White Paper Autofrettage

What is meant by “autofrettage” and what happens inside the component?

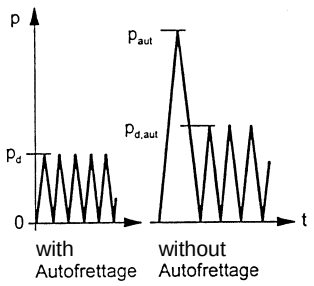
Autofrettage is a process that creates an internal stress in a component, similar to the shot blasting. Autofrettage is used in most cases for the inner pressure active components *without* (tubes) and *with* cross borings (rails).

When a component is pressurized by an autofrettage pressure, which is much higher than the working pressure and is dependent on the material used, hardness, and the geometry of the component, the inner boring will be formed plastically and the deeper areas of the component wall will be formed elastically.

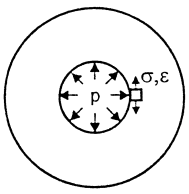
After relieving the autofrettage pressure from the component, the elastically formed areas try to return to their original state while the plastically formed areas prevent this process. Therefore internal stresses are created in a huge part of the wall thickness which tries to work against the stresses that arise from normal working pressure.

Under working pressure the stresses inside the component do not move between 0 and a maximal value any more, but start in the pressure area below 0 and end at a much lower maximal value.

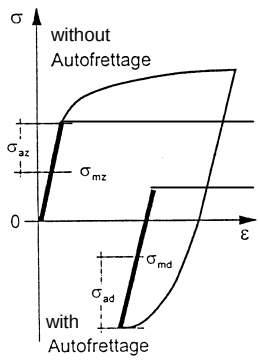
Pressure – Time – Table



Tube (pressurized)



Stress – Table



max. stress without Autofrettage

max. stress with Autofrettage

Picture 1

As you can see from picture 1, the resulting working loads (e. g. in the pipe) can be reduced considerably.

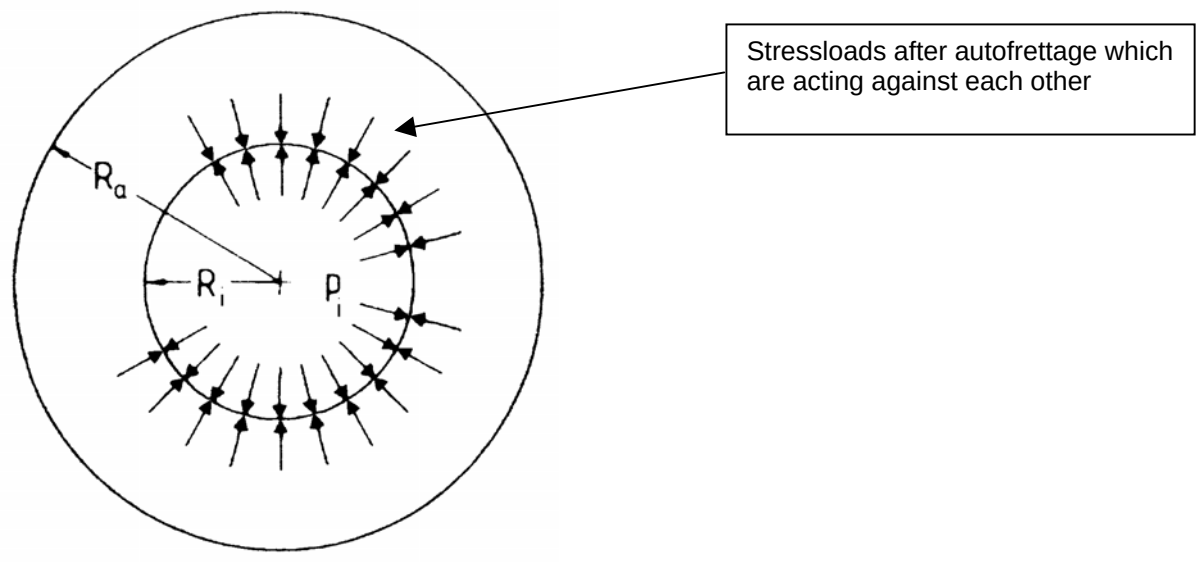
A working pressure which would have led to a failure of the component prior to autofrettage can now be used endlessly – at least for a considerably longer time – without failure. This can lead the design engineer to look for cost saving strategies (i.e. material selection, material reduction etc.).

If you want to use the same positive effects of autofrettage for bent pipes, the autofrettage has to be done *after the bending*.

If autofrettaged after bending, the internal stresses of autofrettage will overlie or neutralize the internal stresses and the effects of autofrettage will be lost.

If you have components with cross cutting there will be an additional effect: On those areas around the drill hole there is a stress concentration.

Therefore these are the weak sections inside a component. Cracks in this part are very often the reason for failure. If you have high dynamic working pressures even the autofrettage cannot prevent a crack in these cross cuttings.



Picture 2: Simplified view of stress loads after autofrettage

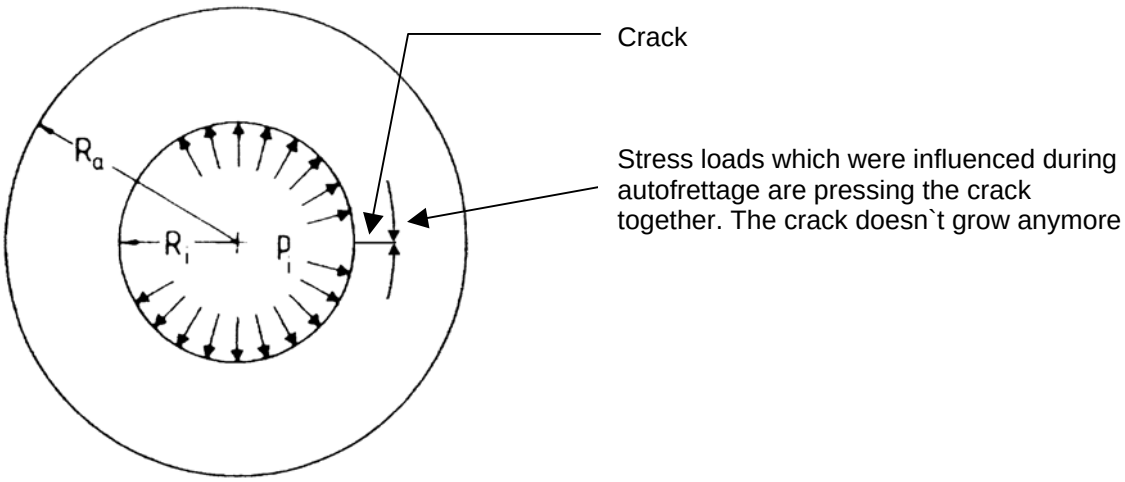
The crack will just grow up to a certain length and will then be stopped by the pressure internal stresses that are inside the wall, picture 3.

The internal stresses “press” the crack together. To receive the requested internal stresses by an autofrettage, the pressure of the autofrettage just has to be held a short time.

A longer time does not increase the internal stresses inside the component, but leads to a strong widening of the inner boring.

As the pressures of autofrettage are calculated in that way that a huge part of the wall thickness is plastic, the pressure does not have to be reached with absolute exactness.

Which deviations are acceptable and which not, depends on every single case. The autofrettage of a component in more than just one case should be avoided.



Picture 3: Stress load prevents crack propagation

Summarization

What are the advantages?

The following effects can be received by autofrettage:

- The working pressure that could be held by the autofrettaged components without failure, increases. (with pipes up to 1.8 times higher, with components with cross boring up to 2.5 times higher)

- The spreading of the achievable pressure changing numbers in the time solidity area of the “Wöhler line” decreases. That means the fracture pressure changing numbers on the pressure horizon, where the autofrettage components fail, come next to each other.

- The spreading is the proportion of the pressure changing numbers N90% (90% of all parts survive) to N10% (10% of all parts survive). Non-autofrettage parts have in general a spreading of T=1,3. Autofrettage components had in tests a spreading of T<=1,1.

- The notch sensitivity decreases strongly.

The following improvements can be achieved:

- The working pressure stays the same - the wall thickness can be reduced.

- The working pressure stays the same - cheaper material can be used.

- In general there is the possibility to increase the working pressure.

- The finishing of borings and surfaces can be eliminated eventually.

- The life time of a component can be increased at a corresponding working pressure.

For further information please consult www.maximator-test.com