement, and installation phases.

Achieving Efficiency by Integrating Pipe Routing, CAD, and Isometric Software Using XML

Central to the efficiency and speed of such an integrated system is the underlying philosophy followed for exchange and interchange of data. An integrated system achieves the objectives of standardizing and optimizing the software developed and validated in-house, making it possible to achieve repeatability and compatibility with the existing standard tools. In this case, QuEST has chosen XML as the basic technology to interface with the design steps instead of using native graphic formats. In other organizations, based on the size of the application, the databases used for achieving the design integration in the power plant design include Access, SQL Server, and Oracle.

A key part of the intelligence built in is in terms of attributes chosen to characterize each pipe, pipe fitting and bought-out item, as well as the interfacing end-types, members and linkages. These fittings include:

- Elbows
- Straight tees
- Reducing outlet tees
- Reducers
- Flanges
- End caps
- Bosses

Manufacturing and assembly process design is also part of this system, and includes attention to facets such as bending and spring-backs, fastener selection -- bolts, nuts, springs, directions and orientation, welding for fabrication and erection. The pipe routing integration system is compatible with engineering standards such as JIS and ANSI.

QuEST has an in-house piping and instrumentation diagram (P&ID) design capability for specific plant design applications. It will draw on this understanding to assimilate the design requirements, assuming that considerations of system characteristics, process optimization and controls have all been built in while specifying the elements, connections and branches in the P&ID.

Pipe Routing Process Using the Integration Solution – Description

Often, to overcome spatial constraints, it is necessary to reorient the equipment or the piping. Typically, the preliminary baseline layout of equipment specified at a 'pre-bid' or proposal stage is then used as a reference framework to work out the details of the final piping layout. The piping design integration system considers the available working envelop to extract the details of the parts (including the pipe lengths, attachments and supports) and factors in accessibility for installation, operation, inspection, and maintenance.

The standard interference checks include those performed on the interface of other piping systems, ducts, electrical cables and conduits, as well as structural members (metal and concrete) using specialized CAD tools such as Pro-E Piping, UniGraphics, AutoCAD, and CAEPIPE.

The piping specification documents include ratings on the following:

- Operating pressures
- Temperatures
- Offsets
- Materials
- Thickness
- Nature of the fittings (threaded, welded)
- Gaskets
- Insulations

The quality assurance aspects include fabrication, testing, inspection and installation. The packaging team works within the overall envelop and the dimensions of the interfacing equipment.

Compatibility with Different Environments

The tools are robust and stable in different operating hardware environments, making it portable with minimum system level changes. The reference data it draws upon is plugged into a design database on a network and need not be stand-alone. This facilitates quick interface checking with other systems including civil and electrical. The resulting output includes the material take-off, bill of materials, interference checks, and offset compliance.

An overall appreciation and understanding of the power plant equipment will help the piping routing process. QuEST possesses an in-house capability to offer detailed design of accessories and equipment. This helps in achieving a good interface for the piping with typical steps that are usually not part of a piping routing integrated system, but are needed for seamless interfacing. These include:

- Buildup of the auxiliary systems
- Base plate, filter house, inlet, exhaust, and ventilation structure
- Enclosure design and drawings
- Civil works design and drawings
- Issue of technical specifications
- The review/issue of sizing of equipment resulting in data sheets
- Sizing/selection of cables
- Sizing/selection of junction boxes or terminal boxes
- Issue of wiring diagrams

Extensive Applications of the Integrated Solution

The activities that are coordinated and executed as part of QuEST's solution include:

- Analyzing the turbine and generator variant and configuration
- Reviewing the specification and requirement documents
- Invoking the baseline piping design
- Confirming the suitability of design based on stress, vibration and thermal expansion considerations (done through validation applications such as CAESAR II)
- Building the overall schematic
- Setting up the piping libraries and global property tables (to help at the design stage later)
- Creating a good data architecture based on the product configuration
- Developing the software systems
- Preparing 'intelligent' P&ID where the schematic diagrams are linked to an electronic design database, thereby aiding P&ID compliance checks
- Translating key design information into XML format
- Conducting piping studies and pipe routing
- Generating fabrication and other drawings
- Generating 3D isometrics for the new and existing piping configuration through software such as ISOGEN
- Re-routing piping in response to the actual layout design, and iteration if deemed necessary, based on standard checks such as nozzle orientation, nozzle loads, flange ratings and designs, permissible stresses, and offsets
- Building the software libraries as per the application design specifications
- Testing and modifying the configuration to respond quickly as the systems 'go live'

Conclusion

QuEST's unique and flexible piping design integration process allows auxiliary systems to be designed efficiently and quickly, so that they can meet performance and cost requirements. The system combines the routing system design software, CAD, and isometric visualization software to create an XML-based seamless link between all three software units. This results in a simpler and more cost-effective piping design capability, while at the same time, ensuring versatility and agility to respond to challenging customer requirements within a realistic time frame.

Author Profile

Dr. Sharatkumar Variyar

Dr. Sharatkumar Variyar has been with QuEST Global since 1999. With a core engineering background in turbo machines, computational mechanics and non-linear finite element analysis, he launched his career in the area of engineering analysis for turbines and aero engines. He then moved as Centre Manager for QuEST Innovation Centre leading the CAD and Engineering Analysis practices. During his initial days, he also initiated the creation of Centers for Advance Design and Manufacturing (CADAM) which focuses on building the skills of engineering students during their academic career. In the year 2006, he moved into a new role as Competency Development Head and was responsible for evolving the competency profile across domains and services. Dr. Variyar is keenly interested in empowering engineers – employability and competency development. He has also been associated with research and implementation of graded technical career paths, learning maps, and competency development methodologies. Dr. Variyar has worked on the soft skills specific to the engineering services industry. In 2010, he proposed a project – Case Studies and Assignment Based Training (CASAT) to NASSCOM which has since been adopted by the Education and Skill Development Initiatives wing of Engineering Services Forum. He is currently the head of university relations program at QuEST Global.

Email : media@quest-global.com

The author wishes to thank Dan Touchton, **Subramanian S (Suby)** and **Srikanth Subba Rao** for their contributions without which this whitepaper wouldn't have taken shape.

About QuEST Global

QuEST Global is a focused global engineering solutions provider with a proven track record of over 17 years serving the product development & production engineering needs of high technology companies. A pioneer in global engineering services, QuEST is a trusted, strategic and long term partner for many Fortune 500 companies in the Aero Engines, Aerospace & Defence, Transportation, Oil & Gas, Power, Healthcare and other high tech industries. The company offers mechanical, electrical, electronics, embedded, engineering software, engineering analytics, manufacturing engineering and supply chain transformative solutions across the complete engineering lifecycle.

QuEST partners with customers to continuously create value through customer-centric culture, continuous improvement mind-set, as well as domain specific engineering capability. Through its local-global model, QuEST provides maximum value engineering interactions locally, along with high quality deliveries at optimal cost from global locations. The company comprises of more than 7,000 passionate engineers of nine different nationalities intent on making a positive impact to the business of world class customers, transforming the way they do engineering.

QUEST

BORN TO ENGINEER

http://quest-global.com