A drilling derrick raised for testing
Courtesy AKERE ENERGY, C.A.

Supporting the **Oil and Gas** Industry

Longevity and safety of drilling derricks and substructures are increased through stress analysis.

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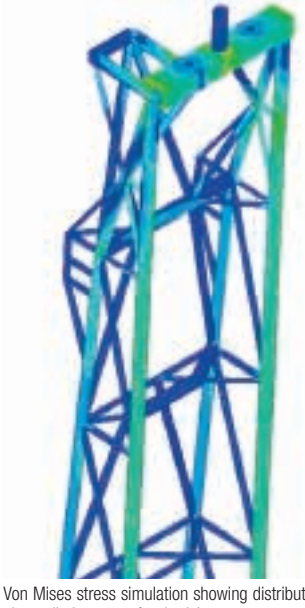
The oil and gas industry faces challenges associated with age-related equipment deterioration. In these scenarios, companies must ask themselves what to do with the equipment; more specifically, should they maintain the equipment as it ages, or retire it and purchase new equipment? In some cases, the most cost-effective solution involves repairing the equipment in order to extend its useful lifespan. One specific challenge is the repair and recertification of oil derricks used in the drilling process.

There are several types of derricks. The structure of each is suitable for the type of activity, which could be drilling, reconditioning or well cleaning. The most common type is a rigid design that has four legs secured to the corners of a metallic substructure.



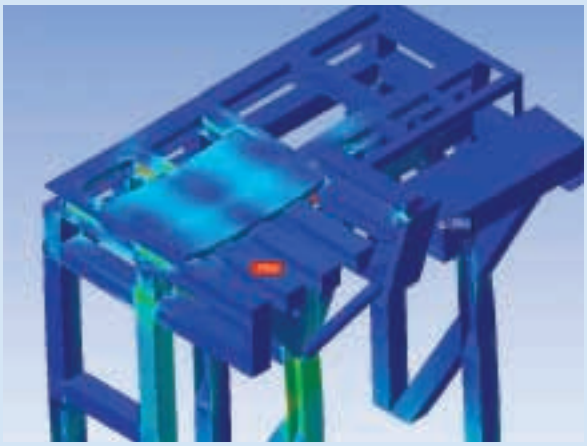
Von Mises stress simulation showing distributed stress along all elements of a derrick
Courtesy AKERE ENERGY, C.A.

Oil derrick design specifications require that the structure is able to support the load of vertical tubes used for the drilling operation; the derrick also must resist wind loads that may have velocities up to 160 kilometers per hour. In addition, during the extraction of the drill pipe, the pipe could get stuck in the well due to irregularities or obstructions in the hole. In these cases, the derrick must resist, within reasonable limits, the force required to release the drill pipe from the hole.

After years of service and perhaps poor operating practices, derricks and substructures involved in drilling operations may begin to exhibit damage such as deformation, fatigue, breakage or misalignment of their structural elements. These problems can be corrected through structural repairs, but the equipment then needs to be recertified for use.

New equipment can be repaired and certified by the original manufacturer. However, much of the equipment currently used in the oil industry has been in operation for more than 10 years. The original derrick manufacturer may no longer exist, therefore, these derricks are considered unidentified equipment. Evaluation made by manual calculation is a long, slow process that does not reach the accuracy level required by industry standards for recertification. In addition, physical variables such as fatigue and remaining life calculations for these large structures are extremely complicated.

Derrick substructure at the yard for maintenance
Courtesy AKERE ENERGY, C.A.



Von Mises stress contours on the substructure
Courtesy AKERE ENERGY, C.A.

According to the American Petroleum Institute standard API-4G *(Recommended Practice for Maintenance and Use of Drilling and Well Servicing Structures)*, load rating for a well servicing or drilling structure of unknown manufacture may be determined by a process including inspection and engineering practices such as simulation. This process may include structural analysis in accordance with API-4F *(Specification for Drilling and Well Servicing Structures)*, which states that the accuracy of standard design ratings of each structure shall be tested by proof loading or by a computer model, such as finite element analysis (FEA), to verify the structure for the design loads.

In order to fulfill these international specifications and to maintain the reliability and structural integrity of equipment during operation, Consultora de Ingeniería Peñalver, C.A. (CIPCA) in Venezuela uses FEA software from ANSYS to examine various clients' drilling structures. CIPCA employs simulation to determine maximum load capacity, stress distribution on the structure, regions prone to failure (critical regions), potential life cycle, fatigue effects and load rating. The ability to determine stress in a structure with more than 20 years' service and for which the manufacturer no longer exists gives oil and gas companies the ability to comply with international specifications and to rescue equipment that would otherwise need to be retired.

CIPCA applied this approach to equipment owned by COMANPA, C.A., an oil and gas drilling company also located in Venezuela. The derrick for the oil rig named COMANPA 27 was built in 1971 and was designed with a maximum lift capacity of 180,000 pounds. After years of service, the derrick showed general deformation in its primary and secondary structural elements and was tagged unusable for drilling service after failing inspection. In order to evaluate the derrick under the API specifications, CIPCA began by modeling the geometry of the existing derrick, including deformed parts, with ANSYS DesignModeler software. Shell elements were used to model the major structural members. This saved computational time in comparison to using solid elements to mesh these relatively thin parts. In addition, better accuracy could be obtained for the same number of degrees of freedom by utilizing shell theory for thin geometries. Also, joints were modeled with edge-to-edge contact elements that were automatically detected between the structural members through ANSYS Workbench simulation.

By using ANSYS contact technology to deal with interactions between parts, mesh densities could be adjusted appropriately without the mesh of one part influencing the mesh density of the adjacent part. The FEA simulation, which included fatigue effects, was performed using ANSYS Mechanical software within the ANSYS Workbench environment.

From the results, CIPCA concluded that the derrick could not operate at its original design specifications; however, it was determined that the derrick could operate safely with a modified lift capacity of 100,000 pounds. Following analysis, the derrick was able to complete scheduled drilling for an additional two years.

Having a drill out of service can significantly impact costs and, therefore, the bottom line, according to AKERE ENERGY, C.A., another company that specializes in oil and gas exploration, drilling and operation based in Venezuela. It is very important for such companies to meet their annual drilling schedule, as these companies maintain contracts to drill a specified number of holes in a region. Derricks that are out of service for certification can only be replaced by equipment that has been previously contracted and certified. If equipment is not available, then production goals are not met, resulting in loss of profit. ■