GAUSSTEC Ingenieurbüro GmbH

ISO 9001 ZERTIFIZIERTES QUALITÄTSMANAGEMENTSYSTEM SWISO

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ACCELERATED AGING WITH SUPERIMPOSED HUMIDITY CYCLES

The laws of accelerated aging for plastic parts often affect the setting behavior. One of the most common questions is whether or not a component can fulfill its function over time under continuous load. Let's take the example of a pump flange for a countercurrent system. To ensure that everything remains tight for years, the plastic must not sag too much under the load of screws.
But we can't develop a pump, test it for 10 years and then launch it on the market, but market it as quickly as possible. Arrenius' law can help us to obtain this information much earlier by raising the temperature a little and thus accelerating the aging process and the setting behaviour.

<u>With which parameters would we then have to age best?</u>
Assuming we have a normal operating temperature of 23°C. The flange would be made of PE, we want to prove the tightness over 10 years and as soon as possible.

$$k(T) = 2^{\left(\frac{AT-RT}{10°K}\right)*}[-]$$

The aging factor k of accelerated aging is calculated according to the above equation. AT is the aging temperature, for example in a laboratory furnace, at 55°C RT is the temperature to which the assembly is normally exposed, in our case room temperature 23°C If we insert the values into the equation, we get the value 9.2 for k. So to age 10 years we can shorten the time by factor 9.2. The aging simulation therefore takes 10a/9.2, i.e. 1.08 years, or 13 months.

<u>And if we lack the time for this?</u>
There are indeed possibilities to further accelerate the process by increasing the temperature. But you have to be careful here, because we don't want to melt the plastic immediately. For thermoplastics, 55°C is the established upper limit, so to speak. But we can superimpose another stress component, namely alternating cycles of moisture and dryness. We use the properties of plastics that they swell when they absorb moisture, whereupon we extract the moisture from them in the next cycle, which causes the components to shrink again. Depending on the plastic, this process can be increased up to an overlap factor of 1.54 and the above 13 months can be reduced to 8 months..

<u>How does it work and how high is the overlay factor concretely?</u>
How high the superposition factor actually is can only be determined experimentally and we usually proceed in such a way that we subject our ageing samples to a standard model as early as possible. Heating to 55°C and superimposed cycles of 3.5 days dry 6-10 r.h. and 3.5 days humidity 98% r.h.
Parallel to this, we start a material investigation with standard samples of the operative materials in the component. Rin-ge (1), which are loaded in a clamping element (2). Thereby two groups are generated. One group is only thermally aged and the second group is superimposed with the dry-humidity cycles.
After three cycles, the samples are taken, measured and then it is determined by which factor the superimposed aged samples have deformed more than the others.

$$F_{Ü} = \left(\frac{\Delta D_{Ü}}{\Delta D_N}\right) * [-]$$

So we will not know how long the aging process of the target samples will take until three weeks. This depends on the materials used and the wall thicknesses, because the transfer of moisture in a plastic is extremely slow.

The superimposed law of accelerated aging is then as follows:

$$k_{tot} = k(T) * F_{Ü} * [-]$$

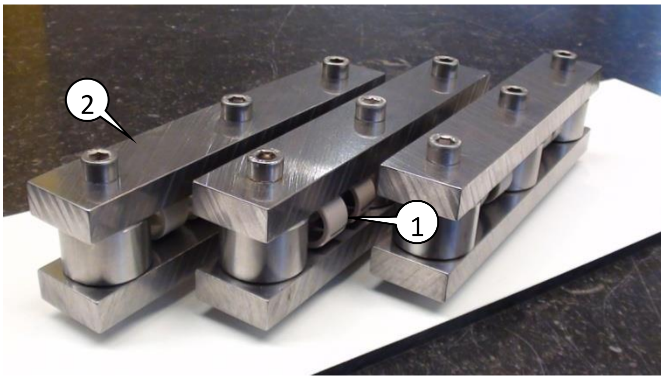

Abbildung 1: Sample ringe (1) Clamping element (2)

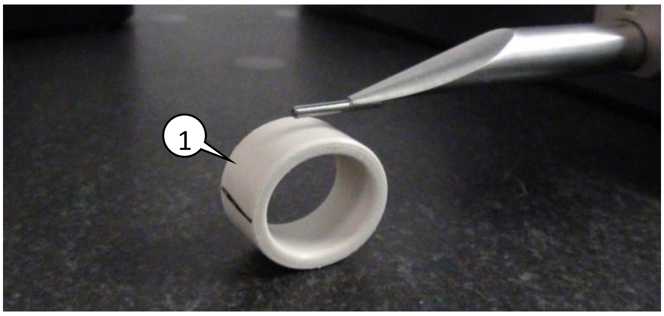

Abbildung 2: Measurement of the deformed sample ring (1) to determine the superposition factor $F_Ü$

Dienstleistungen im Labor Gausstec
We are happy to support you in the testing of products and assemblies of any kind. We have special experience with plastics and plastic assemblies.
You will find further services here in the overview

Einrichtung Gausstec
Gausstec has qualified facilities for carrying out accelerated aging: climate chamber, measuring equipment, etc.

We look forward to your suggestions on the subject of accelerated aging. Just call us or come by to discuss your tasks.

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Your Questions:
We have a product in the automotive sector that is constantly exposed to changing conditions. With which parameters should we age?

In diesem Fall wäre es wohl sinnvoll in den folgenden Schritten vorzugehen:

1. investigate the most extreme climate case. We would first collect all the influencing parameters that affect the product and then ask ourselves how they apply in different climatic zones. Cycles also play a role for individual parameters, such as temperature or pressure changes.
2. generate extreme climate models, based on climate data in countries and regions.
3. determine measurable quality characteristics. The Limes approach is helpful in this context. Limes always asks for the extreme, which in its most extreme form leads to a failure. We want to use the model to ensure that the product delivers the promised performance over a certain period of time. For example, the product could become brittle and thus break more quickly. In this case we choose a method with which we can measure the embrittlement. In each case, continuous parameters are preferable.
4. we now apply our climate models to different groups of samples and measure the change over time based on the defined characteristics. Then we select the model which has the highest influence on the embrittlement. Ideally, a model which, by tightening the parameters, still offers upward air for accelerated aging would be ideal.
5. once we have found our model, mathematics and experiments come into play. The law of Arr-henius is the basis and further thermae follow whose nature it is to tighten the basic law by additional influencing factors. Of course, experience can also help, but we can support you in this.