Creep Life Prediction of Thermoplastic Polymer Polypropylene Using Experimental and Computational Methods

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***Abstract*- The present work details the creep life prediction of commercially available thermoplastic polymer polypropylene (PP) using the advanced experimental technique i.e. dynamic mechanical analyzer DMA. Temperature sweep and frequency sweep are the methodologies applied to predict the creep life of the material using DMA and obtained experimental results have compared and validated using finite element method and the results are found to be in good agreement.**

***Index term*- Creep behavior, Thermoplastic Polymer Polypropylene.**

I. INTRODUCTION

It is important for a design engineer to predict the failure mechanism of the materials under static and variable loading conditions, thus avoiding the fracture of the material and to achieve the reliability of the component. The various reasons for failure of components are design deficiencies and manufacturing defects, material selection heat treatment, fabrication imperfections. Since failure of the component dependent on various factors mentioned above, hence prediction of failure of the component is a tedious task for the design engineer.

Creep is rate dependent material nonlinearity in which the material continues to deform under a constant load and it can occur as a result of long-term exposure to high levels of stress that are still below the yield strength of the material. Creep is more severe in materials that are subjected to heat for long periods, and generally increases as they near their melting point. Creep always increases with temperature. The rate of deformation is a function of the material properties, exposure time, exposure temperature and the applied load. Depending on the magnitude of the applied stress and its duration, the deformation may become so large that a component can no longer perform its function for example creep of a turbine blade will cause the blade to contact the casing, resulting in the failure of the blade. Creep is usually of concern to engineers and metallurgists when evaluating components that operate under high stresses or high temperatures. Creep is a deformation mechanism that may or may not constitute a failure mode.

2. EXPERIMENTAL PROCEDURES

Creep tests has been conducted on dynamic mechanical analyzer for thermoplastic material polypropylene(PP) the reason for selecting this polymer is because it was commercially available and has wide variety of industrial applications. Creep test specimens that has length 16cm,width 1.2cm,thickness 3.5mm in the gauge section is considered for experimentation.

For polypropylene (PP) material creep test for 60 min duration has been performed using five different applied stress levels which varies from 6 to 13 MPa.

3. EXPERIMENTAL RESULTS

Plots of creep strain versus time for the material polypropylene (PP) is shown in Fig.1

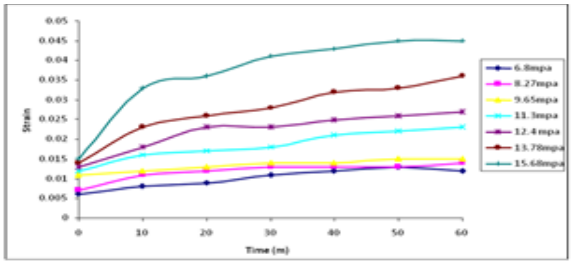


Fig.1.Time –dependent creep for various stress levels.

The creep curve shows for each sample, strain increases with time rapidly for various stress levels and as the effect of stress increases amount of creep strain also increases with time.

4. Finite Element Analysis Results: According to the clamping conditions the constraints were applied on the specimen for all six degrees of freedom. The loading and boundary conditions used for the finite element analysis of the specimen shown in the below figure.

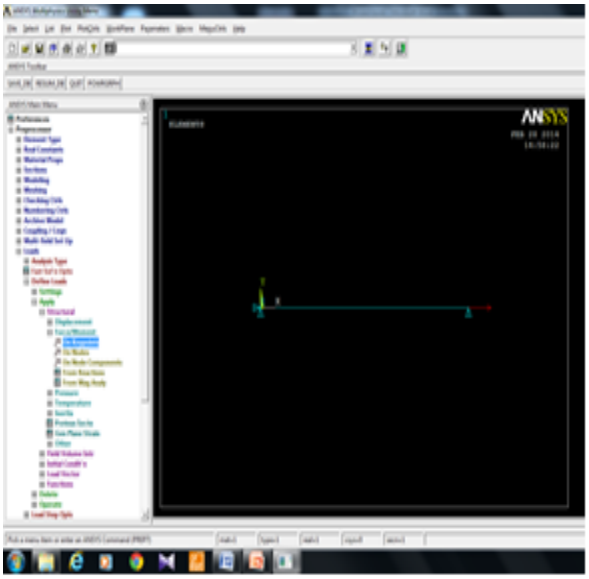
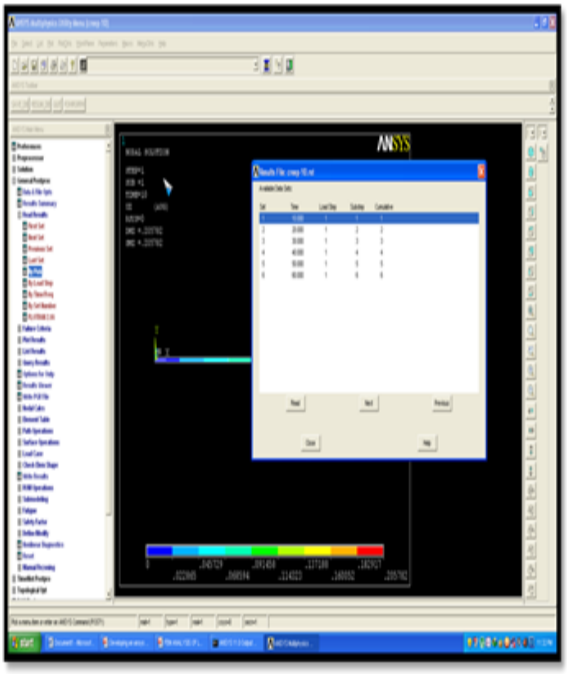


Fig.3.Modeling of link -1 Element in Ansys

While performing creep analysis solution controls has been established which consist of analysis options such as time t = 10 to 60 min and Number of sub steps =6 Choosing automatic time stepping on option and nodal solution is shown in fig.4

5. Results and Discussion: The creep analysis of the thermoplastic polymer polypropylene (PP) specimen at various stress levels has been carried out using Ansys and from the analyzation of results, the value of maximum creep strain is found to be 0.029 at stress level of 13Mpa and at time of 60 min and the creep strain induced in the material at stress level of 6.8Mpa at 60 min is 0.013 and from the figure 5.3 it has been observed that as the applied stress increases along with the time creep strain induced in the material also increases for all the stress levels ranging from (6.8Mpa to 13.7Mpa) this represents the primary



Fig;4 Load Step File for Creep Analysis in Ansys.

creep response of the material in which creep strain rate decreases and from the Fig it has been observed that the experimental creep results denoted by (T) are in good correlation with Ansys creep results denoted by (A) and they were found to be in good agreement

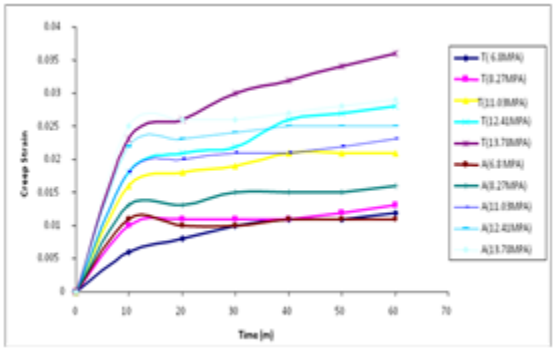


Fig.4. Experimental Creep Results compared with Ansys creep results for various stress levels

6. CONCLUSION

Experimental and Computational methods for the creep life assessment of thermoplastic polymer (PP) has been done .Through the present work, several conclusions can be drawn with regard to the creep life of the mentioned materials.

It can also be seen that for thermoplastic polymer polypropylene (PP) as the stress increases with time creep strain induced in the material also increases.

It can also be seen that creep analysis of thermoplastic polymer polypropylene (PP) comes under primary creep stage i.e. Creep strain rate decreases.

7. REFRENCES

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