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Creep Failure – The Nature's Insidious Plight

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To this day, it may have not dawned on you as significant whenever the phrase of creep failure is uttered about, but are you cognizant that we should particularly care about it for it's prevalent, yet inherently implicit a phenomenon occurring to daily materials around our lives? Or if you may reminisce from those undergraduate engineering lectures on material science or mechanics, have you ever been told or taught about what is it specifically the material failures as a result of creep? Fundamentally, how does that creep mechanism accurately behaves and theoretically, what or how is best to begin explaining it? The following paragraphs will unravel the underlying physics as possessed by the creep characteristics to any in-service components.

Creep is a time-dependent phenomenon from where the deformation is thermally-assisted under the presence of constant stresses which in their magnitudes are usually below than the yield strength of that material. Therefore, both stress and temperature are the two driving factors that affect the rate of creep deformation. Also from undergraduate lectures, the majority of engineering students are taught that a failure occurs whenever the equivalent stress crosses into the yield or ultimate tensile strength regimes of the material. While the notion is still painting the overview on the behaviours of structural materials in general, the revelation, however, suffers on many fronts, from major simplifications and generalisations. As such, a sophisticated explanation is needed to ensure safe equipment are designed according to what nature prescribes.

As the creep failure may also occur below the yield strength point, it may be detrimental to the individual component as well as the overall plant if design engineers are not armoured with sufficient information regarding the creep failure. Accidents involving in-service components failure at high-temperature condition where the thermal stress is profound are of critical consideration for design and material engineers alike as such failures are frequently encountered in industries around the world especially in power generation plant and aerospace sectors. The key to understanding material behaviours at elevated temperature is not only signifies the need to minimise the plant downtime as a result of creep failure which translates to financial repercussions, but equally, to warrant for a safe workplace to human souls working around the equipment.

Creep testing is usually performed onto the in-service equipment to investigate its remaining lifetime before mandatory part replacement is scheduled. The standard test methods for creep are well established across the world, where protocols as given by ASTM E139, ASTM E292 and ISO 204 are vastly being used. Dataset tabulated from the test forms to be a foundation on the overall state to the creep-resistance characteristics for each component and it allows for engineers to make an informed decision on the next step to take.

As it is governed by the timescale, the creep testing is a time consuming affair and one testing programme under those real service conditions alone may take up to 25 years (~220,000 hours of creep time) to conclude which renders it as impractical and expensive.

Therefore, a short-term test scheme is usually preferred by the engineers but of course by not discounting the outcomes and reliability. The so-called correction factor will normally be applied to the test data to reflect the long-term behaviours of the equipment in service. In addition, the empirical-based prediction models such as given by Larson-Miller parameter, Omega and Monkman-Grant models have been widely employed by industries to predict the long-term creep life with proven reliability and confidence. In Malaysia, however, there are limited numbers of creep machines currently available. FTKMA UMP at present owns one creep test machine (as shown in the figure) which is capable to offer creep testing service to both students and industrial clients.

Furthermore, the members of FTKMA's SUPREME Focus Group have also been carrying out experimental research in the field of creep and that includes the computational means by the finite element modelling, life prediction and structural integrity assessments. Alternatively, TNB Research (TNBR) which is based in Kajang, Selangor is the other institution offering creep testing facility on both short- and long-term basis.

To conclude, it is hoped that students as well as the practicing engineers are now wary the criticality in characterising creep behaviours and potential failures it may inflict. Those knowledge will undoubtedly accommodate us in enhancing the safety level for both workplace and to a greater extent, the society at large.

Figure 1. Creep test machine in FTKMA UMP

About the author

Dr. Nasrul Azuan Alang obtained his doctorate degree from the Imperial College London in 2018. His research specialising in damage mechanics while also actively involved in creep study, both experimentally and in numerical modelling for more than six years.