

North of England Evening Meeting: The Design & Analysis Challenges for Advanced Service Valves



Evening Meeting, Newcastle

Department of Marine Technology, Armstrong Building, Newcastle University

Wednesday, 18 January 2017

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SUT North of England's first evening meeting of 2017 was held at Newcastle University on an unseasonably warm evening in January. The event focused on the latest challenges involved in the design and validation of advanced service valves for increasingly onerous operating conditions. The audience was welcomed by the SUT branch chair, Michael Williams, Managing Director of PDL Solutions. He was followed by the chair of the evening, Elizabeth Waterman, Senior Engineer at PDL Solutions who informed us of the evening's agendas and introduced us to the first speaker; Malcolm Hay, Project Engineer at BEL Valves Ltd. Malcom joined BEL Valves 10 years ago as an apprentice and having won apprentice of the year and the prestigious HT Lamb award, has continued working within the valve industry and is involved with valve development processes from start to end. Malcom's presentation focused on the design challenges valve manufacturers face to avoid valve failure and how these require stringent testing and design verification. Malcolm's presentation was titled Design Challenges and Verification of Valves to Keep Pace with Oil Field Development Rate. Malcolm jumped straight in with a project he had recently been involved with, and the difficulties faced with replacing a split gate valve which was leaking whilst in service (not supplied by BEL Valves!). This valve presented many challenges; the fierce operating conditions – a large range of temperatures with a low pressure, it must fit within an existing valve system, be proven to seal under operating conditions (bore pressure and external loads) and meet the all standards for various tests. BEL Valves were faced with supplying a valve which provided a robust solution to these challenges whilst being under a tight development schedule.

The terminology of the split gate valve with visual aids along with the specific characteristics of this valve was explained. Using FEA models to test all of the design considerations is advantageous as it can relatively quickly and cheaply show which considerations would have a positive or no impact at all on the valves, and verify which design is best. The stringent testing, and standards which must be met were explained in depth; FE testing to the client specification, FAT to API 6D and qualification and bending testing to the client specification. The bending test required the design of a new rig to test the external forces in all directions. The valve passed all of the testing stages; FEA and physical testing. Malcolm concluded by observing that the leaking of a valve can have a knock on effect with the necessary testing - key to providing the client with confidence in the design. Questions were then welcomed from the floor, and the testing processes were discussed further.

Elizabeth took to the floor again to introduce the next speaker Lee Brimer. Lee is a senior Engineer who joined PDL Solutions (Europe) Ltd over 5 years ago. He is heavily involved with valve designs and analysis, and has worked with BEL on numerous projects. The focus of Lee's presentation was to talk about the FEA process and how it is carried out to ensure customer confidence. Lee's presentation was titled Advanced Engineering Analysis as a Valve Design Verification Tool. Lee presented an overview of the typical analyses used in valve assessment using FEA, including structural (linear elastic and nonlinear elastic-plastic), thermal and thermal-structural (to mitigate gate jamming). The analyses included Hydrogen Induced Stress Cracking (HISC), relevant for Duplex materials, and various specific components, such as gaskets, bolting and trims.

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The presentation focussed on the FEA work carried out to validate the split gate valve designed by BEL Valves for the same project Malcolm discussed. Particular focus was applied to the performance of the valve design under large external loads, due to previous issues observed by the operator, to ensure that the valve sealing functionality was maintained. Lee described the FEA setup, involving a complex assembly model with non-linear contacts, and outlined how the worst case loading was determined.

The results showed the sealing pressure obtained and how that compared to the pressure required to maintain sealing. Lee showed how a valve capacity could be predicted regarding the maximum external loading that would be acceptable to maintain sealing. Finite element analysis (FEA) was shown to be an invaluable tool in modelling valve operation early in the design process, in order to provide confidence in the design performance and to highlight areas for improvement.

Audience members were invited to ask questions at the end of Lee's presentation and discussions were held, regarding FEA assessments for HISC and how different assessments involved different requirements for mesh refinement.

Elizabeth then introduced the final speaker, James Brierley, a Graduate Project Engineer at BEL Valves Ltd, who is in a good position to assess the current challenges faced in valve production for onerous environments, having completed a R&D dissertation with BEL Valves. James' presentation was titled Expected Challenges and Design Verification of HP/HT Valves Developed for Subsea Service. The motivation for the talk was that, as oil resources have become more depleted, further oil field discoveries require engineering for more onerous conditions to extract the oil. The particular focus for the presentation was high pressure and temperature conditions, at which BEL Valves has led the way in terms of valve development for some of the biggest projects in the subsea engineering sector.

James described the particular regimes involved in high pressure, high temperature and soar service environments for valve operation and various associated problems, such as corrosion, how to maintain valve function over its lifetime and how to comply with Safety Integrity Levels (SIL). The importance of High Integrity Pressure Protection System (HIPPS) valves in protecting subsea piping networks was described, along with the development of valve sizes and operating conditions over time. It was detailed how specialist materials were required under the conditions for corrosion resistance and to reduce friction, such as tungsten carbide and the development of diamond-like carbon (DLC) coatings.

The development of analysis techniques over time was described. FEA analysis has moved from simple linear elastic assessments, to assembly models with nonlinear contacts, to nonlinear material models and fatigue assessments. James offered a view about how the future of FEA will involve assessment of fracture mechanics. In terms of Computational Fluid Dynamics (CFD), analyses have moved from single phase to multi-phase, and assessment of HIPPS valve closure times. An advantage of analysis was explained in terms of being able to reduce the size and weight of valve components and therefore minimise cost. James concluded the presentation with a description of the rigorous testing regime required to mitigate the risk of valve failure. The floor was then opened up to questions and different testing requirements and codes were discussed.

Thanks to the speakers for their time and effort in delivering the presentations, and to PDL Solutions and BEL Valves for their sponsorship.