Design Investigation of Extreme High Pressure, High Temperature, (XHPHT), Subsurface Safety Valves (SSSV)

Research Objectives
The purpose of the project is to investigate sub-surface safety valve design as a graduate engineering design task in expectation of developing new design methods that can be applied to valves subject to pressures of 30,000 psi and temperatures in excess of 400 degrees F.

Approach
The Research Partnership to Secure Energy for America (RPSEA) seeks novel technologies which may result in improved ultra-deepwater production systems. Sub-Surface Safety Valves (SSSV) are a technology that must have a step change in capabilities for extreme high pressure, high temperature (XHPHT) discoveries to become safely producible. Even in the current (15 ksi pressure) environments the major producers have concerns about structural safety and fluid structure interactions. At the new 30 ksi pressures and higher temperatures an incremental change in current designs will likely not be sufficient. New approaches to SSSV design, through a graduate level task design, can only help in developing the XHPHT resources. The first stage is an extensive survey on the current SSSV technologies, the potential improvement of the current industrial standards on SSSV designs are discussed in details; the current advanced SSSV technologies are reviewed; high strength materials that are suitable for XHPHT applications are summarized. The second stage is the design stage.

Accomplishments
This study has validated the concept that it would be practical to design a SSSV for operations at a pressure of 30,000 psi while at a temperature of 400F. Two high strength structural materials have been identified for such a design. However, that conclusion is based on a very narrow set of fluid and structural properties. It will be critical to vastly increase the range of those critical data. The cyclic stress-strain curve data for the high strength materials will probably be the easiest to obtain or create. The XHPHT reservoir fluid/gas properties will probably be the most difficult design data to obtain. Those data seem to be treated as proprietary to reservoir owner. The interests of public safety suggest that such data should be made public. Hopefully, the SPE, API, or RPSEA organizations can coordinate such an effort.

Significant Findings
This study has not specifically addressed how a new design would be experimentally tested for validation. Clearly, the valve should be at least tested at the design pressure and temperature. It is difficult to justify an incremental pressure based on a fixed percentage or a fixed value, as current API standards suggest.

It is felt that the proper and necessary high pressure valve design procedure should follow the ASME BPVC concept of design-by-analysis (DBA). The concept should be applied to each and every aspect of the design: CFD, water hammer, static stress, fluid-structure-interaction, low cycle fatigue, etc. However, the suggestion to replace proven API standards with using individual reservoir conditions and a DBA is meaningless by itself!

Future Plans
The API should consider setting, or adopting, a standard that defines who is qualified to conduct a proper “analysis” of each and every aspect of the valve design. Usually different experts are be required to certify different design aspects. In the relatively mature area of linear and non-linear stress analysis, commercial software tools are often misused by persons without many years of experience.

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