Fatigue assessment of scotch yoke for high cycles applications in heavy-duty valves actuators

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Limitorque Fluid Power System

Preliminar consideration

Actuator performance in high cycles applications: trust or verify?

I
- Actuator life-span is typically measured in cycles of operations – cycle life.

II
- Many flow-control processes require on-off valves and actuators to cycle with great frequency, meaning a reduced temporal lifespan and increased maintenance intervals.

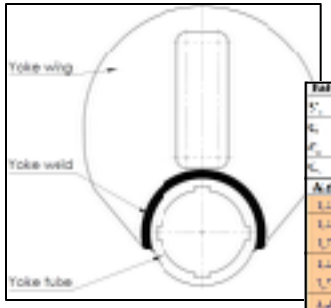
III
- Very often valves and actuators cycle life is based on estimation or field history and is not validated rigorous experimental evidence.

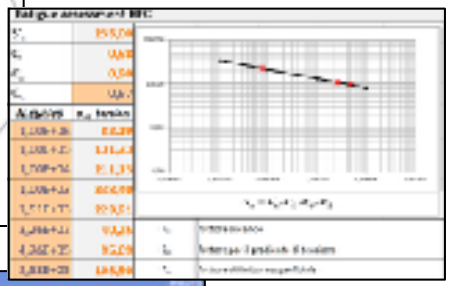
Challenge and applied Methodologies

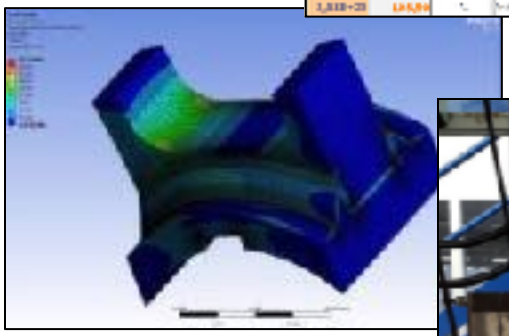
I
- Analytical analysis

II
- Numerical analysis

III
- Experimental test







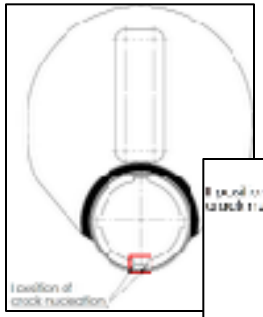
Analytical analysis

Load analysis

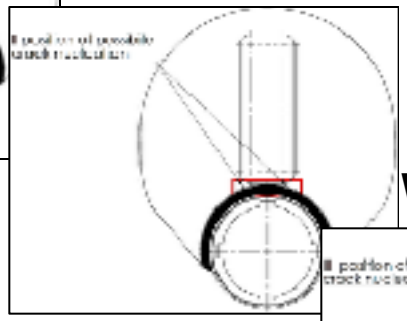
New scotch yoke design

Automatic spreadsheet

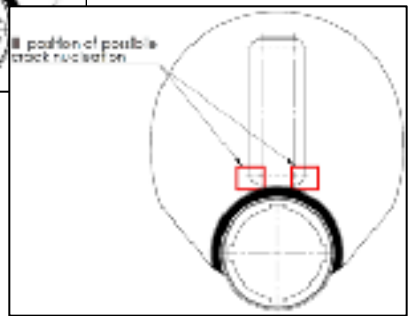
Link between spreadsheet and 3D template



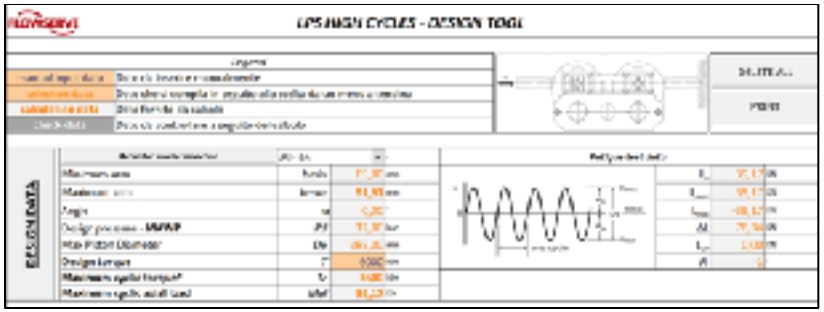
Notches



Welds

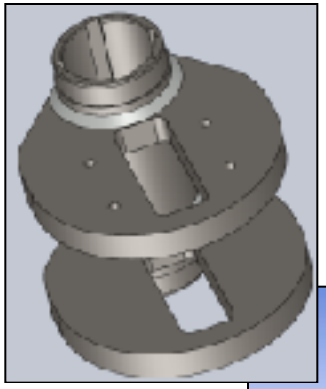


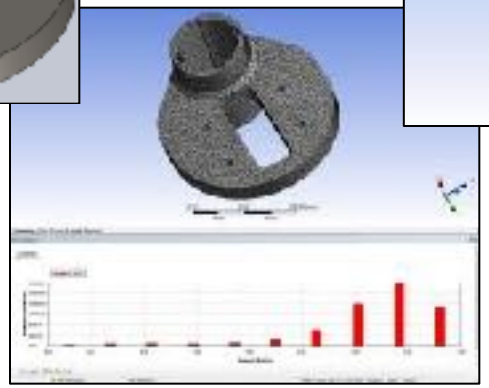
Slider Surface

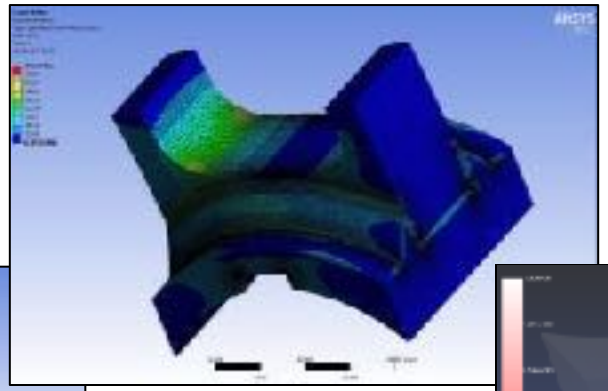


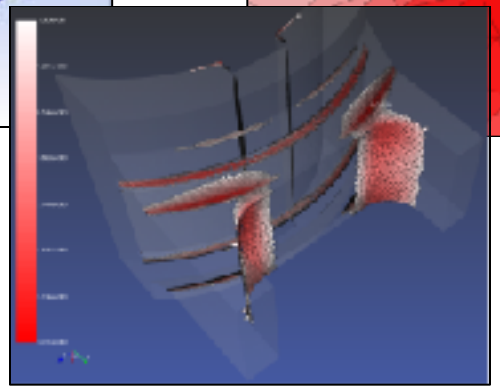
Numerical analysis

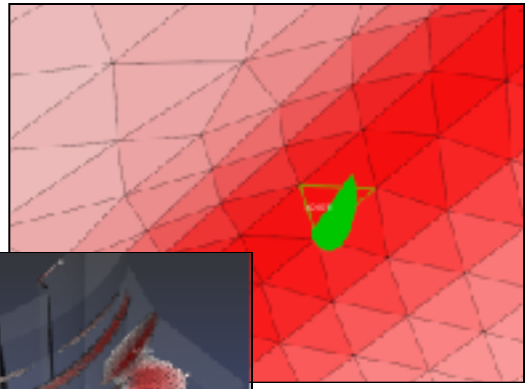
3D cad → **main models** → **sub models** → **Life analysis** → **Post-processing**











Numerical analysis

3D cad

De-featuring operations

main models

Two main models are required in order to evaluate both the loading conditions in the scotch yoke.

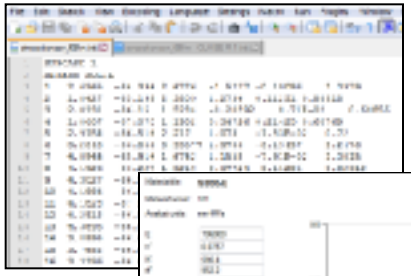
sub models

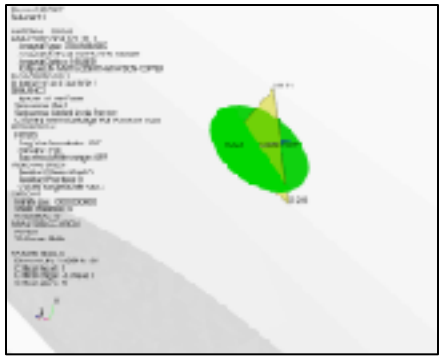
Mesh refinement around the hot spots.
Control in a cut zone
Results convergence is reached.
stress tensor results is exported.

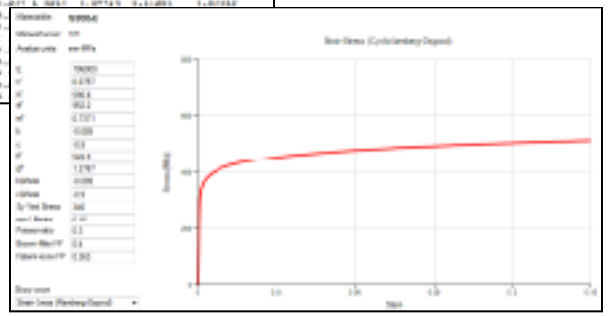
Post-processing

Life analysis

Stress tensor results.







Numerical analysis

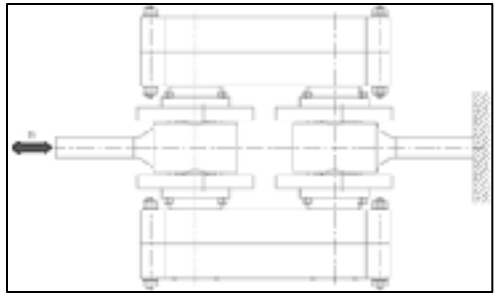
Experimental test

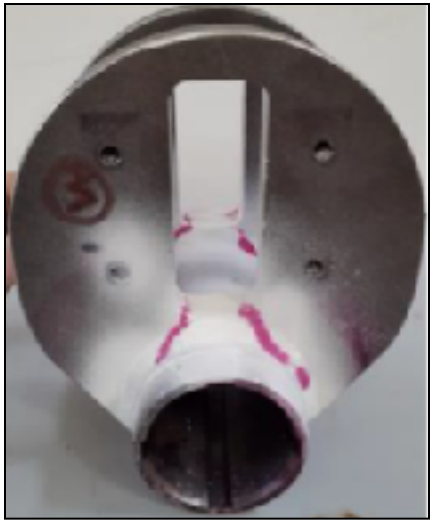
I
- Set-up definition

II
- Tool design

III
- Fatigue test

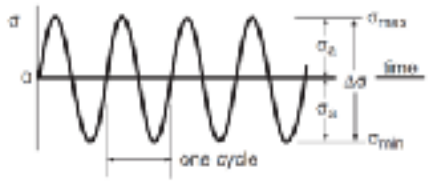
IV
- Output data analysis





Experimental test

I • Set-up definition

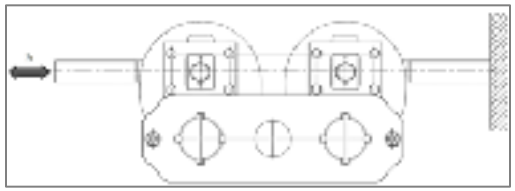


$$R = \frac{\sigma_{min}}{\sigma_{max}} = -1$$

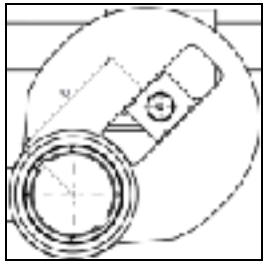
Frequencies to be define base on the noise in the laboratory.

II • Tool design

Defining of b, position of the slider blocks



Tool realization, and pre-mounting

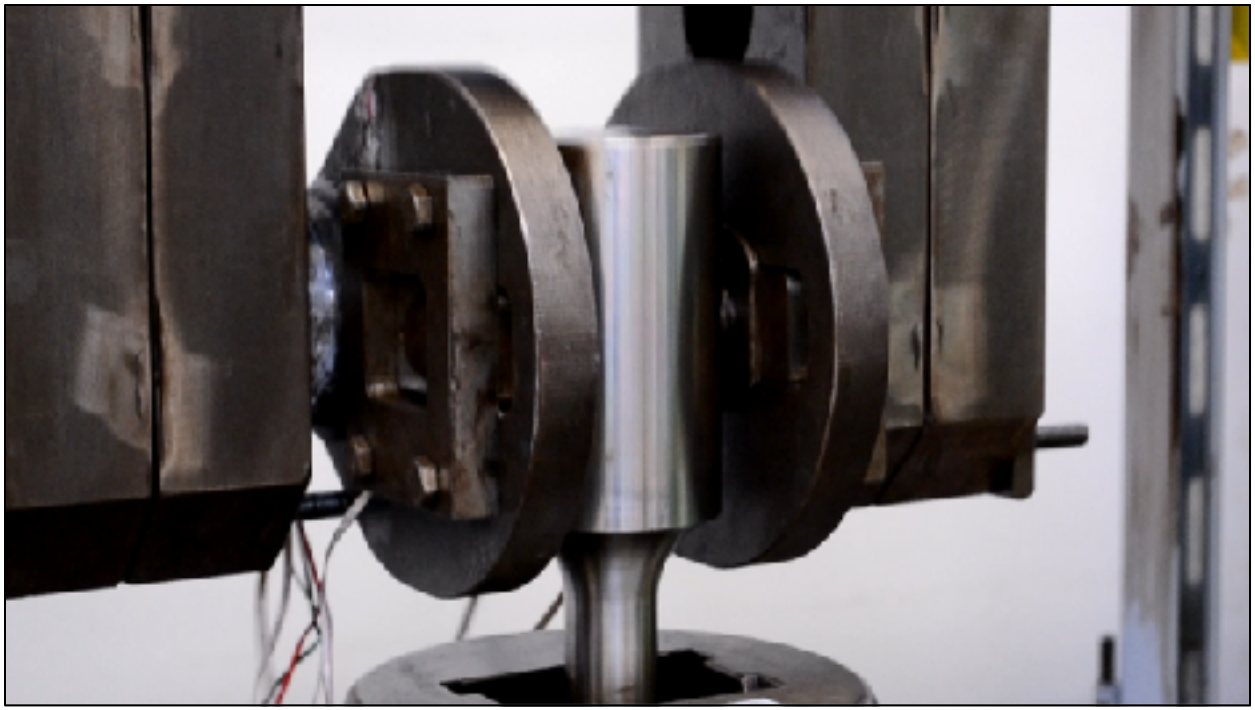


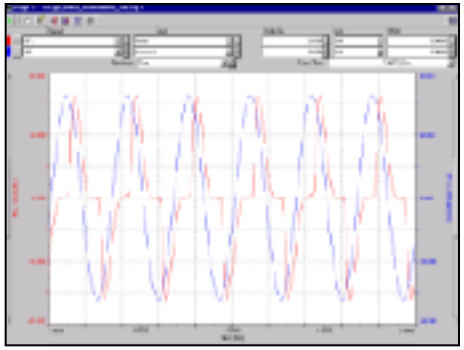
Tool design maintaining the same b

Experimental test

III

- Fatigue test





Finished the tool and samples assembly on the MTS, the fatigue test on two yokes is started.

Experimental test

III

- Fatigue test

Position I

$8{,}59 \cdot 10^5$ *cycles*

$MTT = 6000Nm$

Position II

$8{,}06 \cdot 10^5$ *cycles*

$MTT = 6000Nm$

Position III

$6{,}03 \cdot 10^5$ *cycles*

$MTT = 5900Nm$

ID				cycles	Crack positions	Note
1	130	10000	6000	53000	I	DISCARDED
2	130	10000	6000	859000	I	/
3	90	7000	4200	Run-out	/	/
4	90	7000	4200	Run-out	/	/
3	200	15400	9100	85000	II – III	/
4	200	15400	9100	85000	II – III	/
5	130	10000	6000	806000	III	/
6	150	11500	6900	287000	I – II – III	/
7	150	11500	6900	603000	II – III	/
8	150	11500	6900	316000	III	/
9	180	13800	8300	120000	I – II – III	/
10	180	13800	8300	120000	I – II – III	/
11	130	10000	6000	661000	II – III	/
12	130	10000	6000	661000	II – III	/

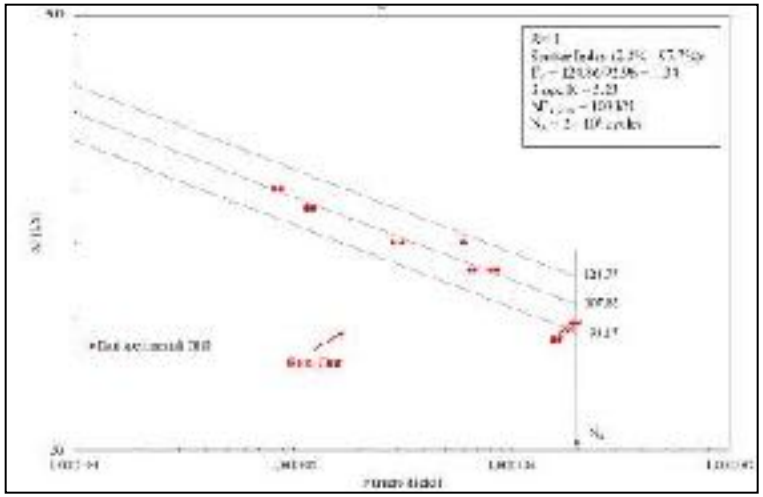
MST – Maximum structural torque;
MTT – Maximum test torque*.

Experimental test

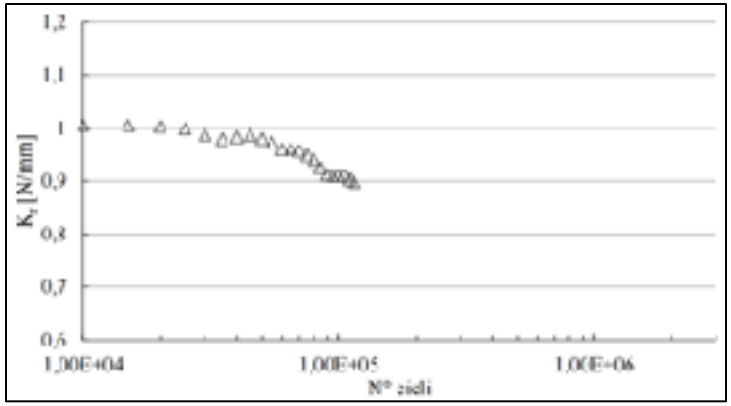
IV

- Output data and results

Crack position highlighted by PT test.



S/N curve of the scotch yoke.
Picture obtained thanks the software "Diciotto", developed by Prof.Eng. Giovanni Meneghetti of the University of Padova.



The stiffness of the components didn't decrease, despite the presence of cracks.

Results comparison

Conclusions

I

II

- From the experimental test conducted in the University of Padova the most critical point of the scotch yoke seems the **position 3, the final part of the sliding surface**.

III

- Despite the presence of some cracks in the sample yoke, the component's stiffness not decreases. **The yoke continues to work without problems despite the cracks.**

Future Developments

I
- Obtain a numerical feedback that the same loading conditions which we can find in a real application are recreate in the laboratory test conducted in this step.

II
- Verify if the surface treatment applied at the scotch yoke influence or not the fatigue behavior highlighted in this first project step.

III
- Some other tests on e new design of scotch yokes are foresee in order to optimize the design with some other adjustments.

Acknowledgments

Special thanks to the other authors of this work:

- **Eng.Davide Pellinghelli** – *R&D Manager – FLOWSERVE Limitorque;*
- **Prof.Eng. Andrea Spagnoli** - *Associate Professor of structural mechanics - University of Parma;*
- **Eng. Matteo Bergonzoni** – *Scholarship holder – University of Padova.*

Sincere thanks to the entire research group of the *Industrial Engineering Department of the University of Padova* who work on the project:

- **Prof. Eng. Giovanni Meneghetti**;
- **Eng. Alberto Campagnolo;**
- **Mr. Gabriele Masiero;**

Thanks also both to **ANSYS** and **LIFING support** for the backing in the numerical analysis and finally to the entire **R&D Team of FLOWSERVE Limitorque – Piacenza**.

Not last…

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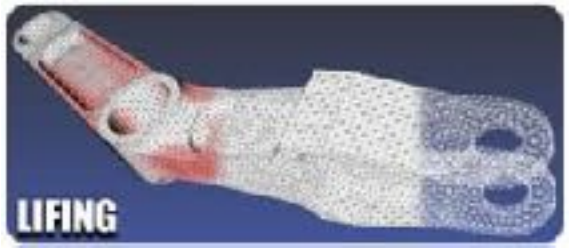
ANSYS



thanks to all for your attention!!!