



A New Bolted Joint Profile, Optimized with FEA, Fixes a Leaking Propane Pump.

John M Schmidt, PE, Oregon

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Biography

Name: John M Schmidt, PE, Oregon, Lead Field Engineer, Sulzer

BSME 1995 , GMI (General Motors Institute) (now Kettering University)

Flint Michigan (Interned for Whirlpool Corp.)

US Navy VFA-131 Intelligence Officer

MSME 2001, Oregon State University

Sulzer. 2001 to 2008. Engineering Design Analyst (Rotordynamics and structural FEA)

Sulzer. 2009 to Present. Field Engineering. (now a pretty well rounded Pump Engineer)





Abstract

A bolted raised face Joint (with O-ring gasket) was failure prone. An axisymmetric FEA (finite element analysis) of the Joint verified why: the flanges were not stiff enough (not thick enough); too much flange rotation occurred. A gap opened that the O-ring could extrude into and fail.

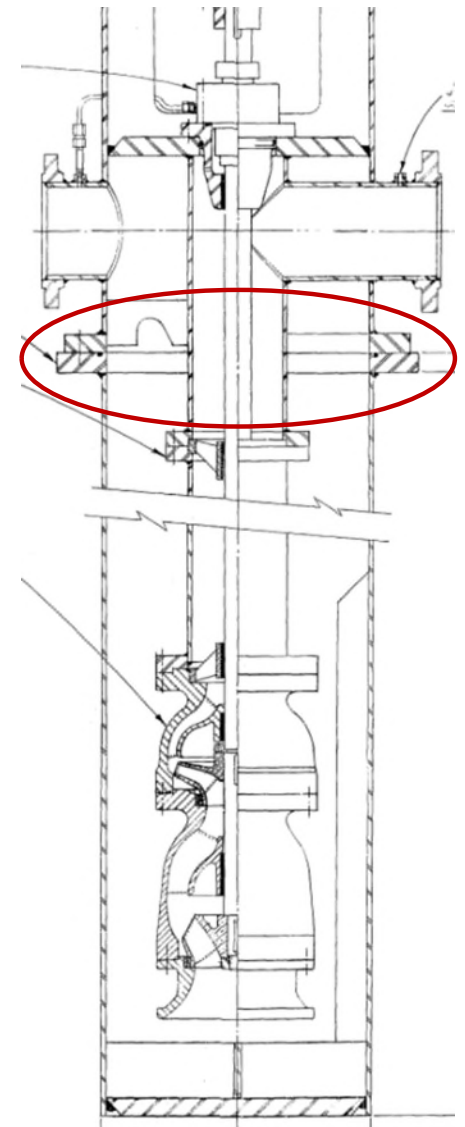
Going with thicker flanges was not an option, but continuing with FEA, various flange profile designs were analyzed narrowing in on a profile that kept the flanges together at the gasket location, minimizing the extrusion gap. This design was implemented into the new replacement discharge head and was successful: The joint is now leak-free.

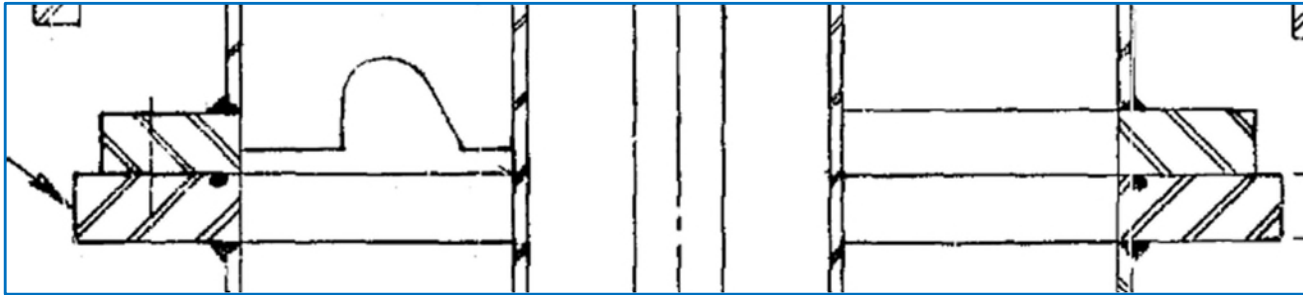
The Issue.

A Vertical Pump (VS6) in Propane loading service (installed 1978) at a Petroleum Refinery.

When a new Discharge Head was ordered (in 2019) there was a request to upgrade the gasket from an O-ring to a Spiral Wound gasket.

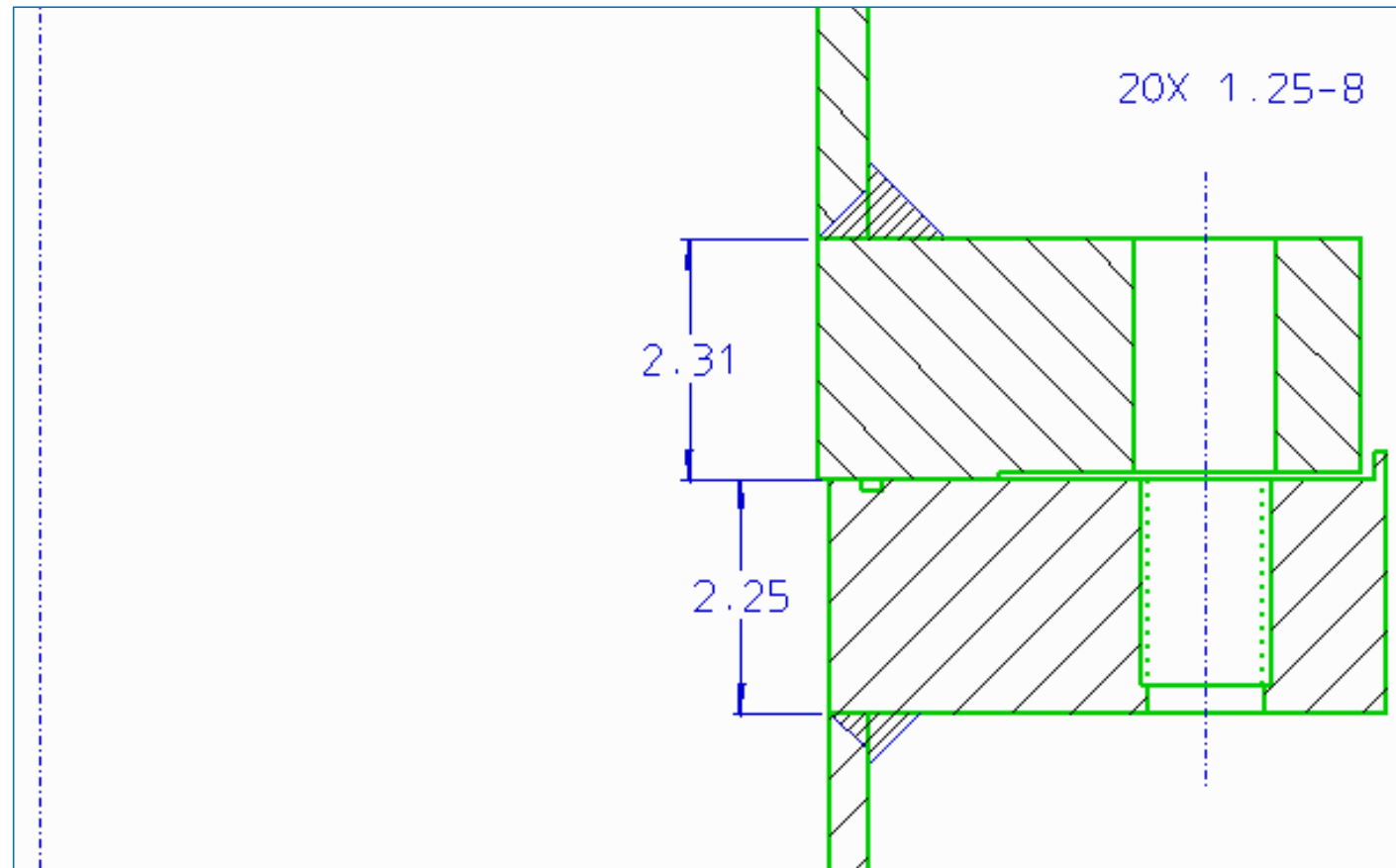
Upon further inquiry, the reason for the requested upgrade was because the current raised faced joint (with an O-ring) would occasionally leak.





The original design

To Scale - >>

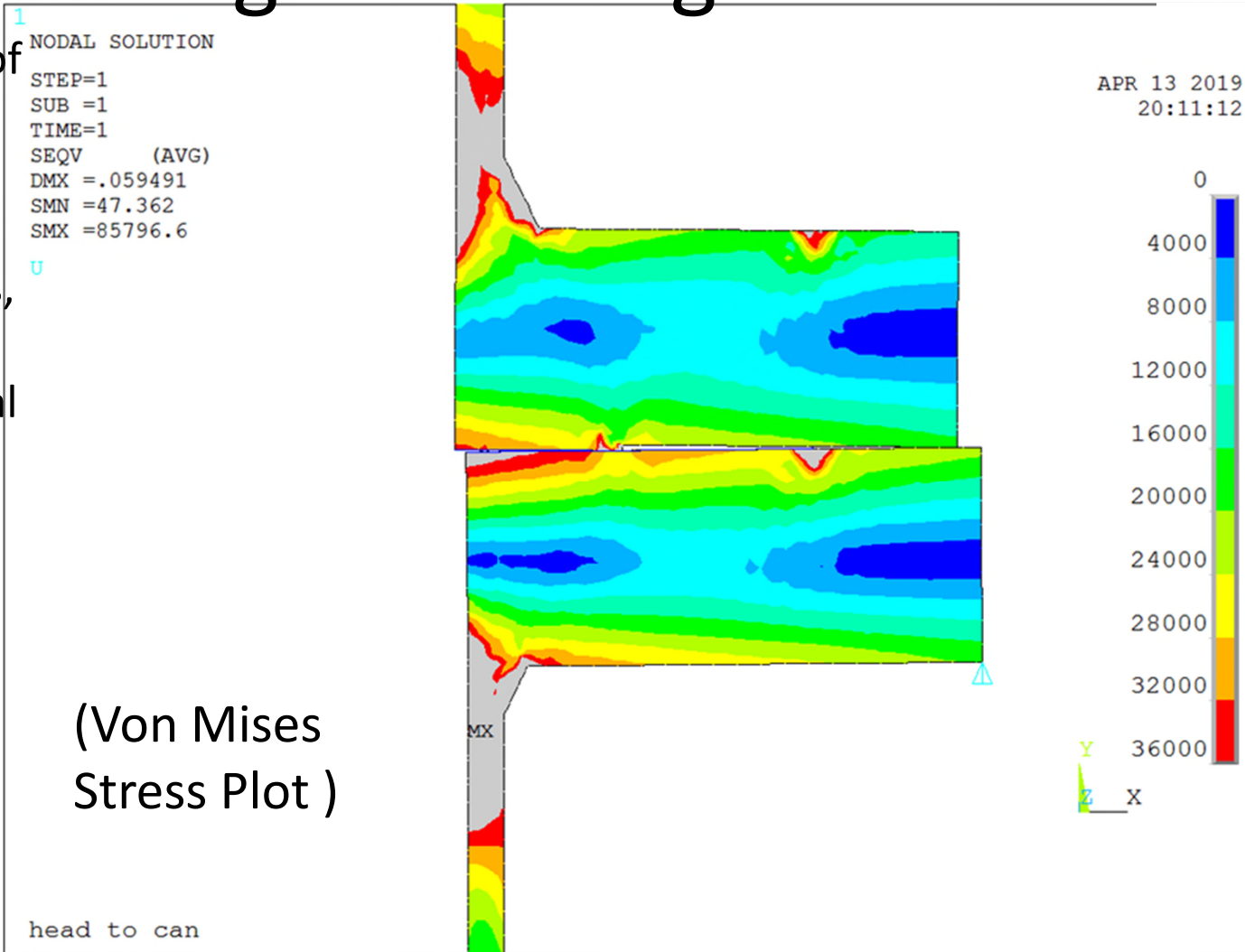


FEA of the original design.

An axisymmetric FEA model of the original circa 1970's design.

Bolt force 0.6e6 lbf (20 bolts, ~ 30% of bolt yield strength, 30,000 lbf each bolt). Internal Pressure: 720 psi.

ISSUE 1: Flange rotation results in exceeding material Yield Strength.



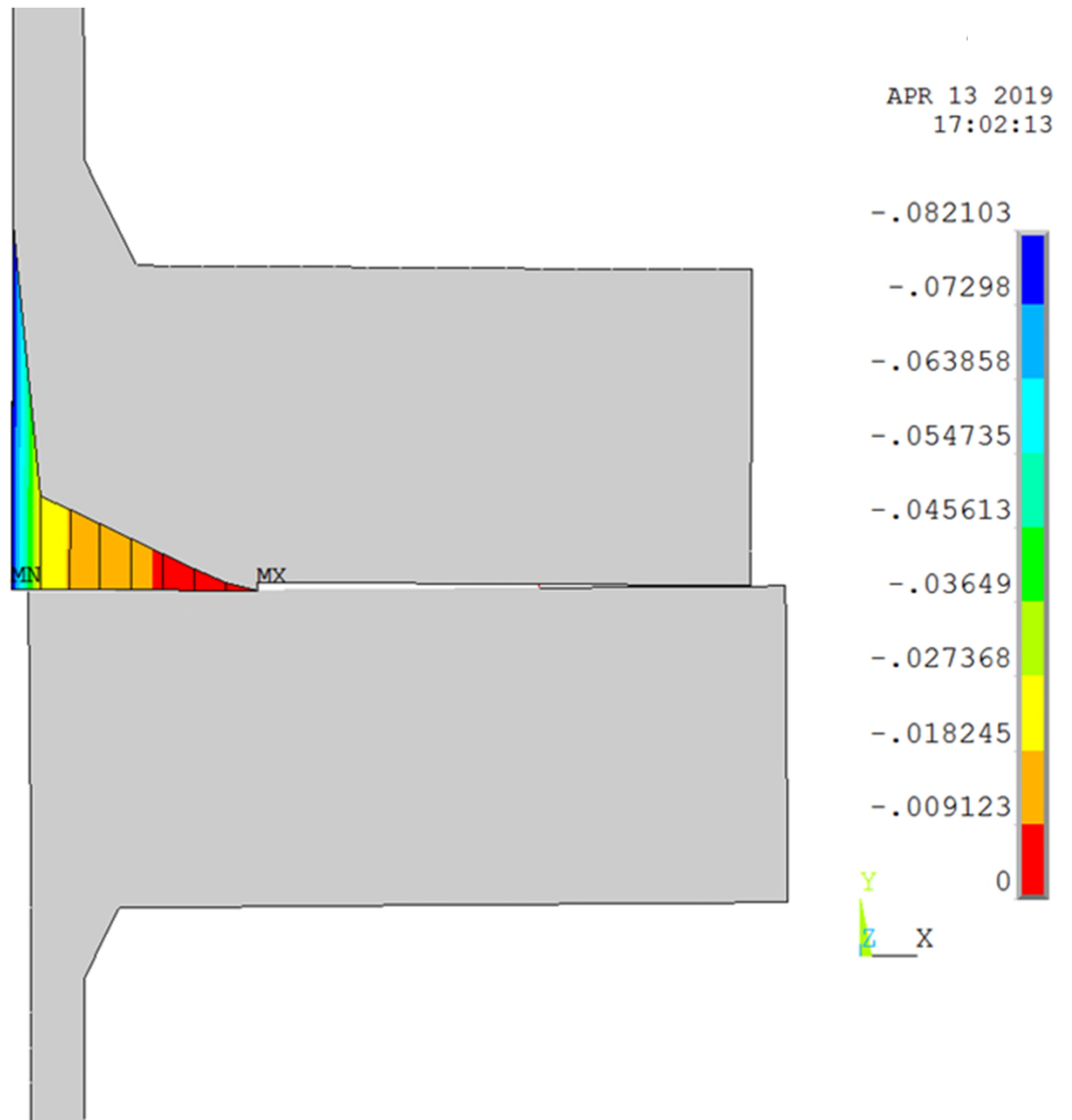
FEA of Original Design.

And ISSUE 2: A gap has opened up at the gasket location (~.018")

```
1
NODAL SOLUTION
STEP=1
SUB =1
TIME=1
CONTGAP (AVG)
DMX =.058033
SMN =-.082103
```

Contact
Gap Plot

head to can

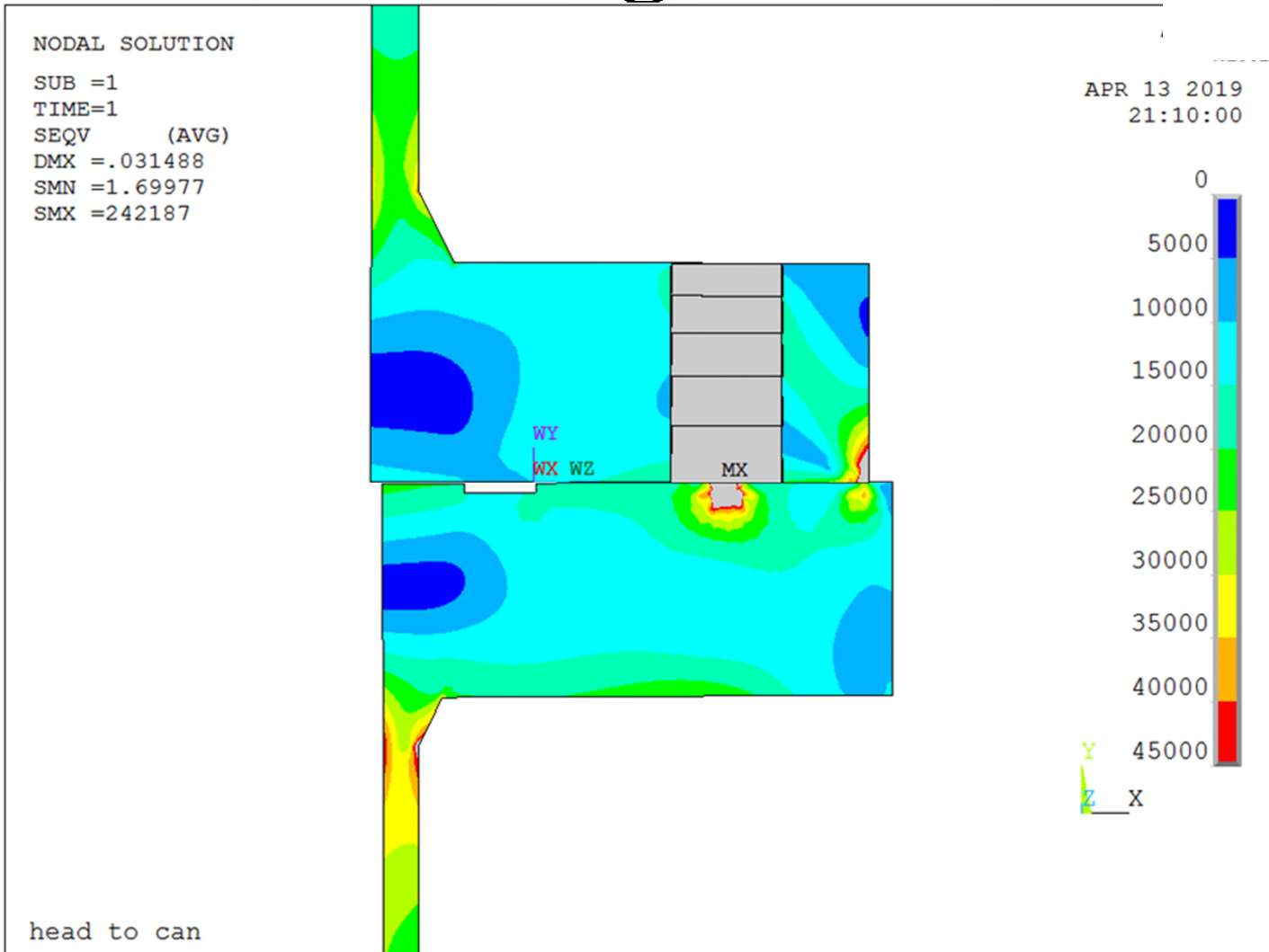


FEA of a Flat Face Design

Try a flat face design with a Spiral Wound gasket.

Hydrotest 1080 psi.

Von Mises Stress Plot ->>
(looks pretty good, but...)

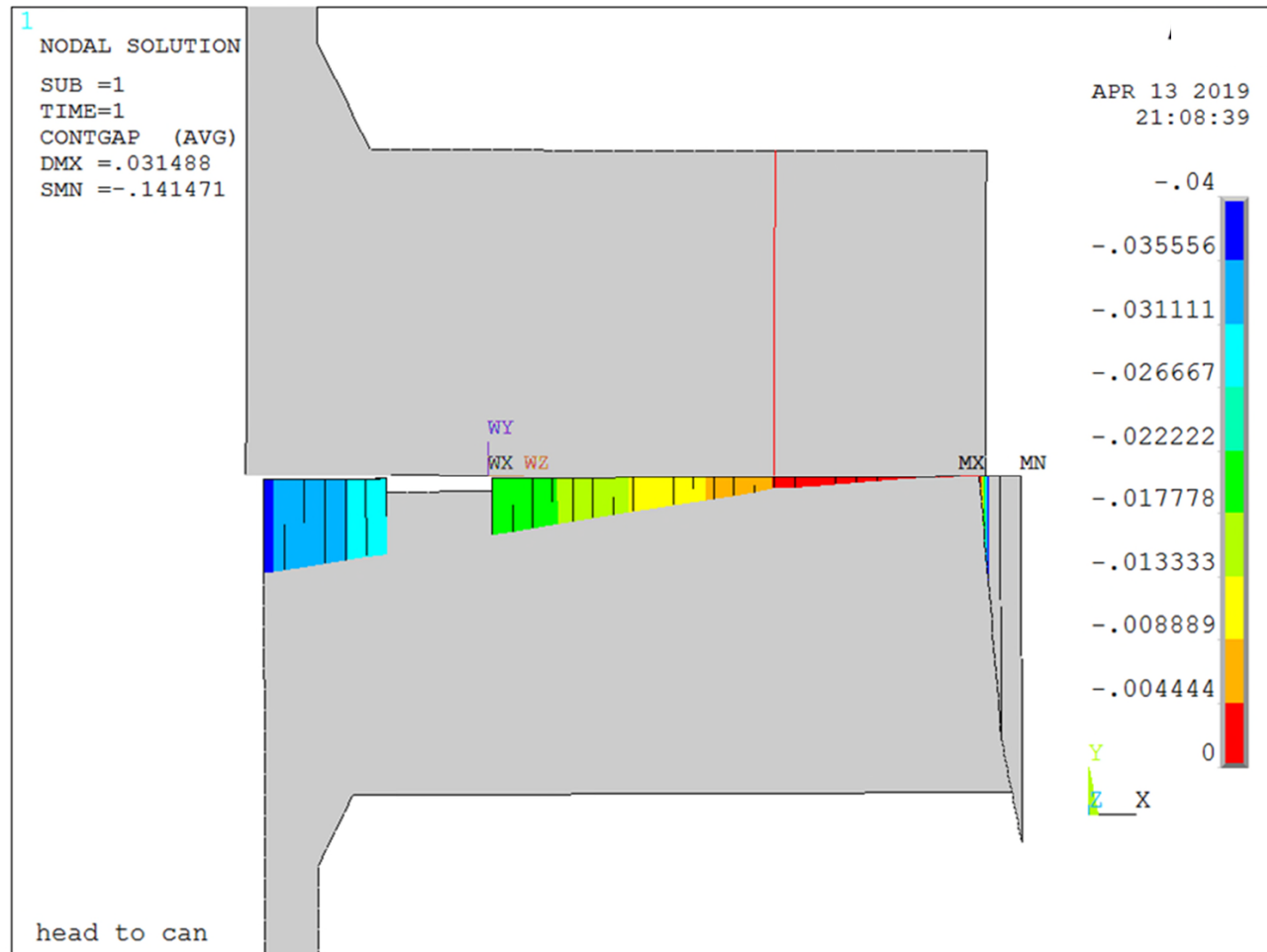


FEA of Flat Face Design

Flat Face with Spiral Wound.

Contact Gap Plot ->>

Problem: Still too much gap / not adequately compressing the spiral wound gasket.



A new profile is needed.

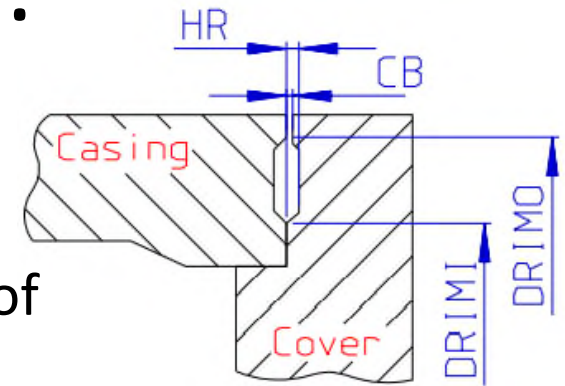
A number of flange profiles were attempted based on Recess (at the bolt location) and Cutback.

-The Spiral Wound Gasket needed a crush pressure of 10,000 psi plus 1080 psi hydrotest pressure.

-Could not keep the flanges together at the gasket location: The flange was not rigid enough, the bolt circle too far out.

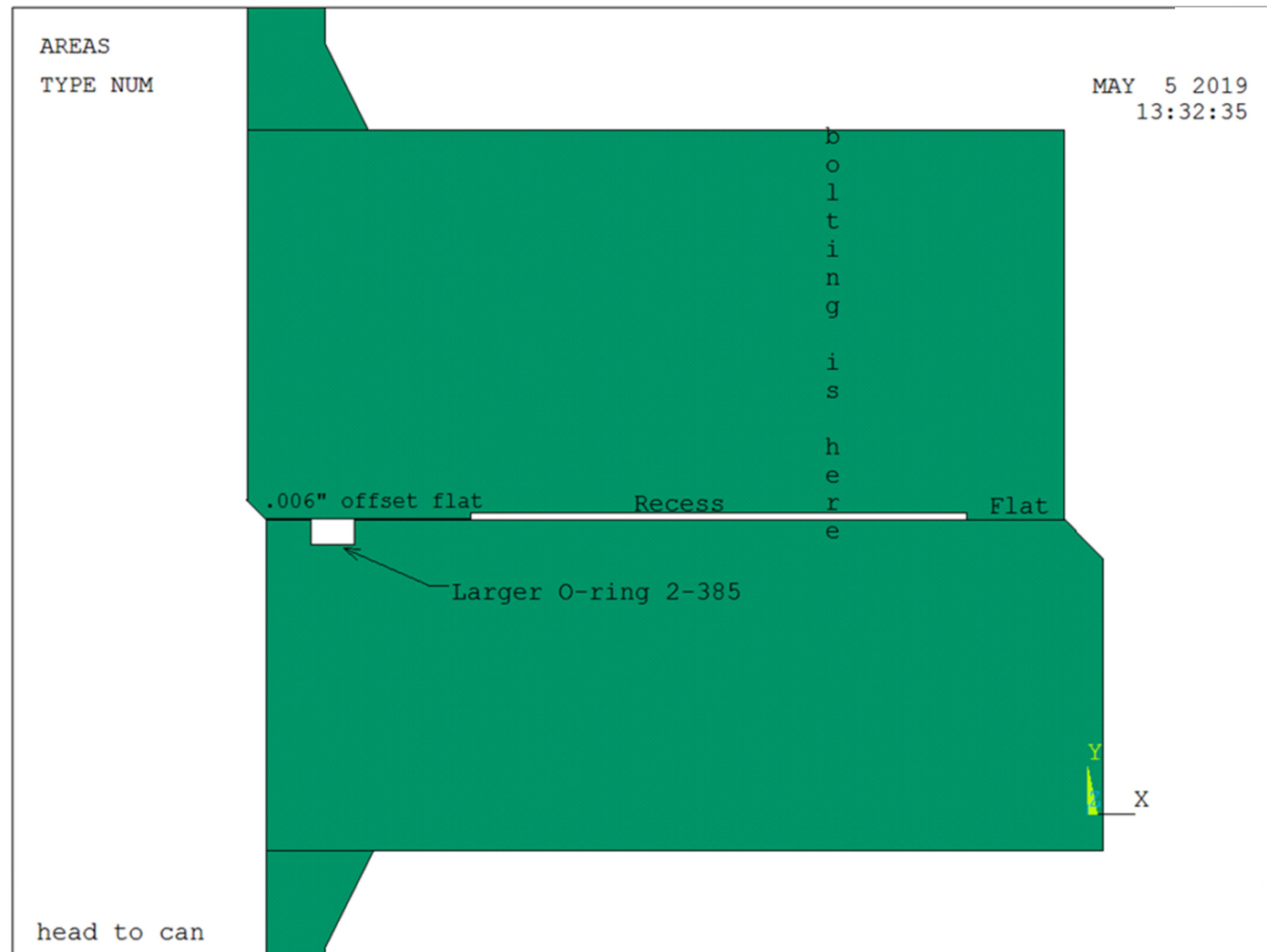
-A conference call with customer determined that they didn't specifically need a Spiral Wound gasket, just a joint that didn't leak.

-Went back to an O-ring since it is self energizing.(It doesn't need as much bolt force).



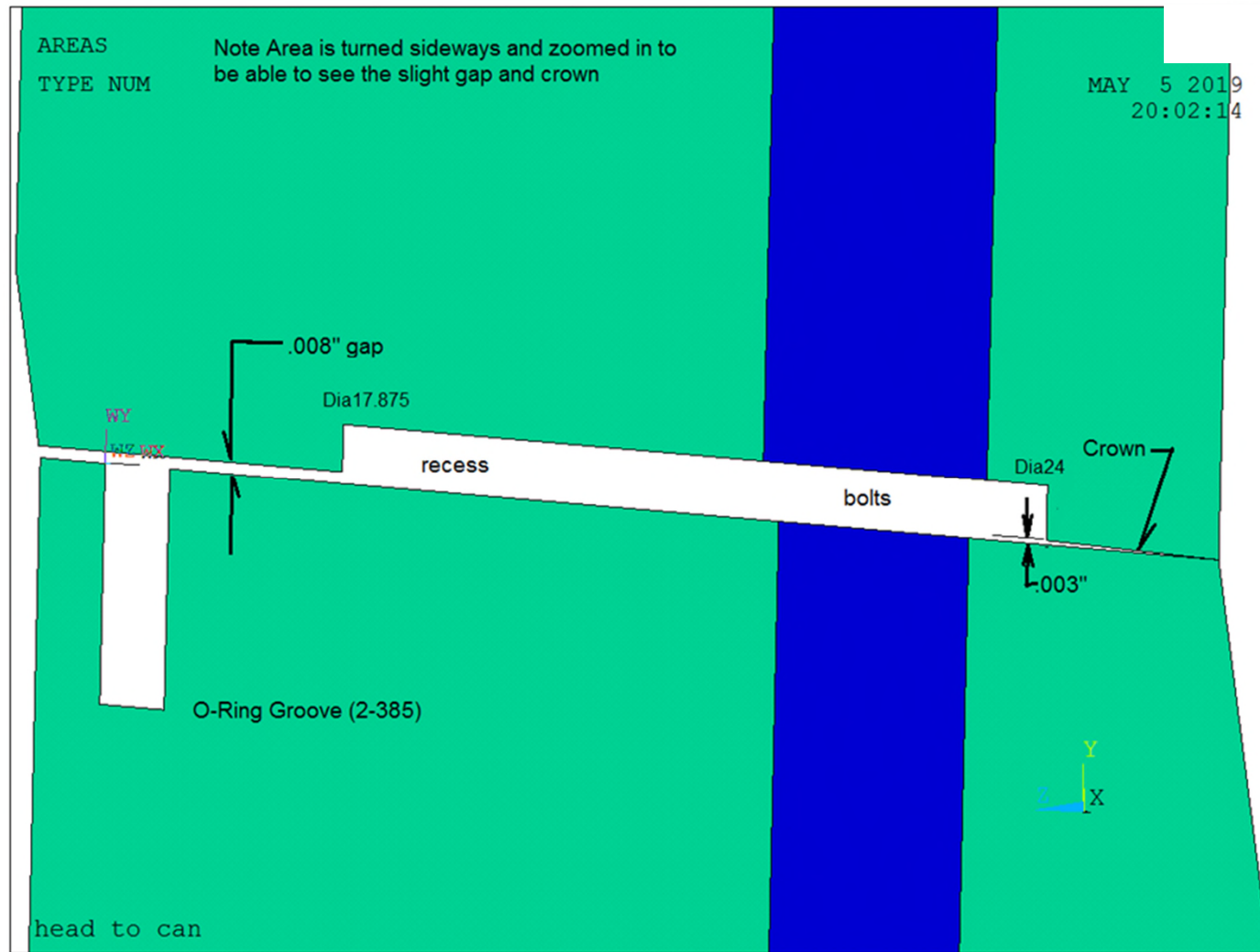
New Joint Profile

A New Profile is tried.



New Joint Profile

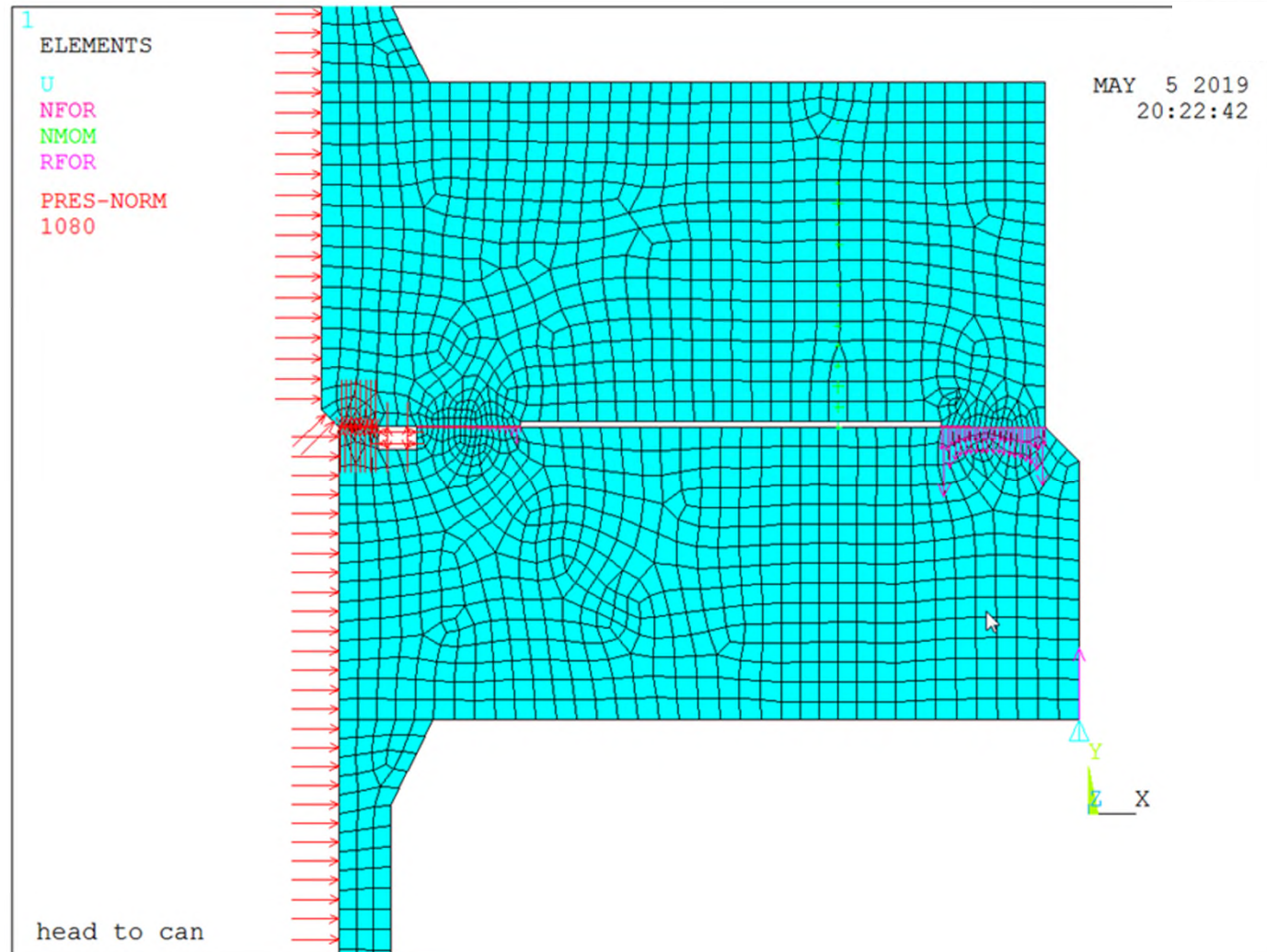
New Profile –
Final fine-tuned
Profile.



FEA Mesh

Hydrotest 1080
psi applied.

Bolt Force \sim 75%
of YS.



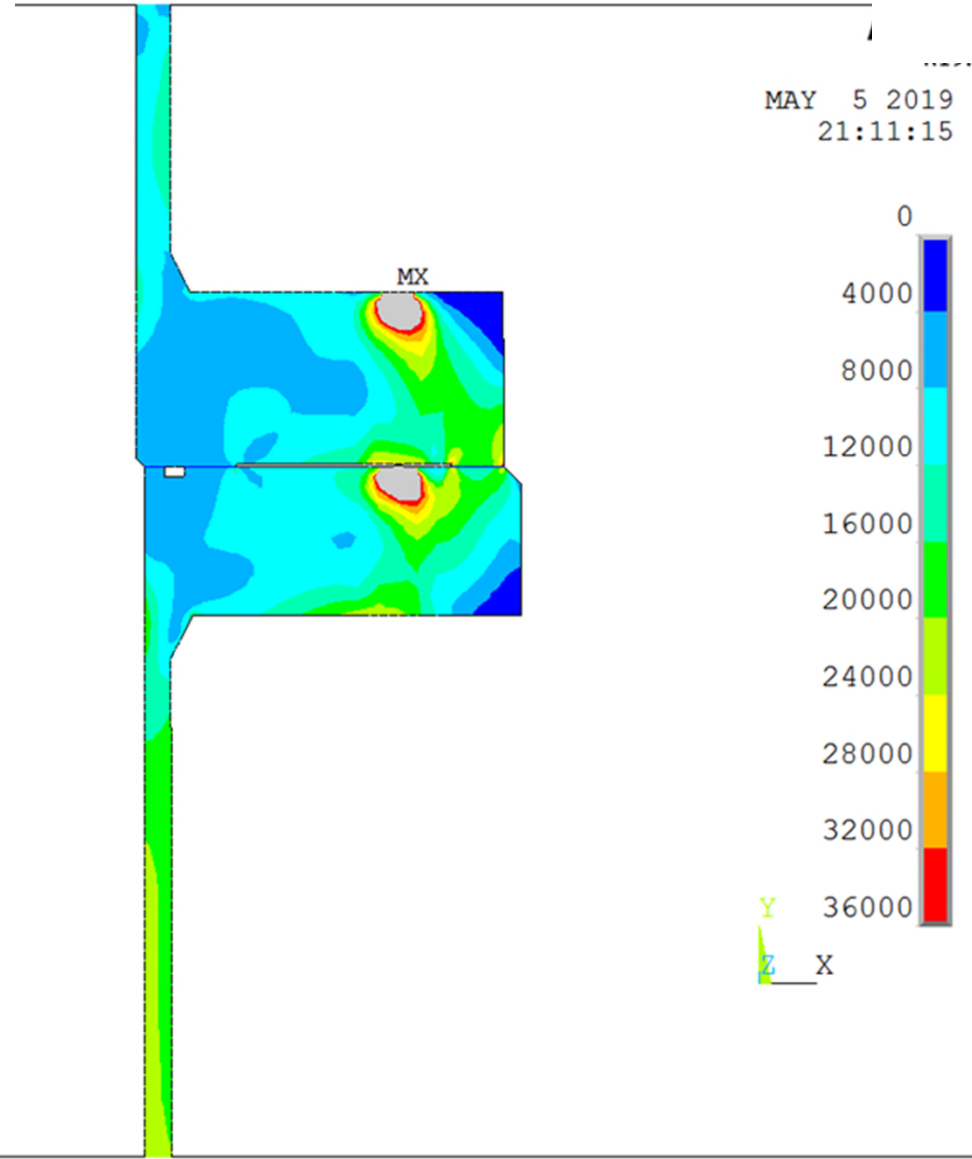
FEA of New Design

```
JOB = 1  
TIME=1  
SEQV (AVG)  
DMX =.006483  
SMN =203.594  
SMX =365625
```

WY
WZ WX

Von Mises Stress

(looks good)



TURBOMACHINERY &
PUMP SYMPOSIA

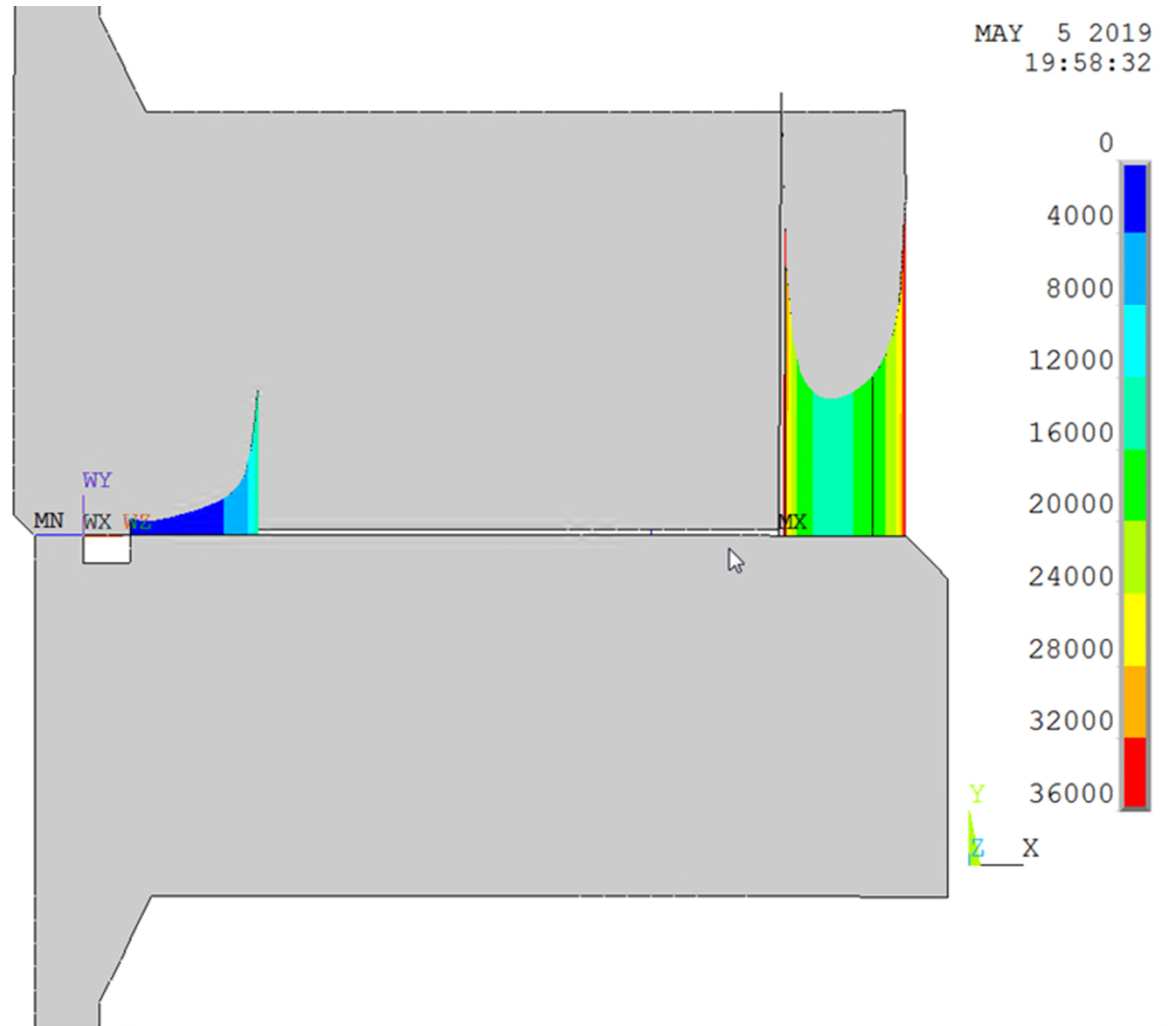
FEA of New Design

Results:
Contact Pressure

(Looks good: there is still contact pressure to the right of the O-ring).

```
STEP=1  
SUB =1  
TIME=1  
CONTPRES (AVG)  
DMX =.006483  
SMX =49496.4
```

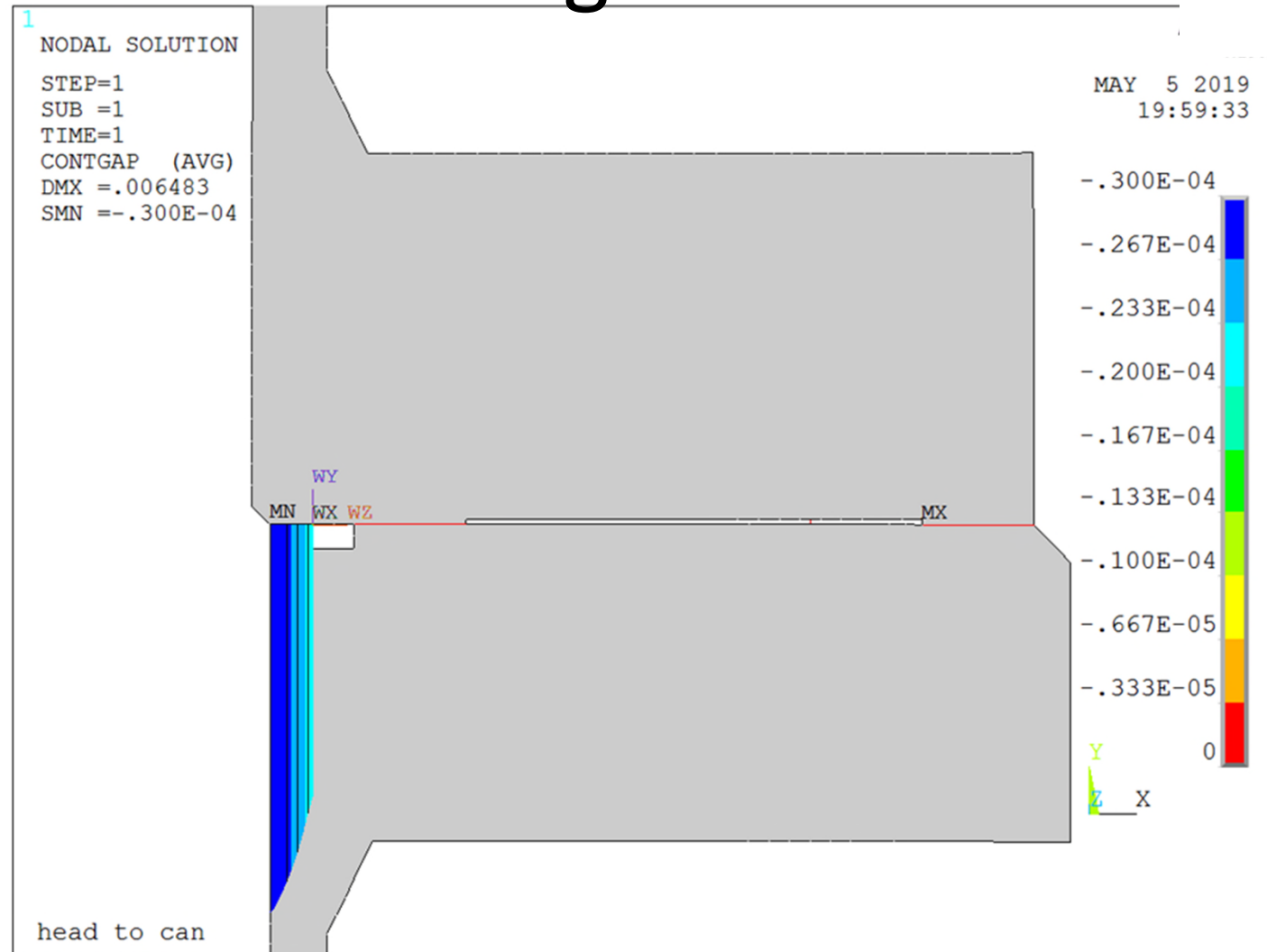
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FEA of the New Design

Results: Contact Gap.

Extrusion Gap is now Zero .



Lessons Learned

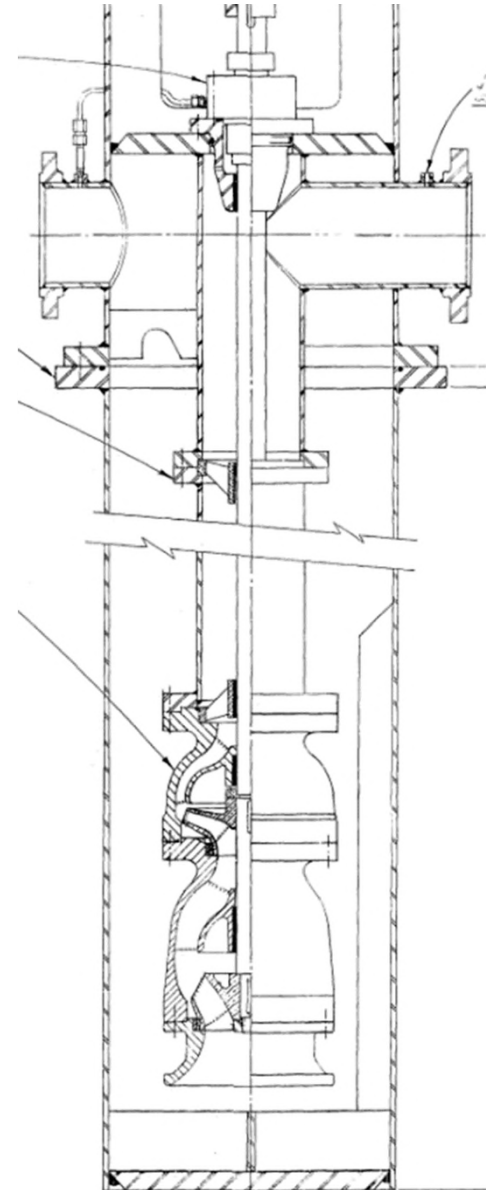
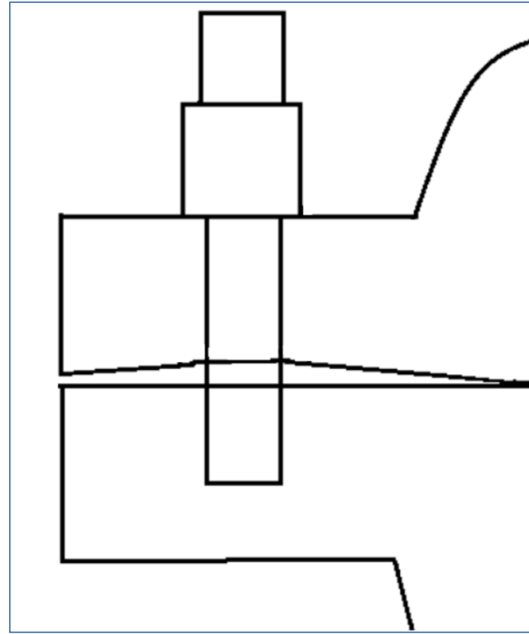
- Older joints designed per ASME are OK stress-wise, but this does not guarantee joint integrity.
- Just upgrading to a “better” gasket might not be enough.
- Flange stiffness is typically the limiting factor for a bolted joint.
- FEA is a good tool for evaluating a flange design and assist in making it robust and safer.
(Axisymmetric FEA is fast, easy and usually good enough.)

In Summary.

Without changing the overall “macro” design,
(That is, No change to:

- Thicknesses,
- Diameters,
- Bolt Circle,
- Bolting)

But by only re-profiling one flange surface,
We were able to pre-load at the O-Ring for zero
extrusion gap, thus a leak free joint.



Questions