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Valve Certification - Fabrication & Design Aspects: A Practical Example

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TOPICS

- Introduction;
- Valve Certification;
- Conesteel Presentation;
- IPEN Presentation;
- Methodology;
- Results;
- Conclusions.

Introduction

Petrobras is a big player in the world petroleum market and one of the biggest companies in Brazil in several aspects. Among them it is a big equipment buyer and in special a big valve buyer.

The valve specifications became more severe as the general safety concern increases (including economic aspects) and also due to the work in very deep water (over 2000m deep), in which Petrobras is a world leader, pushing the technology to a very new standards of design & safety of the needed equipments, among them there are, again, the valves.

So, to maintain themselves as Petrobras equipment providers the valve makers should be certified to prove they are capable to attend the new demands making even better products.

In short they should attend in full the ABNT NBR 15827:2007.

Valve Certification – NBR 15827:2007

One of the requirements of the NBR 15827:2007 is the verification of the valve's project by the use of numerical analysis tools like the finite element method implemented in the ANSYS program (Classic or Workbench) allied with tests with instrumented valves to verify their functional behavior as well the numerical analysis conservativism, considering the design pressure and temperature.

This work describes some of new demands a valve design should attend, the necessary analyses and verifications performed for a specific valve (nominal diameter, pressure class and material) towards its certification. The analyzed valve can work between -29 ºC and 400 ºC. The thermal and structural analyses include non-linear material behavior as well and non-linearities due to the several contacts among some valve parts. All analyses were performed with the ANSYS Workbench v10.

CONESTEEL Presentation

Located on the East Side of Sao Paulo, suburb of Vila Formosa, Conesteel is present in the market for more than 20 years manufacturing forged valves, recognized for providing high quality products, not every effort to be among the most respected companies in the industry.

Our product line covers sizes from 1/4” to 2", in pressure classes that range from 150 to 1500 lbs. The types of valves are: Forged Steel Gate, Globe, Swing Check and Piston Check Valve.

The present goal is the Certification of the ¾” forged gate gate valve for the 800 class (which covers, also, the ½” as well as the 1” valves).

A partnership with IPEN is under development.

IPEN Presentation

Located on the campus of USP in São Paulo, IPEN - Nuclear and Energy Research Institute – is a São Paulo State owned research institute managed by CNEN – Comissão Nacional de Energia Nuclear.

IPEN has today an outstanding performance in various sectors of the nuclear activity and the provision of economic and strategic value to the country, making it possible to extend the benefits of nuclear energy to larger segments of our population.

The experience in pressure vessels design and analyses under the ASME code makes the partnership with IPEN very profitable for the "by analyses" valve Certification as required by the ABNT NBR 15827:2007 standard.

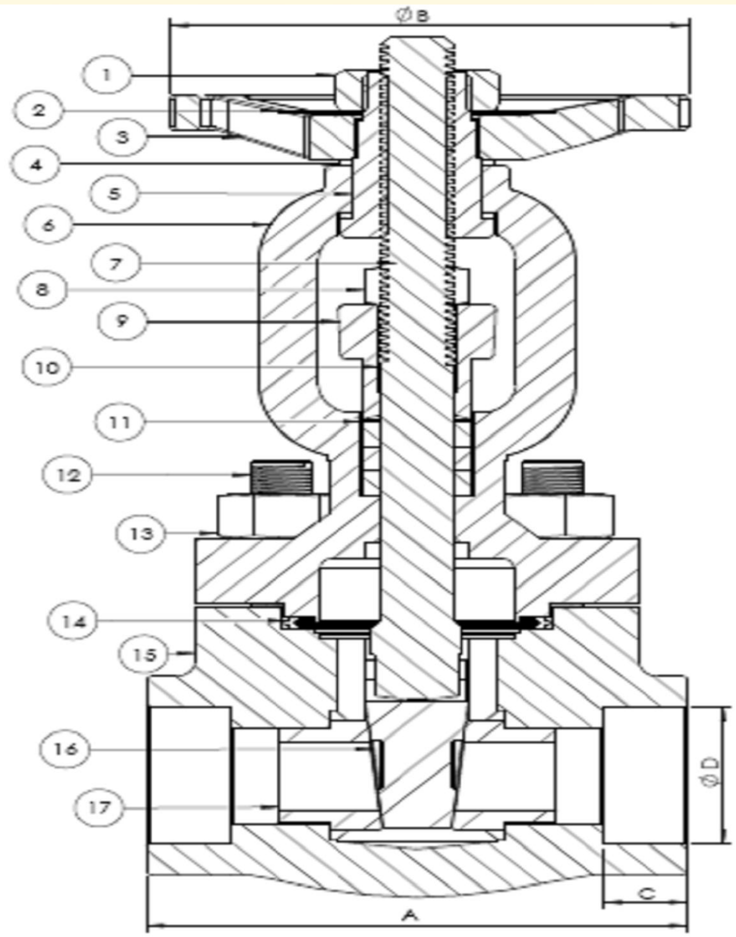
Forged Gate Valve 1/2" Class 800

This study was done for the Gate Valve Gage 1/2", class 800.

The prototype's material followed the item 6.3.2 of the ABNT NBR-15827:2007, with the body of carbon steel ASTM A-105 and the trim with 13 Cr. ASTM A-276 410 and ASTM A-217 CA-15. The Petrobras standard allows non-linear materials as gasket to be simplified to linear models.

It was used the linear elastic model as materials behavior.

Forged Gate Valve - Materials



n	Valve Parts	Materials/Standarts
1	Hand Wheel nut	SAE 1020
2	Identification Plate	Stainless Steel
3	Hand Wheel	ASTM A 216 WCB
4	Plate nut	SAE 1020
5	Stem nut	ASTM A 582 416
6	Bonnet	ASTM A 105
7	Gland Bolting	ASTM A 307-B
8	Gland nut	ASTM A563 A
9	Gland	ASTM A 105
10	Stem	ASTM A 276 410
11	Packing	Graphite + Inconel
12	Body Bolting	ASTM A 193 B7
13	Body Bolting nut	ASTM A 194 2H
14	Gasketing	AISI 304 + Graphite
15	Body	ASTM A 105
16	Gate	ASTM A 217 CA15
17	Seat Ring	ASTM A 276 410

Methodology

The geometry was imported from a CAD program, SolidWorks.

The finite element program used was Ansys Workbench 10.0 SP1, the mesh was automatically refined by the program. The basic configuration used is shown below.

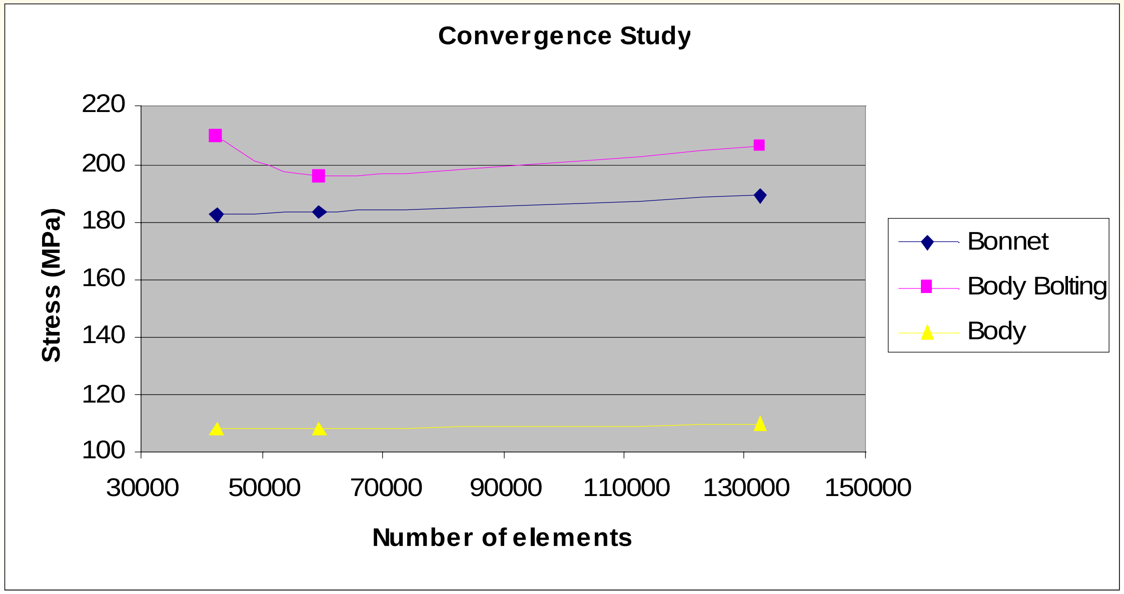
Details of "Mesh"

Defaults	
Global Control	Advanced
Element Size	Default
Curv/Proximity	100
Shape Checking	Aggressive
Solid Element Order	High
Initial Size Seed	Active Assembly
Statistics	

Methodology

The standard requires that the mesh has a maximum error of 5% in the results. To do so, the study was done on different mesh sizes and numbers of elements.

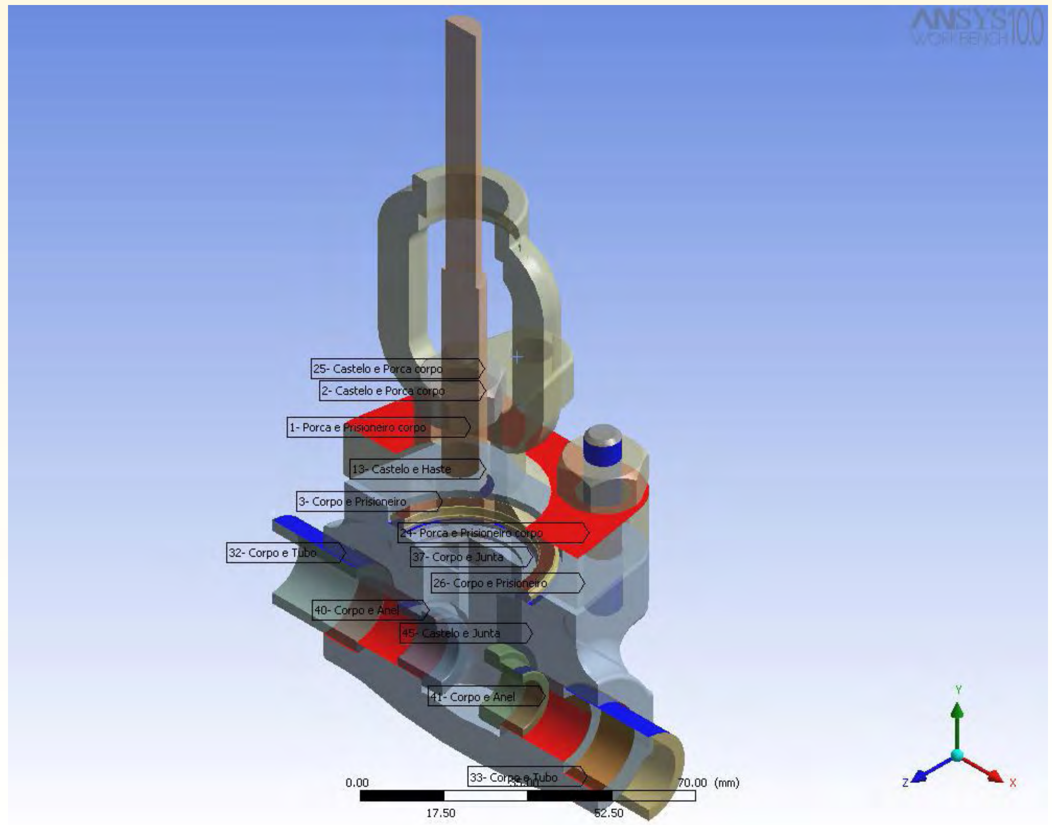
The results of interest were compared among the meshes.



Contacts

Basics Settings

- Bonded;
- Frictional;
- Behavior: Symmetric;
- Formulation: Augmented Lagrange;
- Normal Stiffness Factor: 0,1
- Update Stiffness: Each Equilibrium Iteration;
- Defaults



Boundary Conditions

The gate valve operates under the conditions “fully open” or “fully closed”.

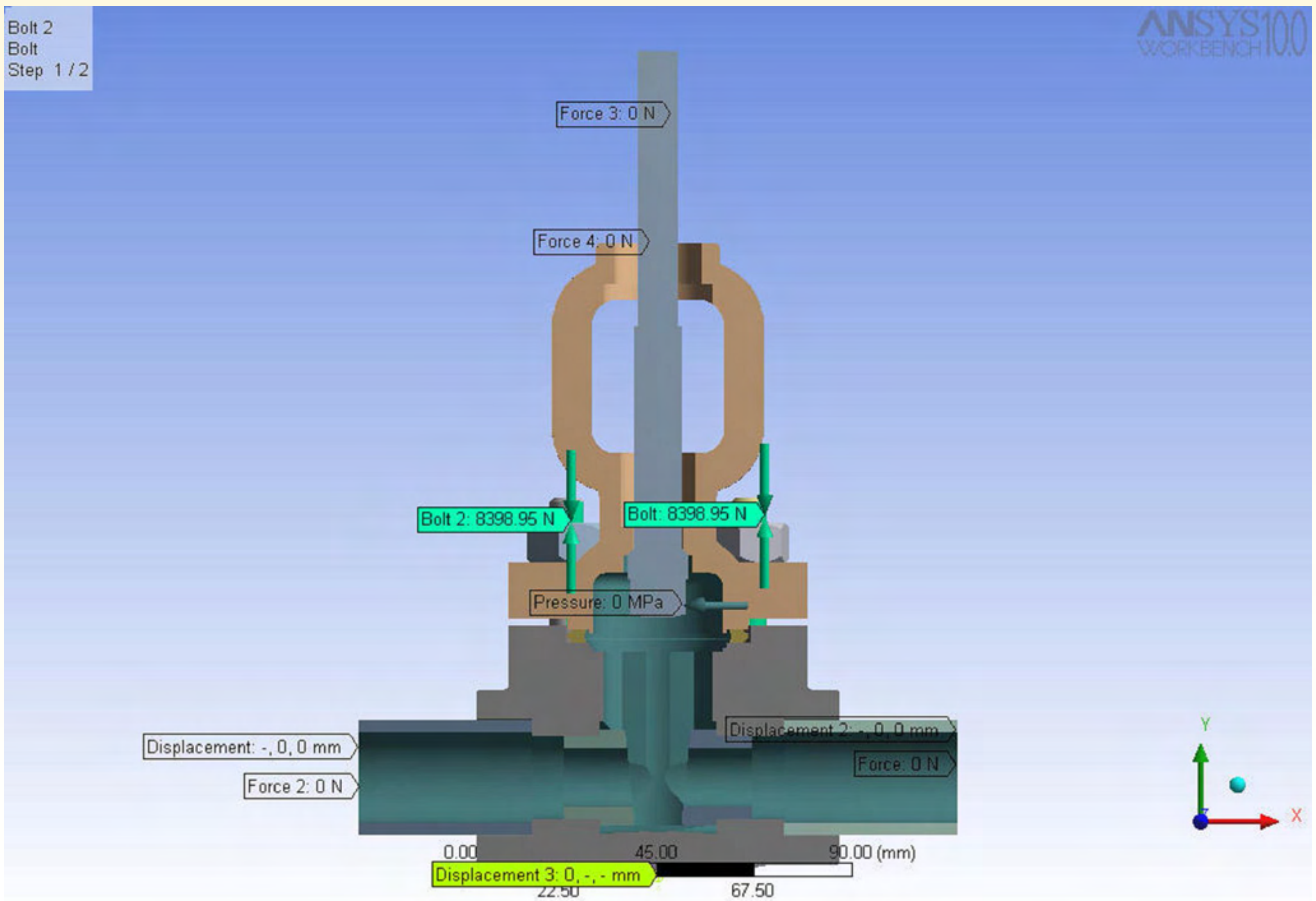
To analyze these conditions three types of simulations were made:

a) fully open ½ half model

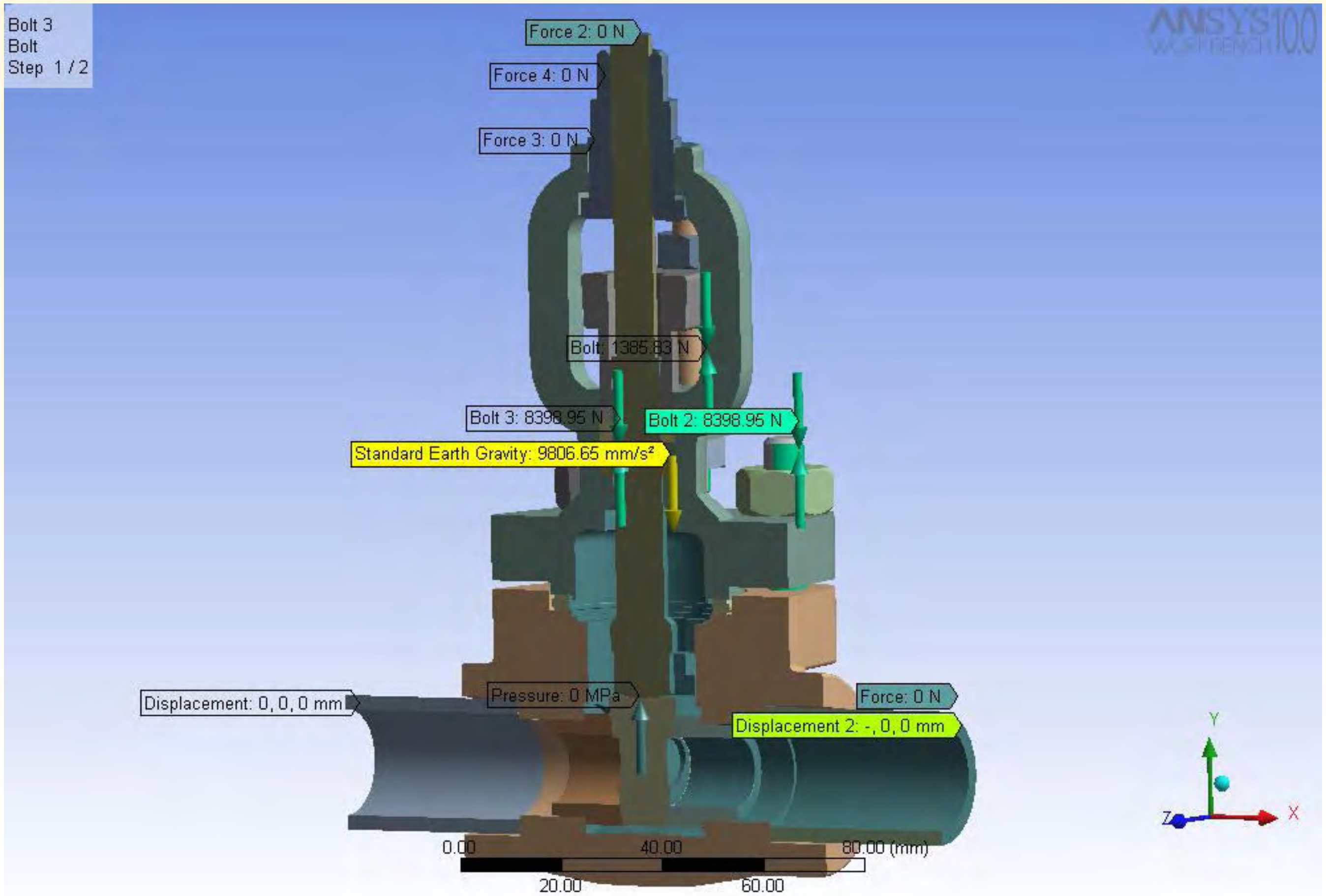
b) fully closed ½ half model

c) 360º model (upper part, under Torsion)

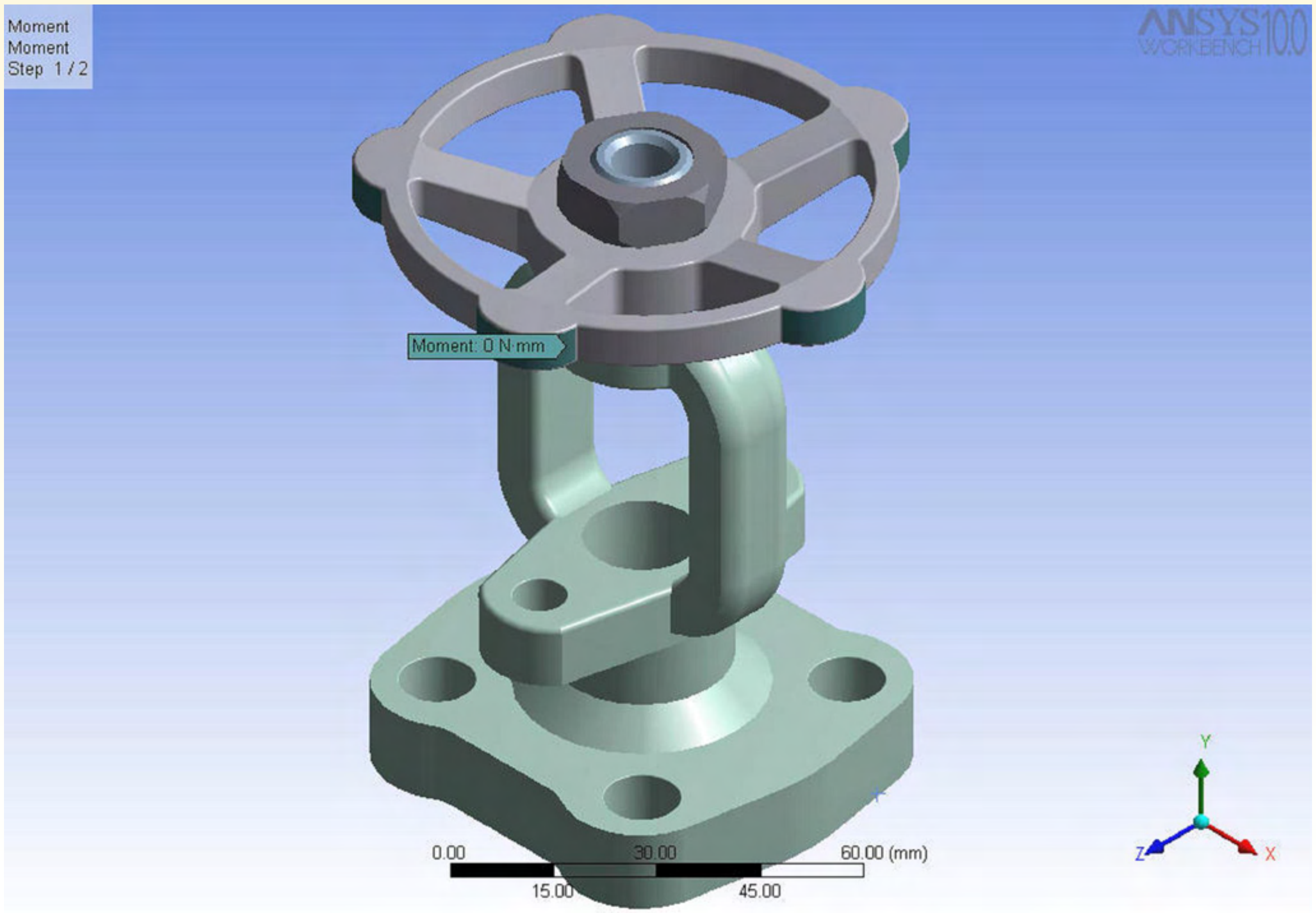
Fully Open - Boundary Conditions.



Fully Closed – Boundary Conditions.

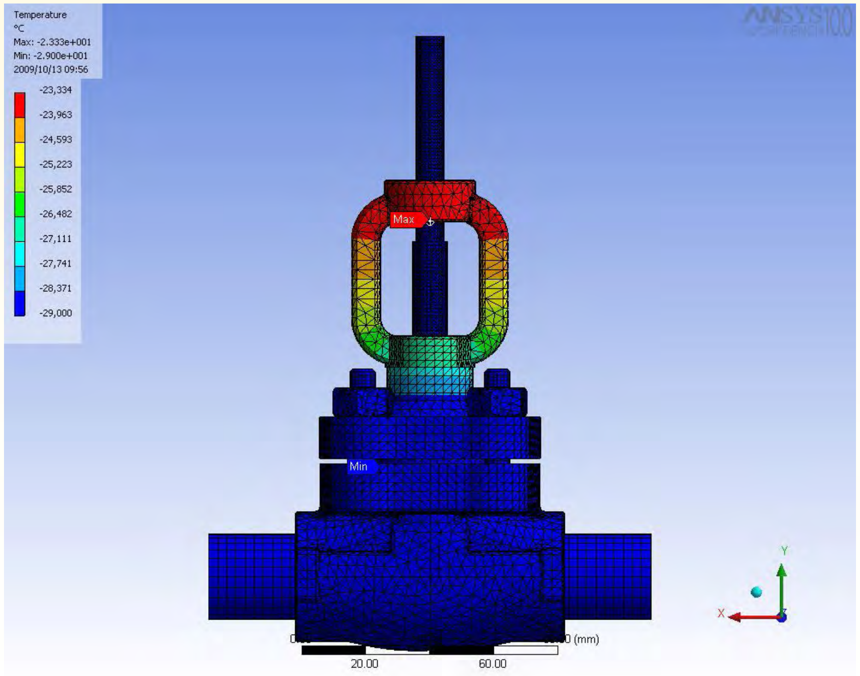


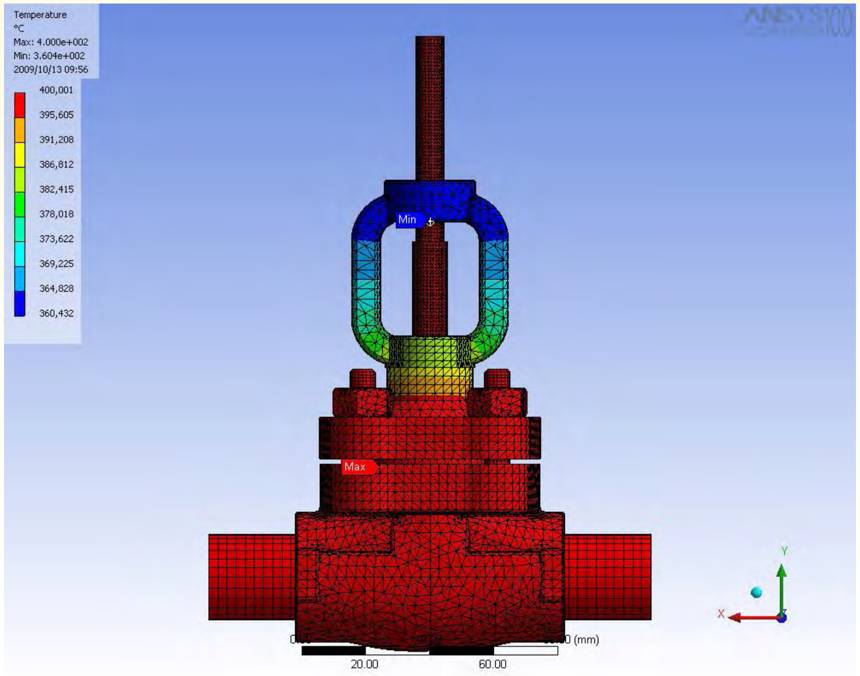
Torsional Moment – Boundary Conditions



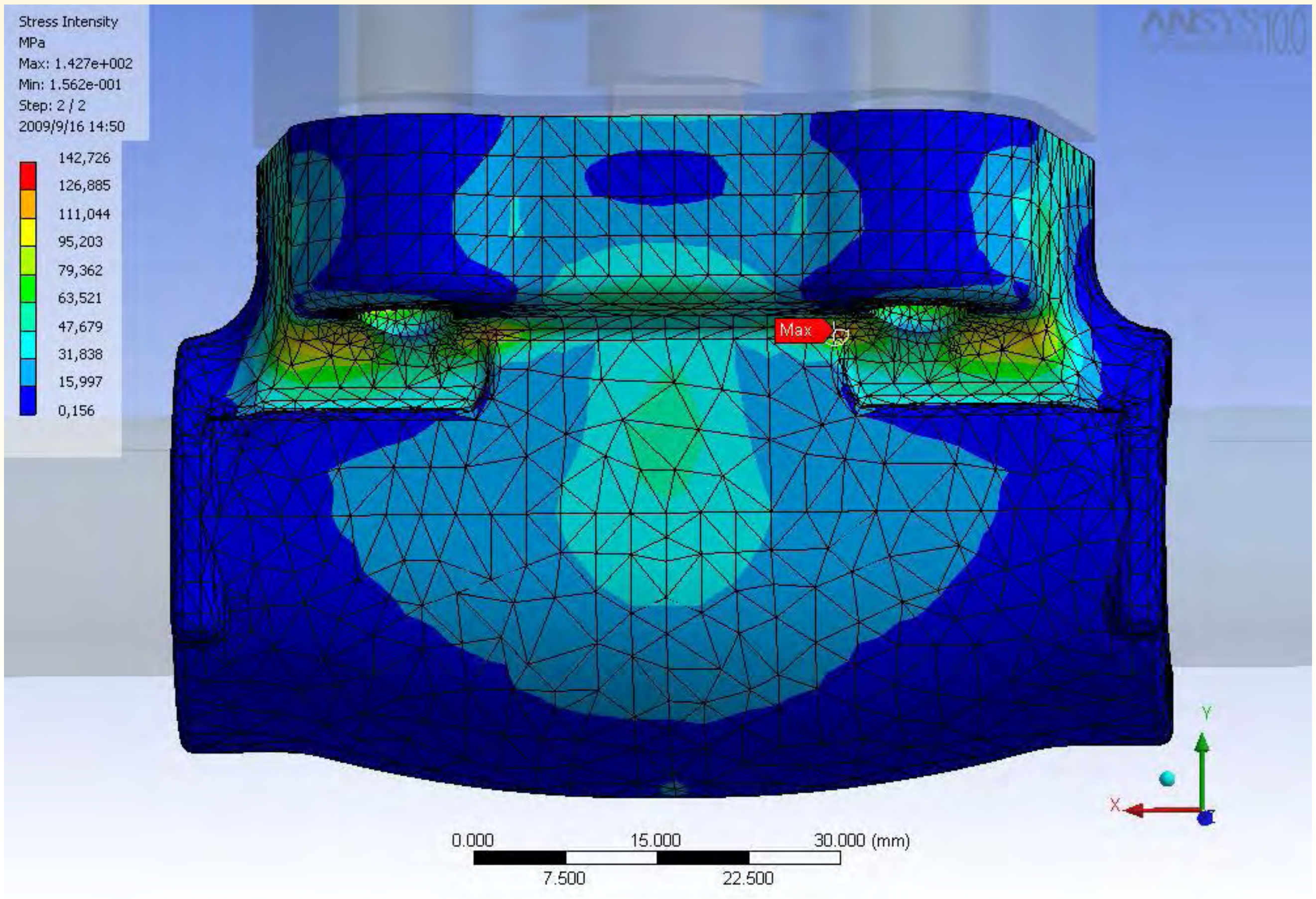
Working temperatures

The valve under analysis can work in any temperature value between -29 ºC and 400 ºC. So, the analyses are performed at these extreme values and at room temperature.

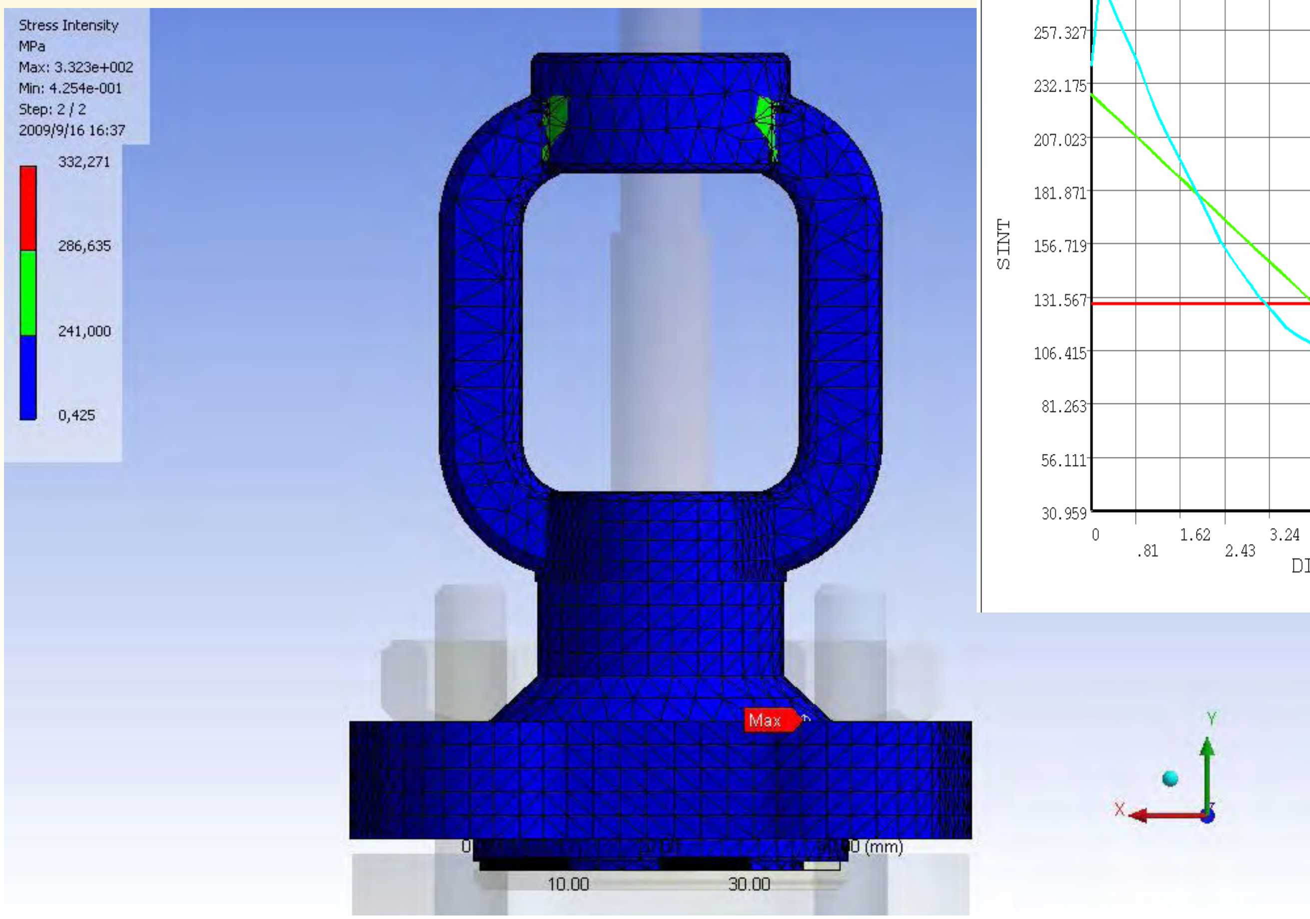


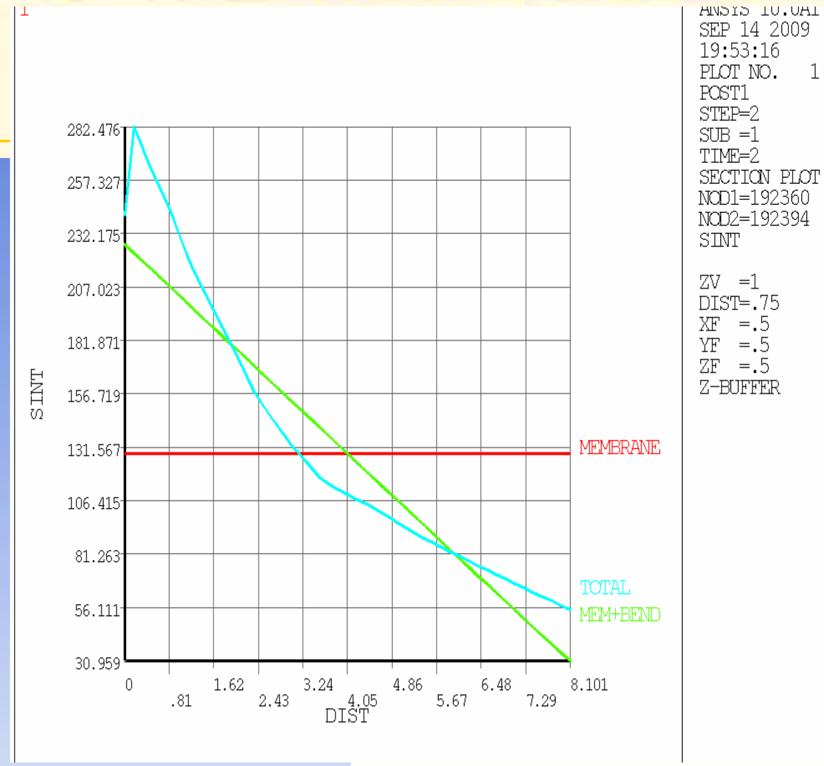


Results – Body

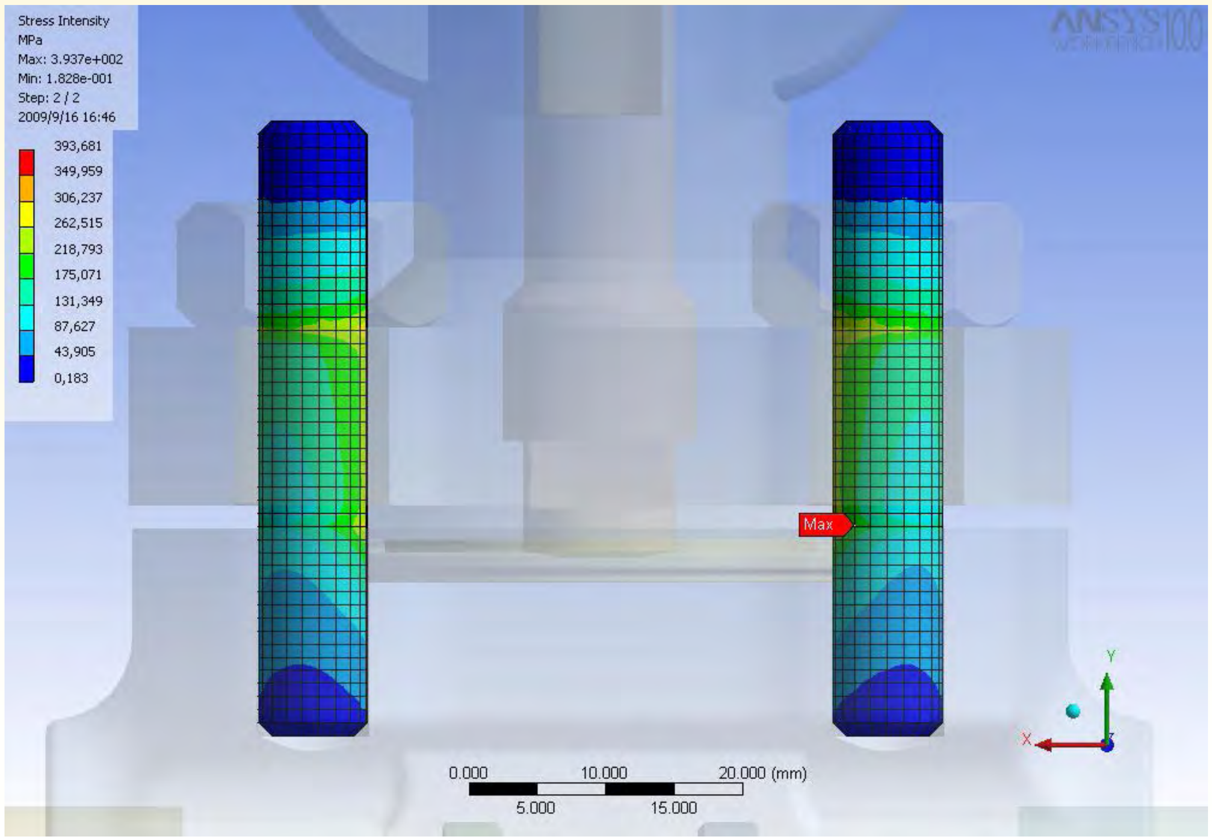


Results - Bonnet

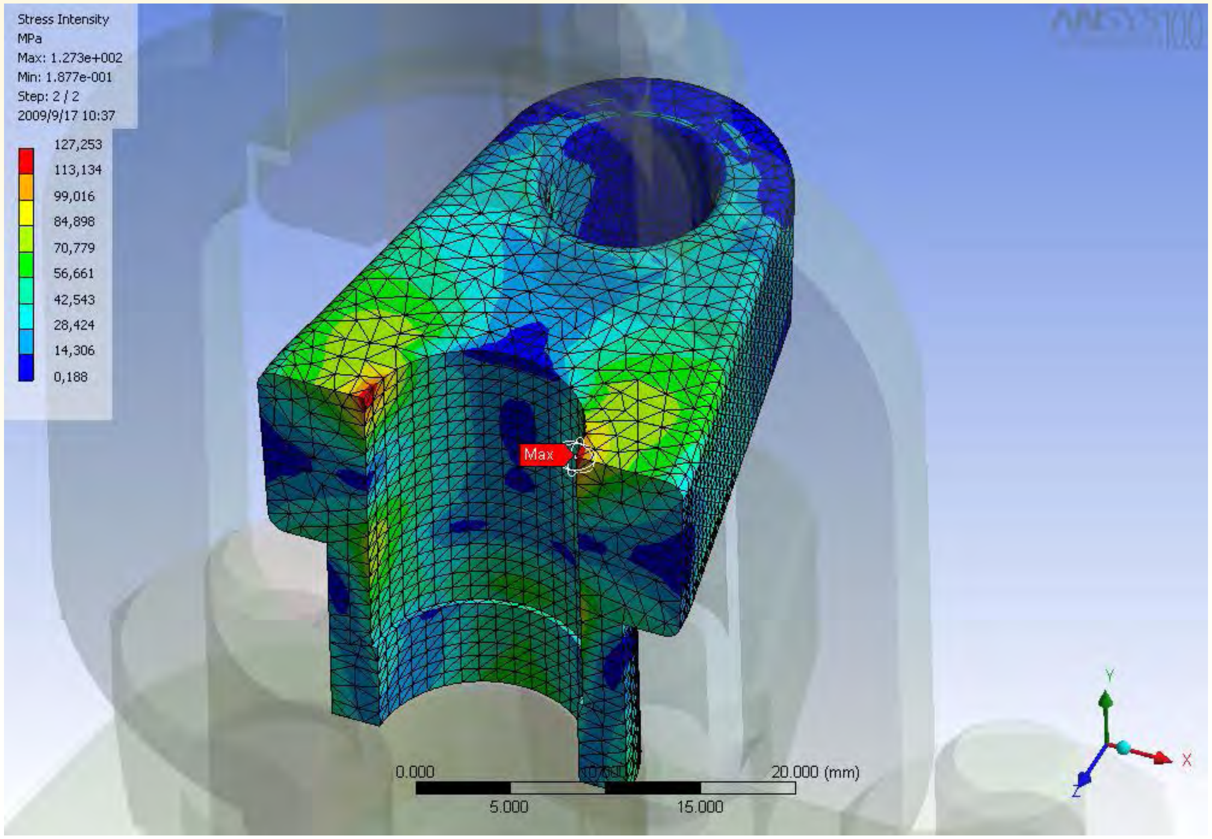




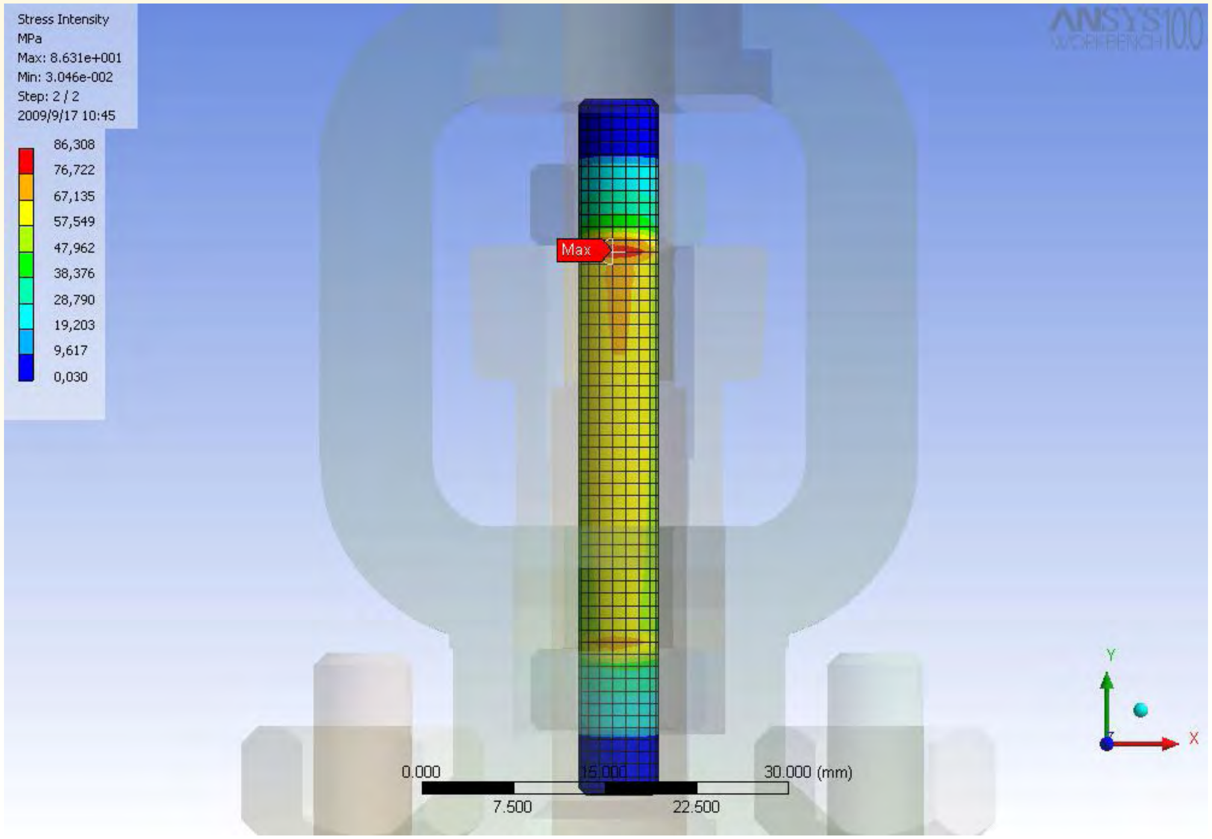
Results – Body Bolting



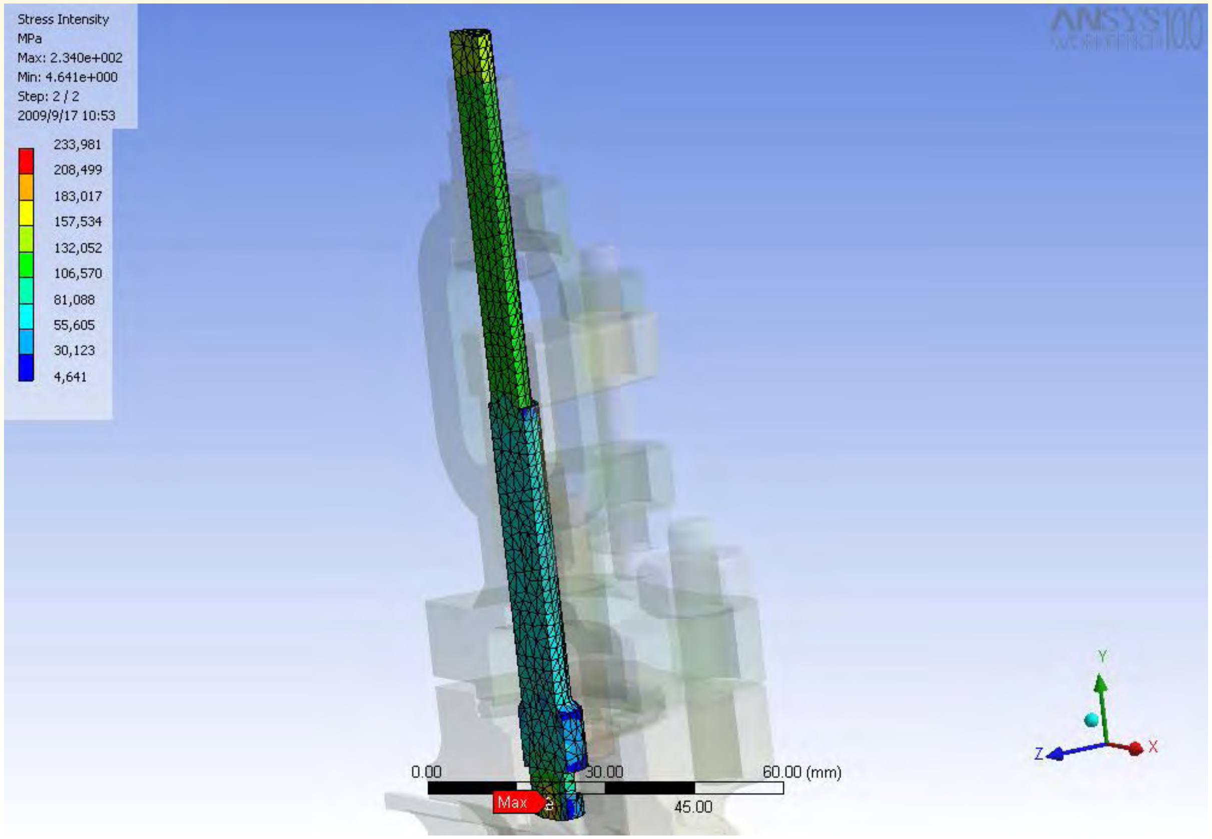
Results - Gland



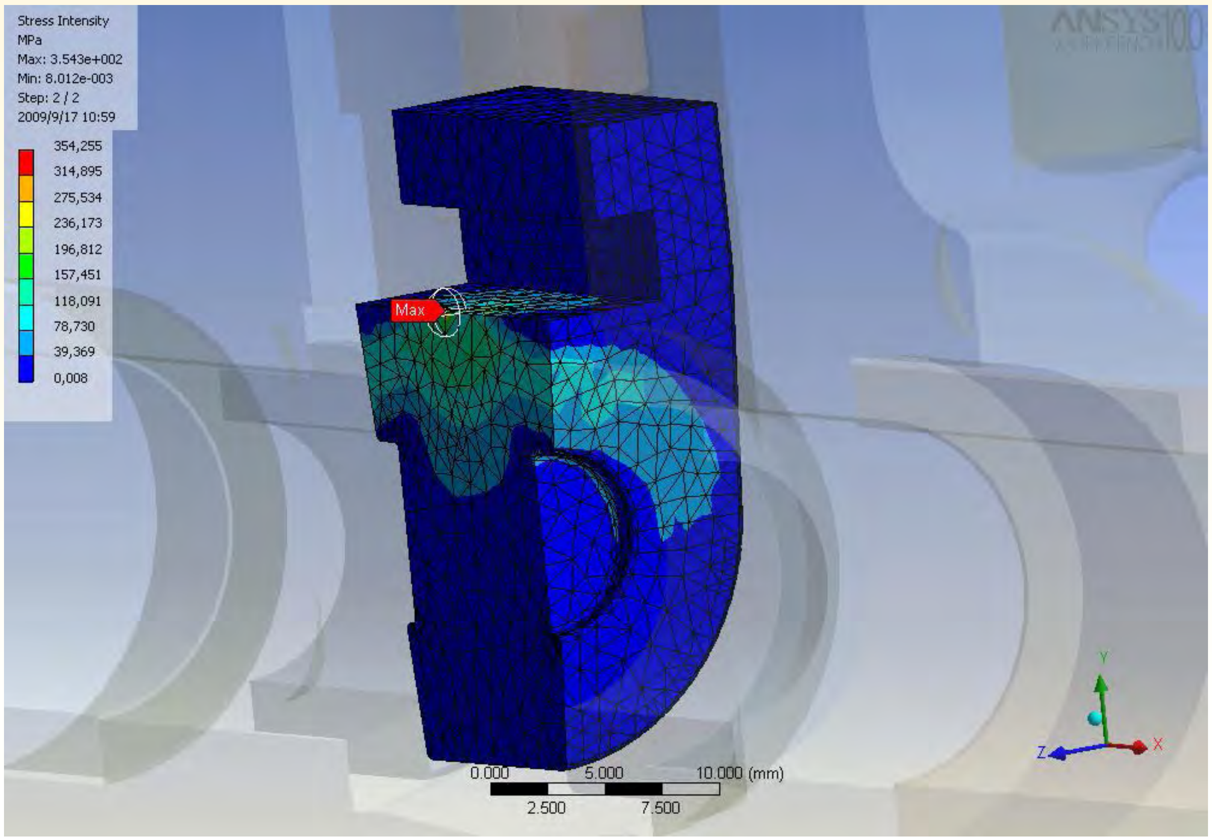
Results – Gland bolting



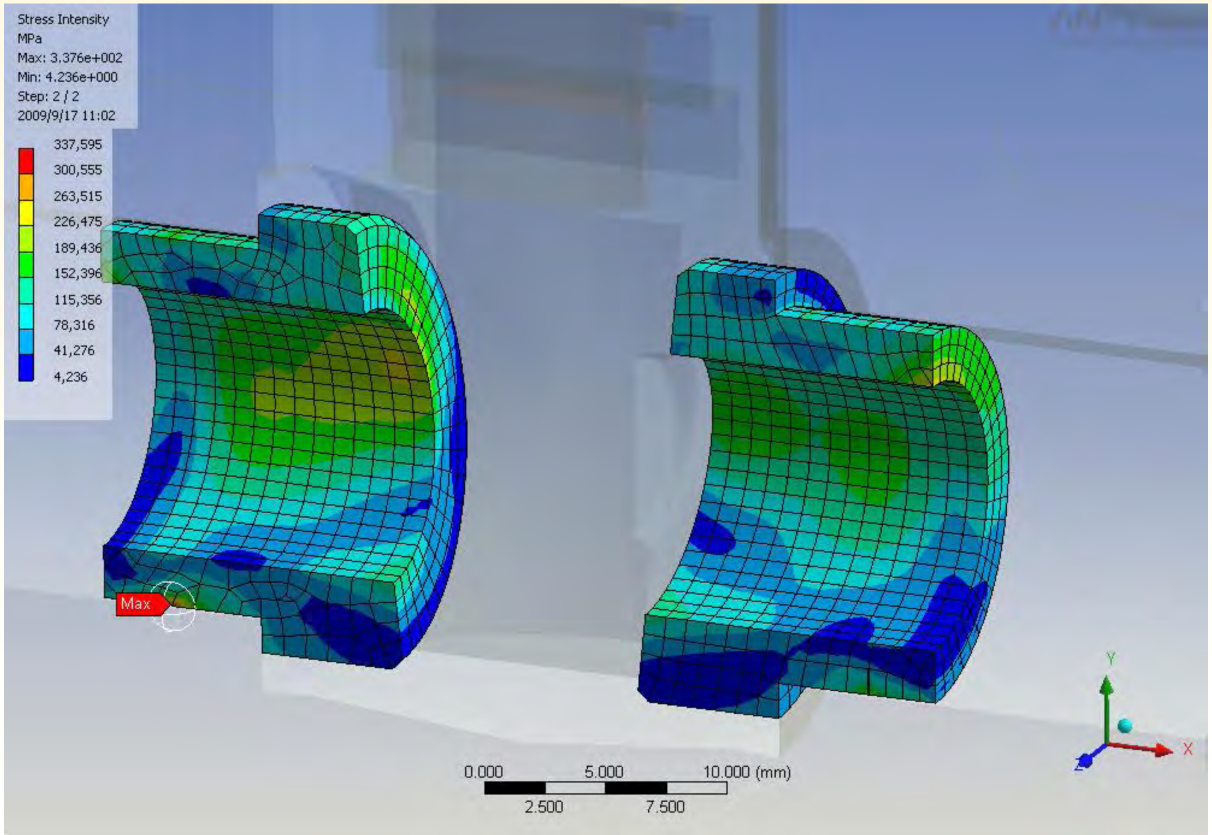
Results - Stem



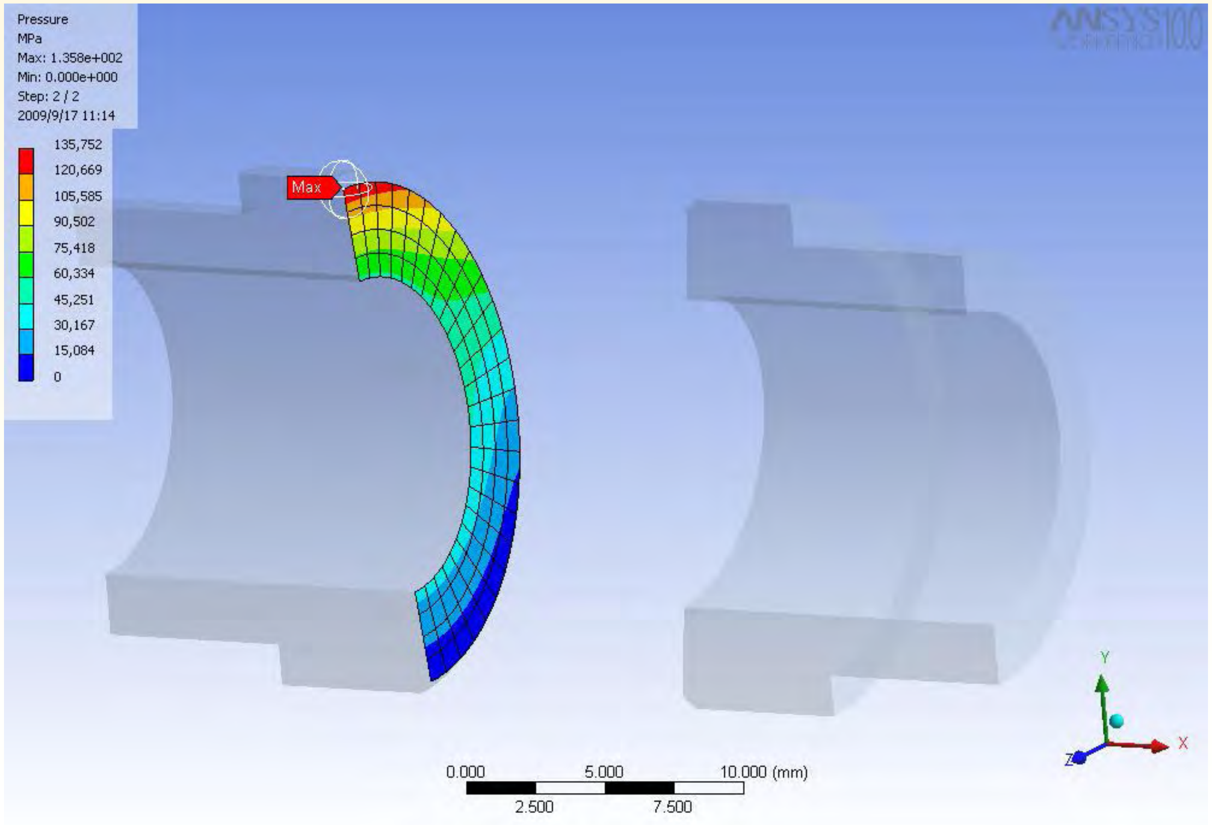
Results - Gate



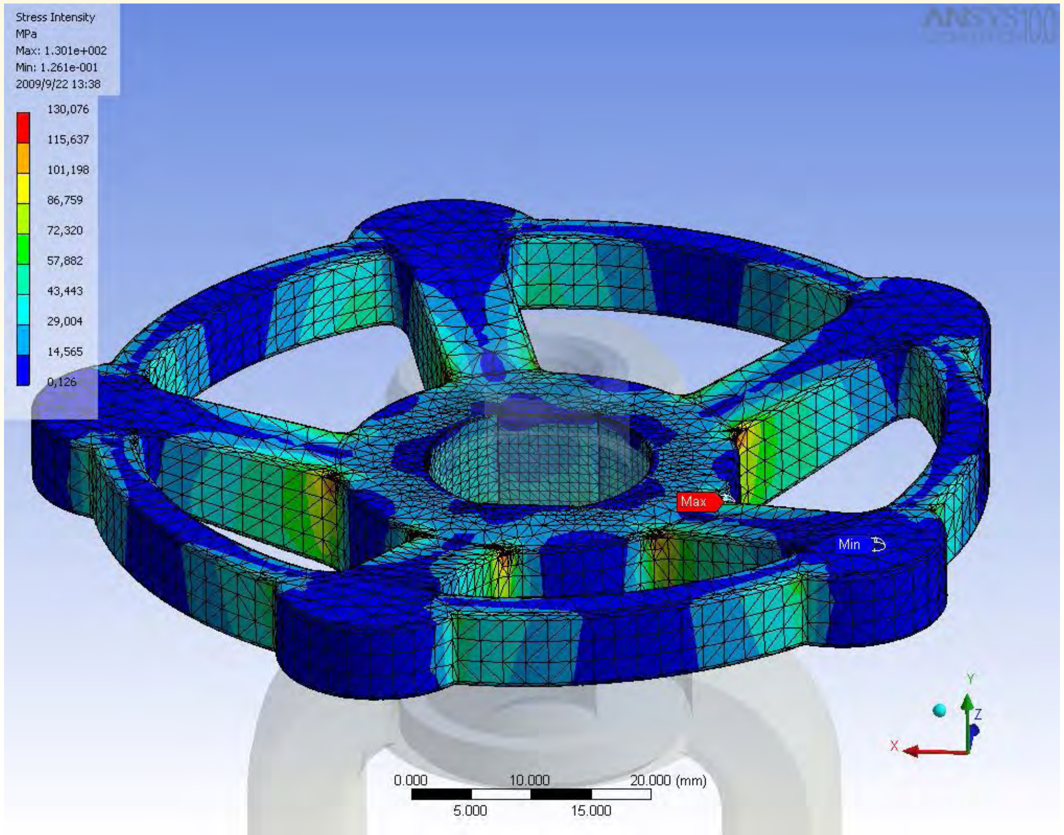
Results – Seat Ring



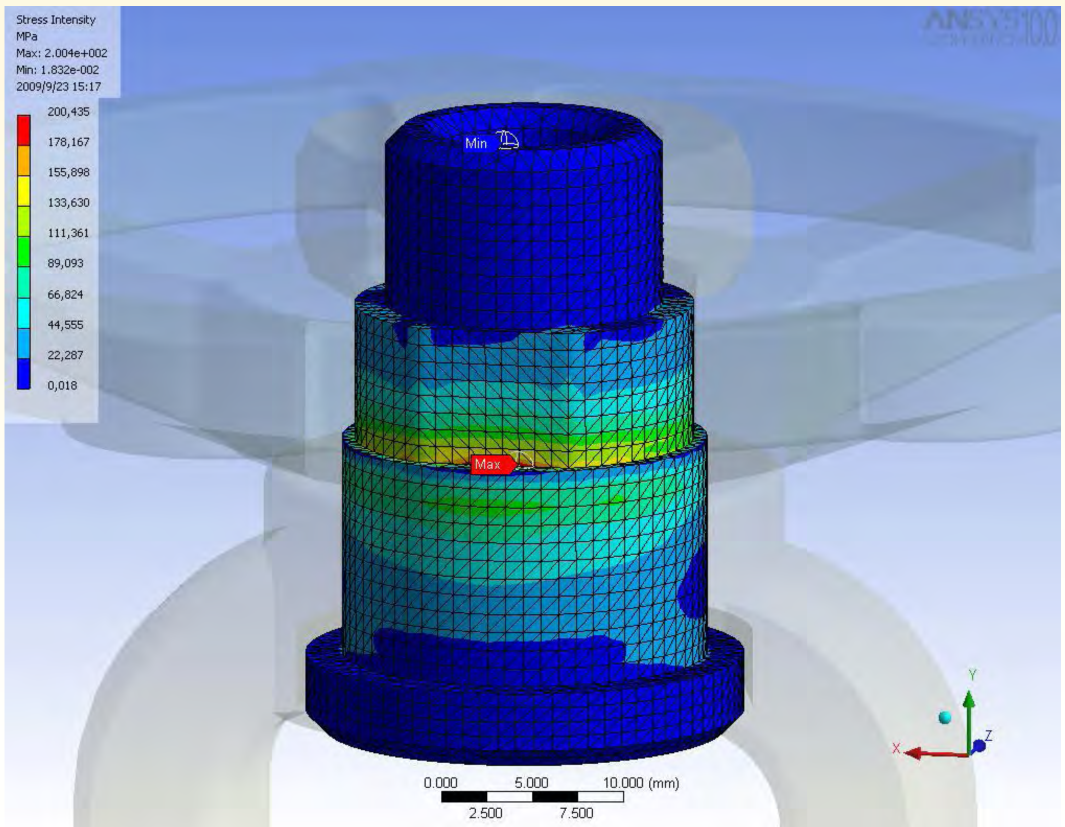
Results – Contact Pressure (between Gate & Seat ring)



Results – Hand Wheel



Results – Stem nut



Conclusions

As the valve is an object of complex geometry, the finite element study helps in better understanding of the most requested requirements facilitating the identification of critical regions where failures may occur.

Following the standard, each failure mode is prevented by specified verification, as typically:

. Plastic Collapse - primary stress: Membrane stress (averaged)
Membrane + Bending stress (linearized)

. Low Cycle Fatigue: maximum stress at a point (to assess the cumulative usage factor)

So far, all verification is within the standard limits.

Experimental analyses, as required by the standard, are under development.