RESEARCH ARTICLE

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Experimental Investigation of Creep Behavior of Polypropylene (PP) Material

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ABSTRACT

This paper covers the experimental investigation on creep for polypropylene material with constant and varying load conditions. In first condition with the help of load hanger a constant load was applied till the specimen breaks and in second condition using tensile helical spring & turnbuckle arrangement, a constant reducing load with respect to time was applied till the specimen breaks. The specimen was subjected to a load of 30 Kg at 70^0c and 50Kg at 75^0c. The result shows that the creep behavior is significantly a time dependent phenomenon. The result also shows that using tension helical spring and turnbuckle arrangement the specimen deflection itself reduces the applied load with respect to time.

Keywords: Polypropylene, Creep rate, Strain.

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INTRODUCTION

The creep is the phenomenon which occurs at gradual and uniform varying load with respect to time. This phenomenon is time dependent as well temperature dependent. As the constant stress applied over the material over certain temperature, due to shifting of molecules in available vacancies towards the boundaries [1]. The creep is performed by applying constant load to one end of the specimen through lever system. The other end of the specimen is rigidly fixed in grippers in furnace in constant temperature condition [2, 3]. For the experimental investigation polypropylene material is utilized due to its wide application. As per the literature, the polypropylene has an application in food industry, automobile sector and medical field [4,5]. Hence the research carried out to observe the creep behavior of the polypropylene.

For the experimentation, a tensile creep testing machine utilized. The experimental set up properly calibrated to reduce the error. The present experimentation shows the comparison of two different experimental condition for creep behavior [6-10]. In a first condition experimentation is carried by using a load hanger and in the other condition it was then replaced with tension helical spring. In both the condition, constant load is applied and service lifetime was measured. The experimental setup were recalibrated after the each test.

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EXPERIMENTATION

Experimental Procedure for system 1 and system 2

The experimental set up for the experiment comprises three main section which are: Furnace setup, suspended

hanger and arrangement for measuring instrument. Inside the furnace, the specimen used for testing kept in vertical position using grippers. After the placing the specimen in the furnace, a constant load is applied using the load hanger. The temperature of the furnace is then controlled by using the microcontroller based controlling system. The attached thermocouple connected with the data acquisition system (DAS) and then specimen allowed to heat for 10 minutes. The creep rate recorded for the specimen using DAS. Figure 1 and Figure 2 shows the schematic view and the arrangements for the components.

Experimental Method 1

The material for the specimen utilized was polypropylene, flat geometric specification has illustrated in Fig. 3. The gauge length of 30mm and thickness of 1mm were taken by following the specifications of the ASTM standard [11, 12, and 13]. The temperature range adopted for the experimentation were 70^0C and 75^0C at a static load condition of 30kg & 50 Kg. respectively.

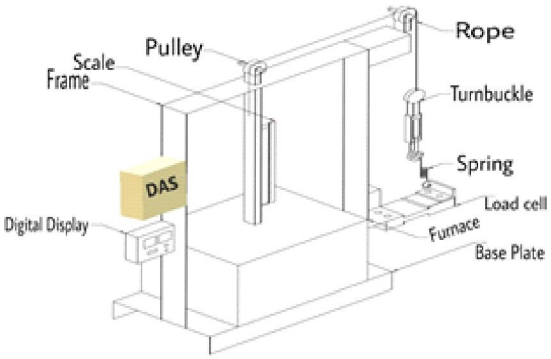

Figure 1: Schematic of the Test Setup

Figure 2: Setup of experiment

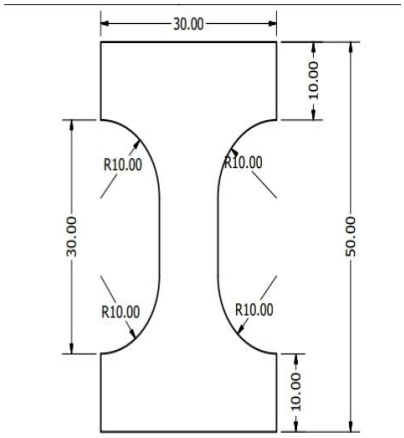

Figure 3: Geometric specification of specimen (mm)

Experimental Result 1

The experimental result shows the different rate of creep at different temperature. At 70^0C with 30 Kg of load, 29.43 MPa stress was noted. The time for the creep failure observed to be 1150 Sec. In similar pattern, at 75^0C with 50 Kg load 49.05 MPa stress was noted. And the time for creep failure was observed to be 570 Sec. Figure 4 and 5 shows the creep strain curve with respect to the time has plotted with varying load of 30 Kg and 50 Kg respectively. The observation of the creep rate along with different particular such as strain, deflection and fraction time has stated in the Table 1. The experimental result shows gain in the creep rate along with gain in the temperature. It was also observed that as the gain in the temperature occurred, the tensile strength of the specimen was reduced.

Table-1 : Creep Behavior for Different Particular using Polypropylene

Temperature (^{0}C)	Strain (%)	Deflection (mm)	Fraction Time (sec)
70 ^{0}C, 30Kg	5.3	1.6	1150
	21	6.3	
	32.3	9.7	
	36.3	10.9	
	39	11.7	
	56.3	16.9	
	77.6	23.3	
	107	32.1	
75^0C, 50 Kg	6.7	2	570
	23.3	7	
	41	12.3	
	49.6	14.9	
	54.3	16.3	
	75	22.5	
	123.6	37.1	

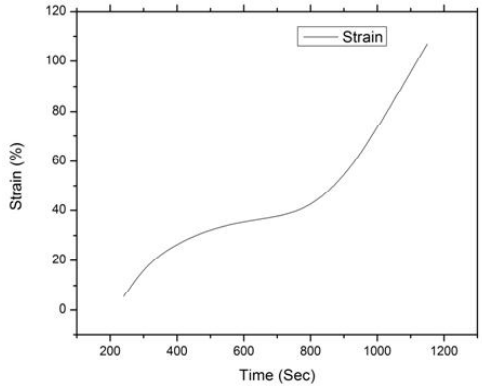

Figure 4: Creep Strain with respect to time at 70 ^{0}C& 30Kg Load

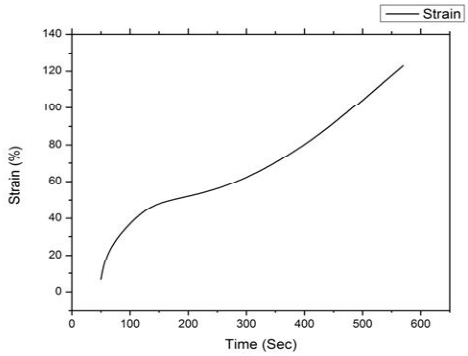

Figure 5: Creep Strain vs. Time at 75 ^{0}C &50Kg

Experimental Method 2

In second method, the load hanger was replaced with tension helical spring and turnbuckle. The other physical condition of the experiment were kept constant. In this method, using tension helical spring and the turnbuckle the load of 30 Kg applied at 70^{0}C and 50 Kg at 75^{0}C respectively. Likewise in the experimental method 1, the creep rate was recorded using the DAS and illustrate in Table 2.

Experimental Result 2

The experimental result shows the different rate of creep at different temperature. At 70^{0}C with 30 Kg of load, 29.43 MPa stress was noted. The time for the creep failure observed to be 1541 Sec. In similar pattern, at 75^{0}C with 50 Kg load 49.05 MPa stress was noted. And the time for creep failure was observed to be 1070 Sec. When the load is applied with turnbuckle, spring gets deflected. As deflection occurs with respect to the time, the spring gets compressed and released some amount of load from the specimen .Ideally it should elongate the specimen and should be equal to the compression in the spring, but practically some errors were identified through the experimentation.

The creep behavior with respect to the time and gradual decreased load with different particular has stated in Table 2. For the corresponding arrangement in the experimentation, the creep strain curve with respect to the time plotted which shows the experimental findings.

Table-2: Creep Behavior for Different Particular Using Polypropylene

Temperature (^{0}C)	Strain (%)	Deflection (mm)	Fraction Time (sec)
70 ^{0}C, 30Kg	5.4	1.61	1541
	10.8	3.25	
	15.7	4.73	
70 ^{0}C, 25.3Kg	19.9	5.89	
	24.6	7.38	
	27.4	8.23	
70 ^{0}C, 21Kg	30.6	9.2	
	33.6	10.1	
	37.4	11.23	
70 ^{0}C, 18.5Kg	42.4	12.72	
	54.6	16.3	
	73.9	22.18	
	99	29.7	
70 ^{0}C, 2Kg	157.9	47.37	
75^{0}C, 50 Kg	0	0	
	7	2.1	1070
	14.3	4.3	
	24	7.2	
75^{0}C, 41.5 Kg	32.3	9.7	
	42	12.6	
	47.6	14.3	
	52.6	15.8	
75^{0}C, 33.1 Kg	59.5	17.9	
	64.3	19.3	
	67	20.1	
75^{0}C, 27.1 Kg	81	24.3	
	103	30.9	
	118.6	35.6	
75^{0}C, 12.3 Kg	129	38.7	

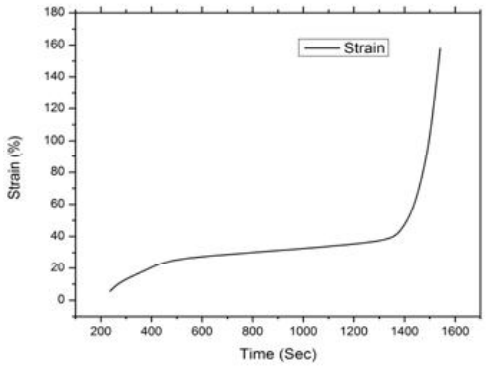

Figure 6: Creep Strain vs. Time at 70 ^{0}C& 30Kg to 2Kg reducing Load

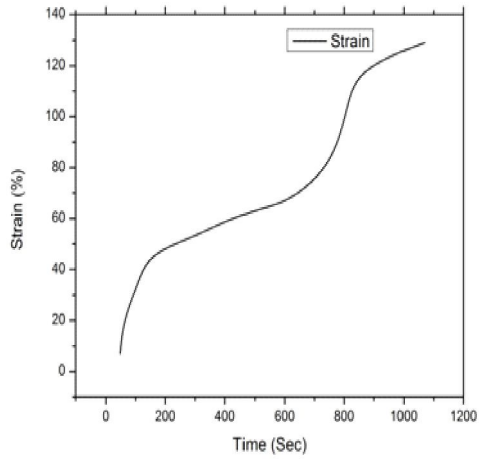

Figure 7: Creep Strain vs. Time at 75 ^{0}C & 50Kg to12.3 Kg reducing load

Table-2 shows that at constant temperature even if the load is reduced constantly stain continues to increase, decreasing the tensile strength of polypropylene gradually and accelerates creep failure of polypropylene. Figure 5 and Figure 6 shows gain in the creep rate with gain in temperature. It was also observed that even if the load gradually reduced the creep rate was high with gain in temperature.

CONCLUSION

In this experimentation, the polypropylene material has examined for the creep behavior. With different load condition along with varying temperature, following are the conclusion drawn from the experimentation.

1. Either by using load hanger or by using the helical spring, gain in rate of creep was observed as the gain in temperature occurred. The parameter such as elastic strain as well as the total deformation follow the similar pattern with gain in temperature.
2. The varying temperature reduced the tensile strength of polypropylene while subjected to the higher load and thus higher creep rate was observed.
3. The fracture timing is observed to be more while gradual releasing of load as compared to the applied constant load. It was also observed that even after reducing the load gradually, the strain of polypropylene specimen increases.

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