

Polymer Creep Lab Report

Matthew John Permintella | HND
Mechanical Engineering | 01/03/2021

Contents

1.0 Introduction	Page 2
2.0 Objectives	Page 2
3.0 Theory	Page 3
4.0 Equipment	Page 4
5.0 Procedure	Page 5
6.0 Data, analysis, calculations, results	Page 5-15
7.0 Conclusions	Page 16
8.0 References	Page 12
9.0 Bibliography	Page 17

1.0 Introduction

The aim of the report is to investigate the behaviour of polymeric materials under creep, using test specimens for each scenario. Both experiments will be undertaken at room temperature. Second experiment the mass has been increased. Results will be taken, and analysis completed to compile a creep curve for the given polymer. Polymeric materials have a higher susceptibility to failure when exposed to creep, impact, and temperature loads than a metallic material. Polymers show responses under the tested mechanical and thermal stimuli that are not found in metallic crystalline materials. Polymeric materials demonstrate higher susceptibility to failure when exposed to creep, temperature, and impact loads than metallic materials. (Stress Relaxation and Creep of Polymers Thermoplastics Composites, 2021) (Scribd.com ,2021)

2.0 Objectives

- Design and implement experiments in material science.
- Gain an understanding of Polymers – their behavior and chemistry specifically creep rates, relaxation and fatigue.
- To experimentally obtain a creep curve.
- To identify the properties of a material while subject to a tensile load.
- To analyze the rate of material deformation under a constant stress & temperature.

3.0 Theory

Creep is time dependant plastic deformation of a viscoelastic material at a constant applied tensile load. Creep can be defined as deformation at a constant stress and temperature, this type of pneumonia is due to inelastic response of loaded material and often occur at high temperature. The temperature has a massive impact on this type of deformation, the microstructure defects within the material are accelerated at high temperature, this process softens the material which counteract material strain hardening exerted by the plastic deformation due to the tensile load. Creep is found within a material when and often depends on the melting point of the material. (Epfl.ch. 2021) (Scribd.com ,2021)

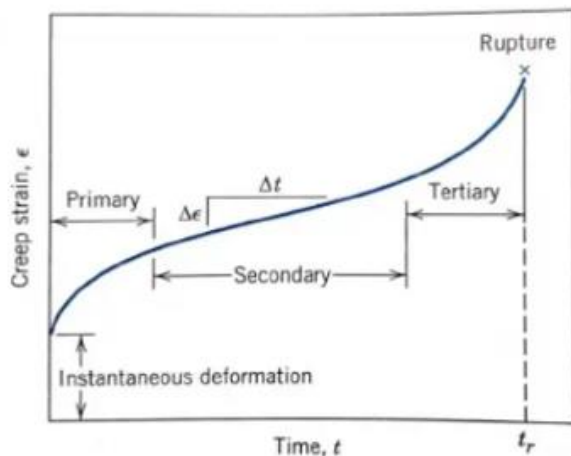
There are three stage of creep below is an explanation of each stage.

- The first stage of creep has a transient rate of deformation and considered non steady state & slows with time.
- The second stage of creep is considered the steady state region of the creep curve the deformation rate is uniform.
- The third stage of the creep curve the deformation rate increases rapidly due to the test specimen necking and internal voiding causing the cross-sectional area of the specimen to decrease. During this stage if continued the specimen is likely to fracture or fail.

(Materialstandard.com ,2021)

(JONES, 2018)

(Creep Experiment, 2021)



Fig(1) Different stage of creep

4.0 Apparatus

Below is a list of the Apparatus needed for the experiment to be completed:

- Vernier Caliper.
- Weight.
- Mole grips * 2.
- Test specimens / Test Specimen
- Scissors.
- Stanley blade.
- Pencil.
- Paper.
- Stopwatch



Fig(2-5) Vernier callipers, scissors, molegrips, stanley,experiment setup, test specimens.

5.0 Procedure

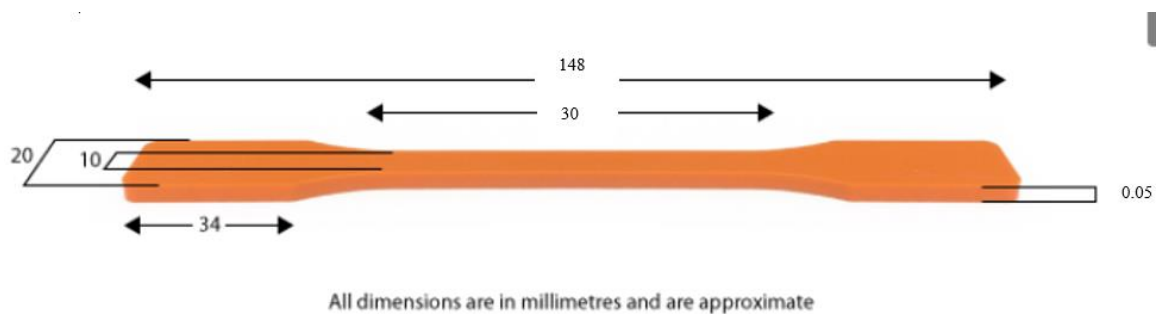
1. Make template for consistent specimen sample creation.
2. Create samples.
3. Record measurement of specimen sample.
4. Maximum load that specimen can withstand calculated.
5. Compile blank table to record results.
6. Ensure sufficient grip on test specimen with mole grips.
7. Place specimen into homemade test setup.
8. Load specimen with 690g weight.
9. Record extension at each 30 second time interval.
10. Complete step 8 until specimen fractures.
11. Calculated strain at each interval and plot strain versus time graph.
12. Complete analysis of findings.
13. Repeat procedure for each of the 6-test specimen.

6.0 Results

Specimens 1-3 had a load of 4905 N

Specimen 4-6 had a tensile load of 6768.9 N

Sample geometry and loads of each experiment have been listed below



Fig(6) sample geometric parameters

There were 6 samples used during the experiment and the findings are listed below.

Specimen Number	1	2	3	4	5	6
Load [N]	4905	4905	4905	6768.9	6768.9	6768.9
Specimen thickness [mm]	0.05	0.05	0.05	0.05	0.05	0.05
Width of gauge length [mm]	10	10	10	10	10	10
Initial gauge length [mm]	30	30	30	30	30	30
Final gauge length [mm]	57.14	65.02	58.62	80.2	78.56	71.96

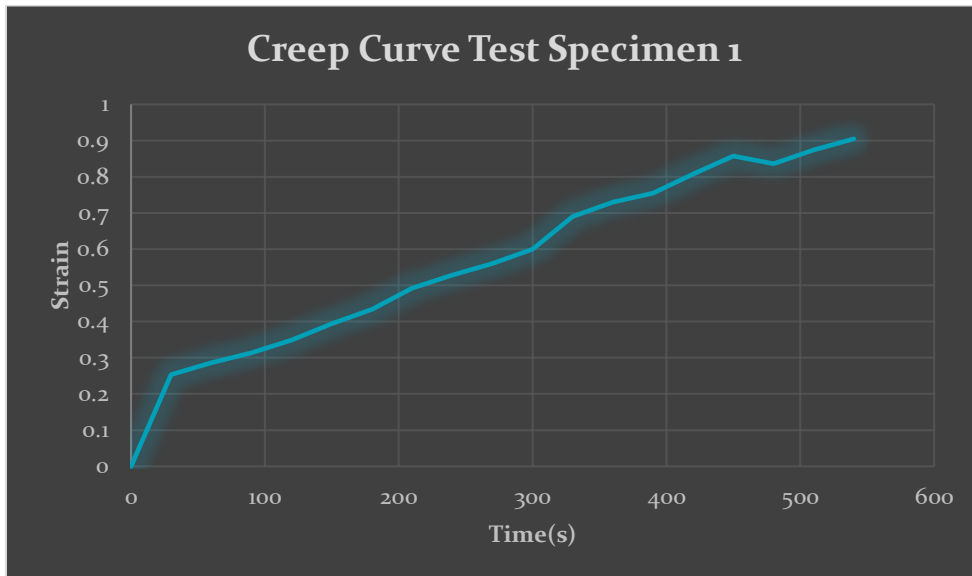
Table 1: Each test specimen load and dimensions.

Experiment 1 (4905N)

Specimen 1

Time (s)	Load (N)	Original Length (mm)	New Length (mm)	Extension (mm)	Strain
0	6768.9	30	30	0	0
30	6768.9	30	37.6	7.6	0.253333
60	6768.9	30	38.59	8.59	0.286333
90	6768.9	30	39.41	9.41	0.313667
120	6768.9	30	40.47	10.47	0.349
150	6768.9	30	41.82	11.82	0.394
180	6768.9	30	43.02	13.02	0.434
210	6768.9	30	44.77	14.77	0.492333
240	6768.9	30	45.85	15.85	0.528333
270	6768.9	30	46.8	16.8	0.56
300	6768.9	30	48.01	18.01	0.600333
330	6768.9	30	50.71	20.71	0.690333
360	6768.9	30	51.91	21.91	0.730333
390	6768.9	30	52.63	22.63	0.754333
420	6768.9	30	54.23	24.23	0.807667
450	6768.9	30	55.73	25.73	0.857667
480	6768.9	30	55.08	25.08	0.836
510	6768.9	30	56.23	26.23	0.874333
540	6768.9	30	57.14	27.14	0.904667

Table (2): Specimen 1 results.



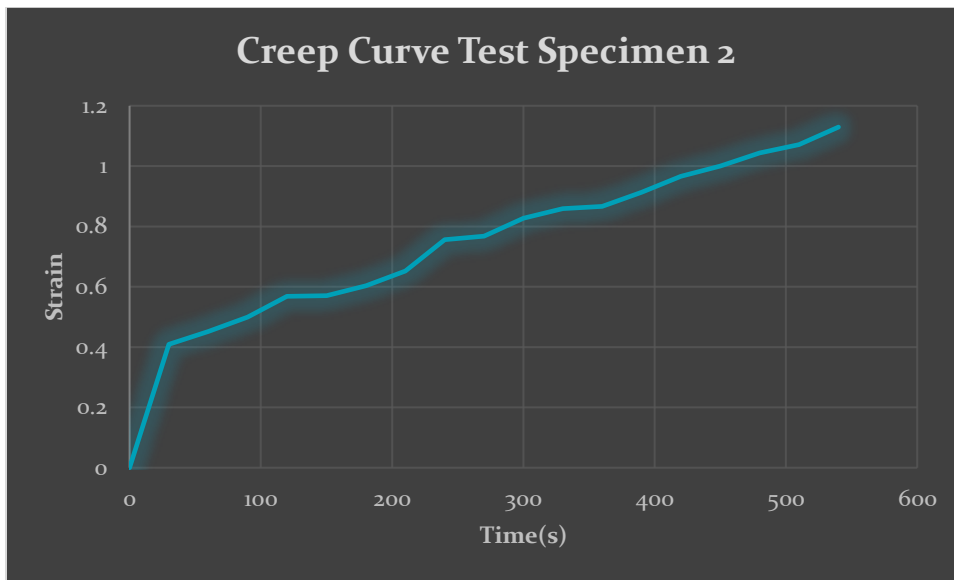
Graph (1) Creep curve graph.

Specimen 2

Time (s)	Load (N)	Original Length (mm)	New Length (mm)	Extension (mm)	Strain
0	6768.9	30	30	0	0
30	6768.9	30	42.26	12.26	0.408667
60	6768.9	30	43.56	13.56	0.452
90	6768.9	30	44.99	14.99	0.499667
120	6768.9	30	47.06	17.06	0.568667
150	6768.9	30	47.12	17.12	0.570667
180	6768.9	30	48.11	18.11	0.603667
210	6768.9	30	49.55	19.55	0.651667
240	6768.9	30	52.69	22.69	0.756333
270	6768.9	30	53.04	23.04	0.768
300	6768.9	30	54.81	24.81	0.827
330	6768.9	30	55.76	25.76	0.858667
360	6768.9	30	56	26	0.866667
390	6768.9	30	57.4	27.4	0.913333

420	6768.9	30	58.99	28.99	0.966333
450	6768.9	30	60	30	1
480	6768.9	30	61.3	31.3	1.043333
510	6768.9	30	62.13	32.13	1.071
540	6768.9	30	63.88	33.88	1.129333
570	6768.9	30	65.02	35.02	1.167333

Table (3): Specimen 2 results.



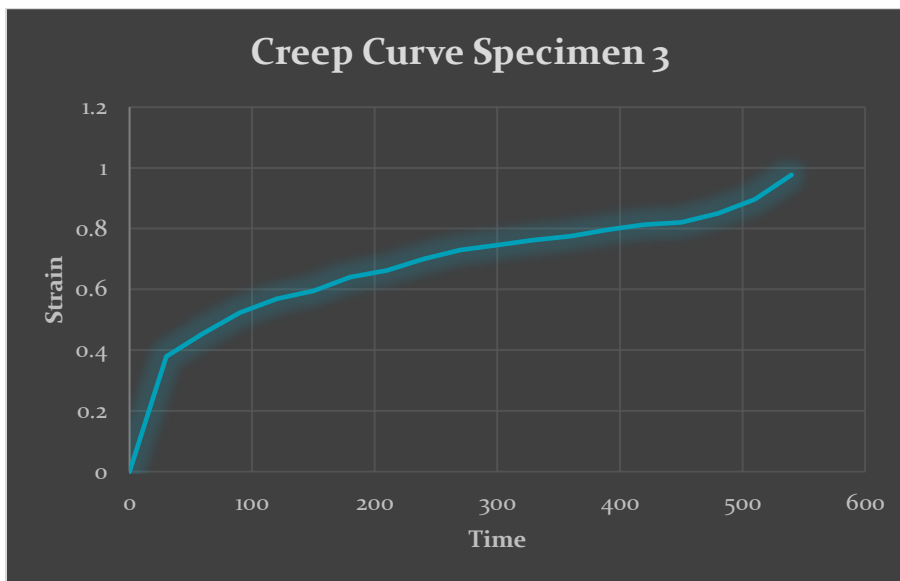
Graph (2) Creep curve graph.

Specimen 3

Time (s)	Load (N)	Original Length (mm)	New Length (mm)	Extension (mm)	Strain
0	6768.9	30	30	0	0
30	6768.9	30	41.36	11.36	0.378667
60	6768.9	30	43.64	13.64	0.454667
90	6768.9	30	45.69	15.69	0.523
120	6768.9	30	47.06	17.06	0.568667
150	6768.9	30	47.86	17.86	0.595333
180	6768.9	30	49.21	19.21	0.640333

210	6768.9	30	49.89	19.89	0.663
240	6768.9	30	51	21	0.7
270	6768.9	30	51.89	21.89	0.729667
300	6768.9	30	52.36	22.36	0.745333
330	6768.9	30	52.89	22.89	0.763
360	6768.9	30	53.26	23.26	0.775333
390	6768.9	30	53.89	23.88	0.796
420	6768.9	30	54.23	24.4	0.813333
450	6768.9	30	54.03	24.63	0.821
480	6768.9	30	55	25.51	0.850333
510	6768.9	30	56.23	26.88	0.896
540	6768.9	30	58.62	29.31	0.977

Table (4): Specimen 3 results.

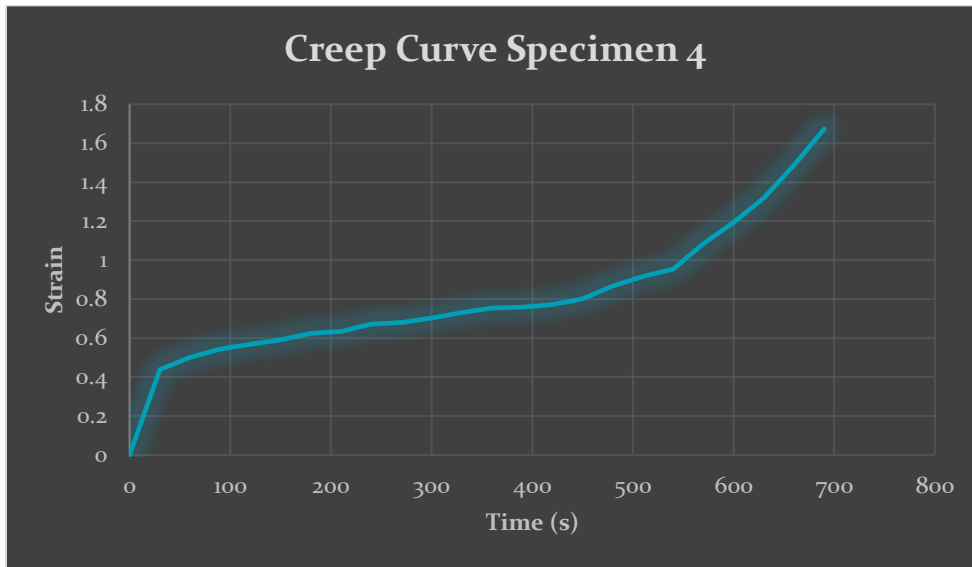


Graph (3) Creep curve graph.

Experiment 2 (6768.9N)
Specimen 4

Time (s)	Load (N)	Original Length (mm)	New Length (mm)	Extension (mm)	Strain
0	6768.9	30	30	0	0
30	6768.9	30	43.14	13.14	0.438
60	6768.9	30	45.03	15.03	0.501
90	6768.9	30	46.28	16.28	0.542667
120	6768.9	30	47.06	17.06	0.568667
150	6768.9	30	47.74	17.74	0.591333
180	6768.9	30	48.71	18.71	0.623667
210	6768.9	30	49	19	0.633333
240	6768.9	30	50.12	20.12	0.670667
270	6768.9	30	50.39	20.39	0.679667
300	6768.9	30	51.09	21.09	0.703
330	6768.9	30	51.91	21.91	0.730333
360	6768.9	30	52.63	22.63	0.754333
390	6768.9	30	52.74	22.74	0.758
420	6768.9	30	53.15	23.15	0.771667
450	6768.9	30	54.03	24.03	0.801
480	6768.9	30	56	26	0.866667
510	6768.9	30	57.5	27.5	0.916667
540	6768.9	30	58.62	28.62	0.954
570	6768.9	30	62.52	32.52	1.084
600	6768.9	30	65.8	35.8	1.193333
630	6768.9	30	69.56	39.56	1.318667
660	6768.9	30	74.6	44.6	1.486667
690	6768.9	30	80.2	50.2	1.673333

Table (5): Specimen 4 results.



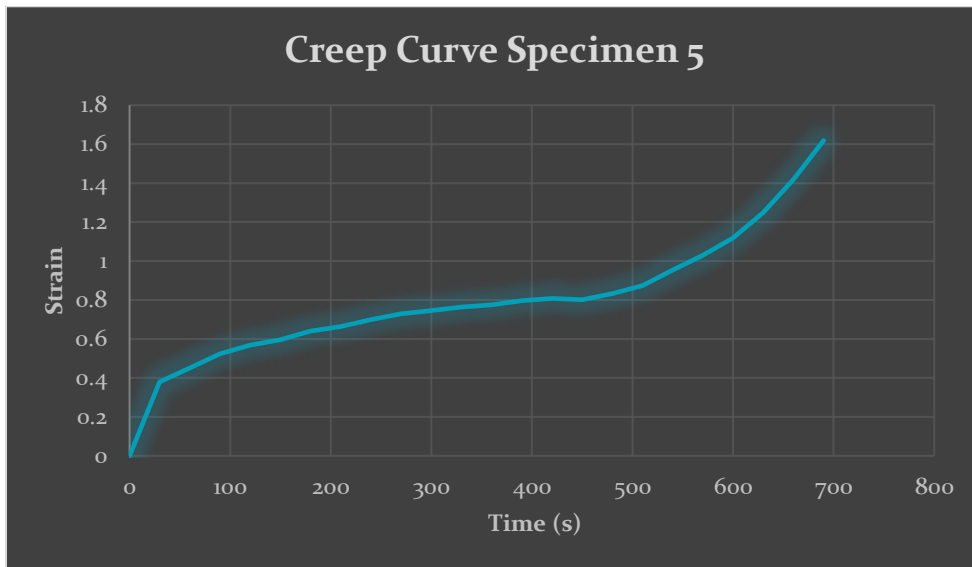
Graph (4) Creep curve graph

Specimen 5

Time (s)	Load (N)	Original Length (mm)	New Length (mm)	Extension (mm)	Strain
0	6768.9	30	30	0	0
30	6768.9	30	41.36	11.36	0.378667
60	6768.9	30	43.56	13.56	0.452
90	6768.9	30	45.69	15.69	0.523
120	6768.9	30	47.06	17.06	0.568667
150	6768.9	30	47.86	17.86	0.595333
180	6768.9	30	49.21	19.21	0.640333
210	6768.9	30	49.89	19.89	0.663
240	6768.9	30	51	21	0.7
270	6768.9	30	51.89	21.89	0.729667
300	6768.9	30	52.36	22.36	0.745333
330	6768.9	30	52.89	22.89	0.763
360	6768.9	30	53.26	23.26	0.775333
390	6768.9	30	53.89	23.89	0.796333
420	6768.9	30	54.23	24.23	0.807667
450	6768.9	30	54.03	24.03	0.801

480	6768.9	30	55	25	0.833333
510	6768.9	30	56.23	26.23	0.874333
540	6768.9	30	58.62	28.62	0.954
570	6768.9	30	60.89	30.89	1.029667
600	6768.9	30	63.56	33.56	1.118667
630	6768.9	30	67.45	37.45	1.248333
660	6768.9	30	72.56	42.56	1.418667
690	6768.9	30	78.56	48.56	1.618667

Table (6): Specimen 5 results.



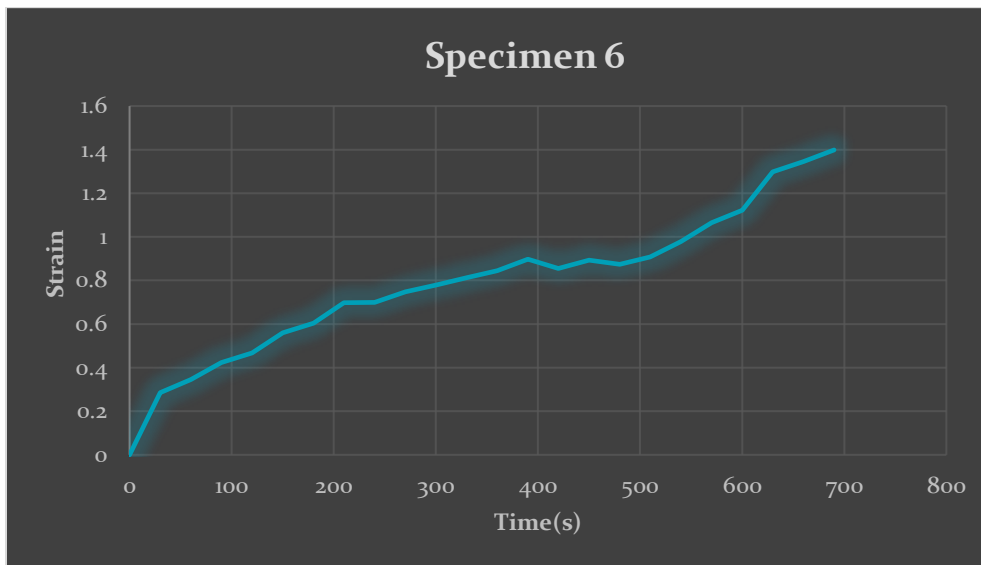
Graph (5): Specimen 5 creep curve.

Specimen 6

Time (s)	Load (N)	Original Length (mm)	New Length (mm)	Extension (mm)	Strain
0	6768.9	30	30	0	0
30	6768.9	30	38.56	8.56	0.285333
60	6768.9	30	40.36	10.36	0.345333
90	6768.9	30	42.71	12.71	0.423667
120	6768.9	30	44.03	14.03	0.467667
150	6768.9	30	46.81	16.81	0.560333
180	6768.9	30	48.12	18.12	0.604
210	6768.9	30	50.92	20.92	0.697333

240	6768.9	30	51	21	0.7
270	6768.9	30	52.45	22.45	0.748333
300	6768.9	30	53.36	23.36	0.778667
330	6768.9	30	54.36	24.36	0.812
360	6768.9	30	55.36	25.36	0.845333
390	6768.9	30	56.92	26.92	0.897333
420	6768.9	30	55.63	25.63	0.854333
450	6768.9	30	56.81	26.81	0.893667
480	6768.9	30	56.23	26.23	0.874333
510	6768.9	30	57.23	27.23	0.907667
540	6768.9	30	59.36	29.36	0.978667
570	6768.9	30	61.96	31.96	1.065333
600	6768.9	30	63.65	33.65	1.121667
630	6768.9	30	68.96	38.96	1.298667
660	6768.9	30	70.36	40.36	1.345333
690	6768.9	30	71.96	41.96	1.398667

Table (7) Specimen 6 results



Graph (6): Specimen 6 creep curve.

The results in graph 4-5 show a relatively decent creep curve, it shows an increasing elongation at each time interval. However better results could of be obtained if more accurate equipment like a creep test machine were utilised, due to measuring errors you can see variation in measurement taken as the curve is not as smooth as it could be. Stage one can be observed as being instantaneous as expected. Stage 2 slows a linear response which is expected behaviour for the region of the curve. Lastly stage 3 slows an increasing slope due. However, graph 6 shows a poor test results and deemed to have a lot of human error due

to erratic results be obtained. Graph 3 does not clearly define stage 3 creep as they test specimen did not break on this occasion, it was determined for test specimens 1-3 that enough weight was not applied on the test specimens and the results did not change even over a 4 days' period these results were neglected due to mass number of results being identical, hence experiment increased mass gained better creep curve, it is concluded that temperature, time and weight are important factors on gaining a creep curve for a polymer.

6.1.1 Calculations

$$\text{Strain} = \frac{\Delta L}{L} = \frac{13.14}{43.14} = 0.438 \text{ from table 5}$$

7.0 Conclusion

In conclusion many of the samples lead to a more successful creep curve being obtained, the creep graph reflected a typical creep curve for a polymeric material. Stage 1 of the creep curve was instantaneous as one would expect. Stage 2 obtained in most cases a steady state linear response which is expected behaviour. Lastly the tertiary creep the slope increased rapidly which is due to internal cracking occurring within the material. However not each test was performed successfully, and each test had a massive range of deviation these reasons are listed below with suggestions on how to improve experimental results.

During the experiment gaining an accurate measurement was not easy even though digital vernier were used as the mole grips tend to get in the way having longer tabs on the test specimens would of made it easier to measure, however when measuring every 30 seconds the sample tend to get knocked slightly each time which could of lead to poor reading and results, utilising a creep test machine would of enabled repeatability therefore it would have been easier to minimise all variables bare the material variation which was of interest. Random human error would have been vastly mitigated if such machine was used. ISO standard test specimens could have been used to obtain less variation in sample geometry as these were hard to create equally even when a template was used with a carrier bag folded up several times and one cut made for several samples to minimise any variation as much as possible. Measuring every 30 seconds

interval was not always done on time due to trying to gain a more accurate result which would lead to results being taken longer than the time interval on numerous occasions, which potentially would have influenced the results.

If the experiment was retried a creep test machine with variable accuracy, samples with variable properties and a temperature-controlled environment would be a must to gain a high degree of accuracy in the results. This however would cost vastly more than the present experiment.

9.0 Bibliography

Bird, J., 2015. *Science for engineering*. 5th ed. 2 Park Square, Milton Park, Abingdon, Oxon OX14 4RN: Routledge.

R. C. Hibbeler, 2010. *Engineering Mechanics*. 12th ed. Person Education south Asia Pte. Ltd.

Pethrick, R., Hodge, P. and Wang, R., 2015. *Polymer Structure Characterization*. 3rd ed. Cambridge: Royal Society of Chemistry.

Sciencedirect.com. 2021. *Specimen Dimension - an overview | ScienceDirect Topics*. [online] Available at: <<https://www.sciencedirect.com/topics/engineering/specimen-dimension>> [Accessed 22 Feb 2021].

<https://web.science.uu.nl>. 2021. *Introduction Polymer Theory*. [online] Available at: <<https://web.science.uu.nl/scm/ucc/lectures/IntroductionPolymerTheory.PDF>> [Accessed 27 February 2021].

Reusch, W., 2021. *Polymers*. [online] [Www2.chemistry.msu.edu](http://www2.chemistry.msu.edu). Available at: <<https://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/polymers.htm>> [Accessed 25 Feb 2021].

Matse1.matse.illinois.edu. 2021. *What are Polymers?*. [online] Available at: <<http://matse1.matse.illinois.edu/polymers/ware.html>> [Accessed 28 Feb 2021].

(Specimen Dimension - an overview | ScienceDirect Topics, 2021)
Materialstandard.com. 2021. [online] Available at: <<http://materialstandard.com/wp-content/uploads/2019/06/AshbyEngineering-Materials-2.pdf>> [Accessed 05 March 2021].

Scribd.com. 2021. [online] Available at:
<<https://www.scribd.com/presentation/359712357/Creep-Testing>> [Accessed 11 March 2021].

Finite Element Analysis FEA Consulting Services | Hyperelastic Thermoplastics Rubber Material Characterization Fatigue Testing Laboratory S-N Curve.
2021. *Stress Relaxation and Creep of Polymers Thermoplastics Composites*.
[online] Available at: <<https://advanses.com/stress-relaxation-and-creep/>>
[Accessed 01 March 2021].

Michigan Technological University. 2021. *Creep Experiment*. [online] Available at: <<https://www.mtu.edu/materials/k12/experiments/creep/>> [Accessed 07 March 2021].

Scribd.com. 2021. [online] Available at:
<<https://www.scribd.com/doc/202275581/Creep-Test-Lab-Report>> [Accessed 11 March 2021].

Scribd.com. 2021. [online] Available at:
<<https://www.scribd.com/document/488221359/creep-test>> [Accessed 25 March 2021].

Scribd.com. 2021. [online] Available at:
<<https://www.scribd.com/document/286873647/Creep-Test>> [Accessed 08 March 2021]

Epfl.ch. 2021. [online] Available at: <https://www.epfl.ch/labs/lmm/wp-content/uploads/2018/12/TPDefFract1213_Creep.pdf> [Accessed 26 March 2021].

.