International Journal of Current Advanced Research
ISSN: O: 2319-6475, ISSN: P: 2319-6505, Impact Factor: 6.614
Available Online at www.journalijcar.org
Volume 7; Issue 6(B); June 2018; Page No. 13203-13205
DOI: http://dx.doi.org/10.24327/ijcar.2018.13205.2342

Research Article

SPEADSHEETS FOR ANALYSIS THE STRAIN IN A CREEP TEST IN THE KELVIN MODEL

Syafridatun Nikmah[1]*, Latifah Ratnaningtyas[2] and Heru Kuswanto[3]

[1,2]Physics Education Student, Postgraduate Program, Yogyakarta State University
[3]Physics Education Lecturer, Yogyakarta State University

A R T I C L E I N F O

Article History:

Received 8th March, 2018
Received in revised form 24th April, 2018 Accepted 16th May, 2018
Published online 28th June, 2018

Key words:

Spreadsheet; Simulation; Creep Behavior; Kelvin Voigt Model; Viscoelasticity.

A B S T R A C T

Spreadsheets are familiar to computer users and its widely used in the areas of mathematical calculations, engineering, and other fields. Spreadsheets are also helpful in understanding physics through graphs and simulations for example to simulate the strain in a creep test (constant stress) in the Kelvin model. This study has been designed using a spreadsheet to analyze the strain in a creep test in the Kelvin model. Based on the data and graph, it is found that the strain value depends on the temperature. Experimental activities in physics lessons can be carried out away from laboratories using computer-based simulations, such as spreadsheets. Such simulations can be made by students thus can improve students' understanding and motivate to study physics.

INTRODUCTION

Spreadsheets are familiar to computer users. Its ability in data processing was no doubt. Spreadsheets are widely used in the areas of mathematical calculations, engineering, statistics, health, economics and business, and other fields. These spreadsheets, without demanding programming skills, easily process experimental data sets, evaluate complex analytical and numerical models and correlations, not formerly considered and, convey results in tables and plots (Stammitti, 2013).

Spreadsheet program can be used as a useful tool in science, mathematics, and engineering education. Most of the engineering, science, and mathematics experiments can easily be simulated by developing low-cost spreadsheet (e.g.Excel) based simulators (Ibrahim, 2009). Spreadsheet can be used to visualize effects of various parameters in a physical system. It can be used as a simulating tool (Uddin, Ahsanuddin, & Khan, n.d.).

Physicists create spreadsheets customarily to carry out numerical calculations and to display their results in a meaningful, nice-looking way. Spreadsheets can also be used to display a vivid geometrical model of a physical system (Gonz, 2018). Spreadsheets were surveyed and expressed the added value of the sheets, being user-friendly, helped them to fulfil lab objectives by reducing their workload and, allowed them to complete deeper analyses that instructors could not request before, as they were able to quickly evaluate, compare and validate different model assumptions and correlations (Stammitti, 2013). Combining information on structural properties of spreadsheet tables with lexical matching to external vocabularies results in higher precision and recall of annotation of individual terms (de Vos *et al*., 2017).

The instrument developed with spreadsheets allows the comparative study of a large number of situations employing different sets of input data in order to monitor the effect. Thus, it is proven that the spreadsheet can be a didactic instrument beneficial for a variety of problems, obtaining important results without having to use a special programming language (Grigore & Barna, 2015).

Teaching physics is more difficult than other subjects. The main reason why teaching physics subjects are more difficult is because of the requirements of laboratories. One of the physics material that can be simulated with a spreadsheet is the strain in a creep test in the Kelvin model.

Kelvin–Voigt model of viscoelasticity

Viscoelasticity is the response of a material to an applied stress that has both a viscous and an elastic component. In addition to a recoverable elastic response to an applied force, polymers can undergo permanent deformation at high strains (Mitchell, 2004:499). The time dependent material behavior is often referred to as viscoelasticity (Minnesota, 2001).

Plastics are more prone to creep than metals. For plastics in long-term and outdoor applications it is important to have knowledge about the creep behavior (Lorandi *et al*., 2018). Although creep data are most accurately presented as the plot

Corresponding author: **Syafridatun Nikmah**
Physics Education Student, Postgraduate Program,
Yogyakarta State University

of strain vs. time for various stresses and temperatures, many theoretical and empirical relations have been suggested for the dependence of creep strain on stress and temperature for plastics. A simple model is a Kelvin (or Voigt) unit which consists of a Hookean spring and a Newtonian dashpot (Minnesota, 2001).

The spring models the elastic response while the dashpot models the viscous (or time dependent) response to load

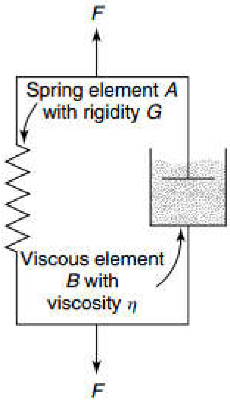

Fig 1 Kelvin–Voigt spring and dashpot in parallel model of viscoelasticity the *Kelvin–Voigt model* of viscoelasticity, the stresses are additive

$$\tau = \tau_e + \tau_v \tag{1}$$

and the strain is distributed

$$\gamma = \gamma_e + \gamma_v \tag{2}$$

Hooke's Law and Newton's Law can once again be substituted, this time into Eq. (5.70), to give

$$\tau = G\gamma + \eta\frac{d\gamma}{dt} \tag{3}$$

Under conditions of constant stress, $d\tau/dt$ = 0, Eq. (3) can be solved to give a relation for the total strain as a function of time:

$$\gamma = \frac{\tau}{G}\left[1 - \exp\left(\frac{-Gt}{\eta}\right)\right] \tag{4}$$

Practically, the time needed to achieve the equilibrium after removal of the stress is called the *retardation time*, t_{ret}, which is equal to the ratio η/G, as in the Maxwell model. Equation (5) can then be written

$$\gamma_r = \frac{\tau}{G}\left[1 - \exp\left(\frac{-t}{t_{ret}}\right)\right] \tag{6}$$

where γ_r is the strain at time *t*, *G* is shear modulus, η isviscosity, τ is shear stress. If the retardation time is small, the recovery will take place at finite time. The Kelvin–Voigt model illustrates the behavior of materials exhibiting a retarded elastic deformation, as occurs in such phenomena as the *elastic aftereffect, creep recovery*, and *elastic memory* [10].

METHODOLOGY

This section shows how the spreadsheet program can be used to simulate a physics problem.

From the equations (5) and (6) we can determine the value of each variable, so that it matches the strain in a creep test (constant stress) in the Kelvin model we will analyze using a spreadsheet program. The viscosity (η) of material used is water with temperature variation 10°C up to 100°C. The time (*t*) used is 0.1s to 15s. The variables used are shown in Table 1.

Table 1 The variables used to determine strain in the creep test (constant stress) in the Kelvin model

T Strain/Stress	Shear Modulus G	Viskosity Of Water At Temperature T (°c)	Viskosity Of Water At Temperature H (Mpa.S)	T_{ret} *(S)*	T(S)
		10	1.308	1.8	
		20	1.002	1.4	
		30	0.7978	1.1	
		40	0.6531	0.9	0.1s
5	0.713333333	50	0.5471	0.8	Up
		60	0.4658	0.7	To
		70	0.4044	0.6	15.0s
		80	0.355	0.5	
		90	0.315	0.4	
		100	0.2822	0.4	

The steps used to determine the strain in a creep test (constant stress) in the Kelvin model are shown in the following figure:

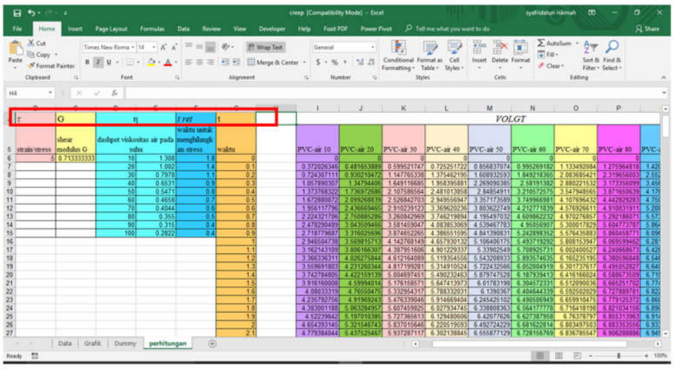

Fig 2 Determining the value time (*t*), shear modulus (*G*), viscosity (*η*), shear stress (*τ*) *and retardation time*t_{ret}

To determine the strain in a creep test (constant stress) in the Kelvin model, then the formula is formulated on the sreadsheet according to (6) using several variables.

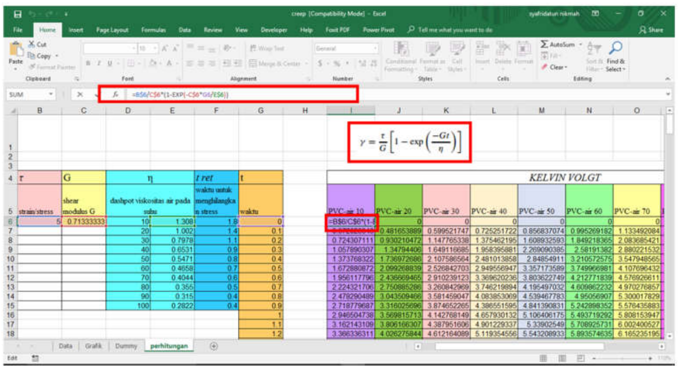

Fig 3 Create a formula on the spreadsheet to determine the strain in a creep test (constant stress) in the Kelvin model.

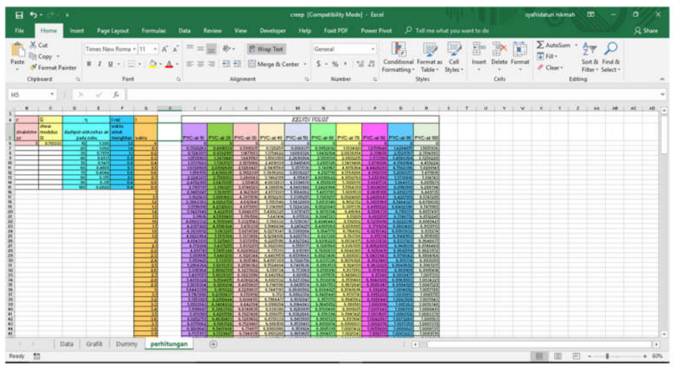

Fig 4 Adjust the time and variations of viscosity (η) required.

The next step to display the simulation using a spreadsheet using macros is shown in the following figure:

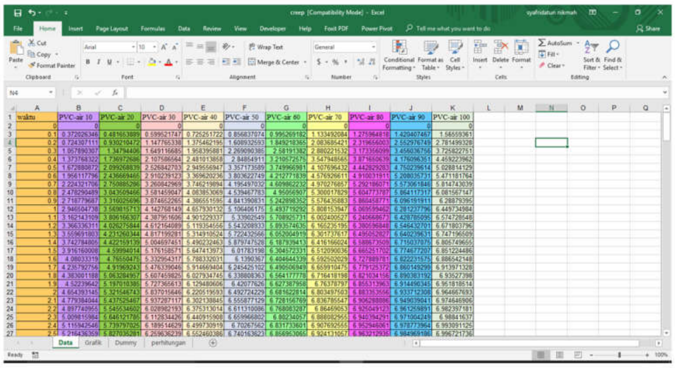

Fig 5 Input the calculation results in the Data sheet in the template that has been created.

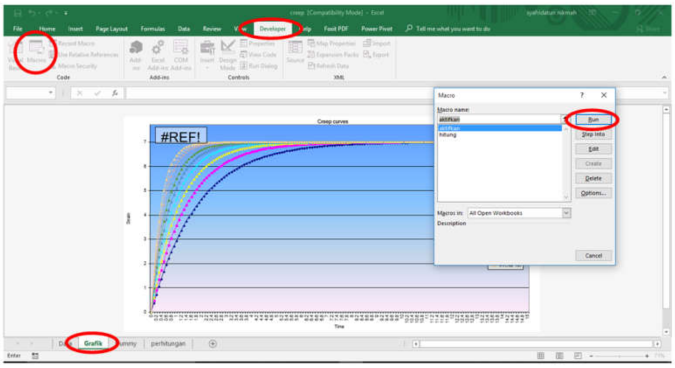

Figure 6 Run on Graph Sheet by selecting Developer on the menu -> Macros -> Run

RESULTS AND DISCUSSION

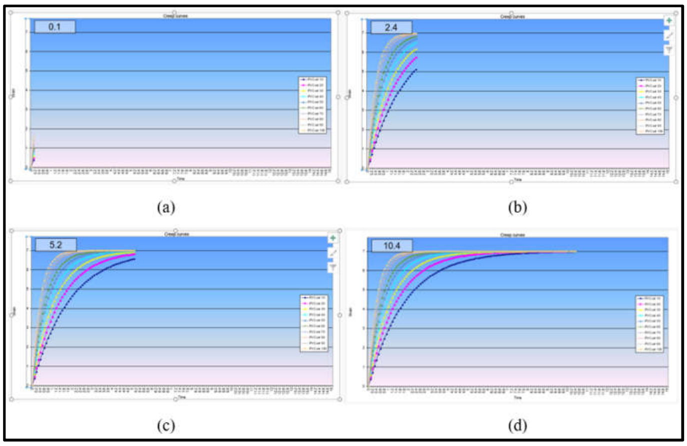

Fig 7 Output graph at time (a) 0.1s, (b) 2.4s, (c) 5.2s, (d) 10.4s.

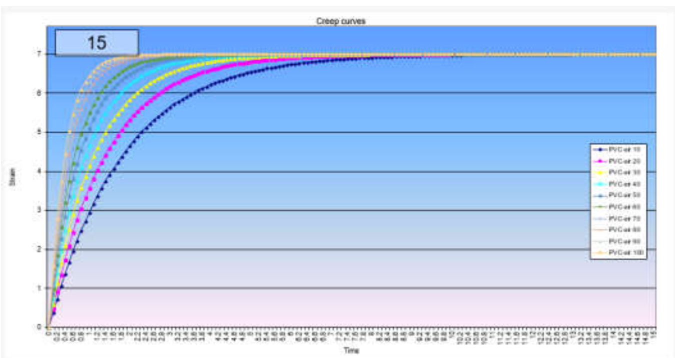

Fig 8 Output graph at time 15s.

Based on the graph above, it is found that the strain value depends on the temperature. That is because Kelvin viscosity (ηK) showed to be dependent of the stress and temperature, indicating that the materials behavior with higher rigidity due nanoparticles incorporation (Lorandi *et al*., 2018).

This observation was often made at lower temperatures. In addition, creep would relieve the clamping load on the bolt so a complete absence of creep may in fact make it more likely to break (Krappedal, 2016).

Creep measurements were based on dynamic mechanical runs. Higher temperatures lead out to a higher instantaneous deformation due to a higher molecular mobility achievement. In general, temperature and stress increased viscous flow, leading to higher molecular chains relaxation and resulting in poorer properties. (Lorandi *et al*., 2018).

CONCLUSION

The paper has described how the spreadsheet can be used as a useful tool in physics education. Spreadsheets are helpful in understanding physics through graphs and simulations e.g. to simulate the strain in a creep test (constant stress) in the Kelvin model. Based on the data and graph, it is found that the strain value depends on the temperature. That is because Kelvin viscosity (η) showed to be dependent of the stress and temperature. Spreadsheet are easy to use and do not cost a fortune. So that experimental activities in physics lessons can be carried out away from laboratories using computer-based simulations, such as spreadsheets. Such simulations can be made by students thus can improve students' understanding and motivate to study physics.

References

de Vos, M., Wielemaker, J., Rijgersberg, H., Schreiber, G., Wielinga, B., & Top, J. (2017). Combining information on structure and content to automatically annotate natural science spreadsheets. *International Journal of Human Computer Studies*, *103*(February), 63–76. https://doi.org/10.1016/j.ijhcs.2017.02.006

Gonz, M. I. (2018). Lens ray diagrams with a spreadsheet.

Grigore, I., & Barna, E. S. (2015). Using Excel Spreadsheets to Study the Vertical Motion in A Gravitational Field. *Procedia - Social and Behavioral Sciences*, *191*, 2769–2775. https://doi.org/10.1016/j.sbspro.2015.04.259

Ibrahim, D. (2009). Using the excel spreadsheet in teaching science subjects. *Procedia - Social and Behavioral Sciences*, *1*(1), 309–312. https://doi.org/10.1016/j.sbspro.2009.01.058

Krappedal, S. (2016). Creep in a plastic fastening component.

Lorandi, N. P., Cioffi, M. O. H., Shigue, C., Ornaghi Jr., H. L., Lorandi, N. P., Cioffi, M. O. H., … Ornaghi Jr., H. L. (2018). On the creep behavior of carbon/epoxy non-crimp fabric composites. *Materials Research*, *66*(AHEAD), 0–0. https://doi.org/10.1590/1980-5373-mr-2017-0768

Minnesota, U. of. (2001). Long term performance of polymers. *University of Minnesota*, 1–11.

Stammitti, A. (2013). Spreadsheets for assisting Transport Phenomena Laboratory experiences. *Education for Chemical Engineers*, *8*(2), e58–e71. https://doi.org/10.1016/j.ece.2013.02.005

Uddin, Z., Ahsanuddin, M., & Khan, D. A. (n.d.). Teaching physics using Microsoft Excel.

Mitchell, S. Brian. 2004. An Introduction Materials Engineering and Science. Canada: John Wiley & Sons, Inc, pp. 452-454

****