Investigation of extruded polyethylene blend films tensile creep elongation with different open holes configurations

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Abstract: *In this article,tensile creep elongation of PE plastic films with two configurations of open holes stressed at the incremental temperatures of 23,30,37,43,51,58 degrees and a constant dead weight of 50 kg will be analyzed. The aim of the article is to analyze influence of the two configurations of open holes on the relative elongation. The test was conducted with the same blend, under the same test conditions. The test was conducted entirely according to the conditions established in the ASTM D6992 standard.*
Keywords*: CREEP TESTING,TENSILE STRENGHT,ELONGATION,PLASTIC FILMS.*

1. Introduction

In engineering practice, there is often the presence of parts with open holes[1]. The presence of such holes is most often due to the following technological reasons:

- Lightening structure
- Access to various fasteners
- Access to other parts of assembled units
- Access for repair work
- Access for electrical switches,etc.
- Functional dimensions for assembly

Parts with open holes have lower strength properties than those without holes because stress concentrators are created and cross section is reduced [2]. In solid mechanics, stress concentrators are locations in a part where the stresses are greater than the surrounding area (Fig. 1). Stress concentrators include holes, grooves, notches, scratches, etc. Stress concentrators also reduce fatigue strength.

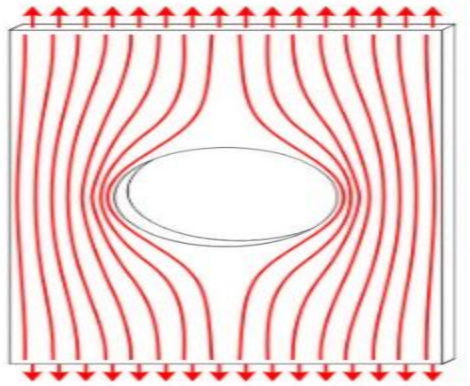


Fig.1 *Internal force lines*

It is known that the size and configuration of the holes play an important role in elastic properties of the material[3]. The dimensionless stress concentration factor k is used, which is equal to the maximum stress divided by the nominal stress. For round holes, the coefficient is equal to 3, i.e. the stresses along the edge of the hole are three times higher than the nominal stresses[4]. Despite the availability of CAE tools such as the boundary element method and finite element method predictive strength calculations with them through simulations are not particularly accurate[5]. A number of scientific articles study and optimize the influence of hole configuration on the tensile and compressive strength of various materials[6]. In engineering practice, the following solutions have become necessary to reduce the effect of stress concentrators:

- Optimizing holes
- Hole reinforcement
- Optimizing shapes of parts.

In plastic materials, localized plasticity occurs, while in brittle parts, stress concentrators lead to failure.

Polyethylene(PE) is the most common plastic worldwide[7]. Research into its mechanical, physical and chemical properties is very current.Polyethylene has wide application in industrial practice. Creep of materials is a slow increase in plastic deformation caused by mechanical stresses[8]. It is an important characteristic of plastics because the process can start at room temperature[9].

2. Materials and methods

The material under the study is a PE blend, with a concentration of HDPE and LDPE 75 to 25 percent. It is characterized by low density, good chemical resistance, flexibility, easy processing by various methods, weldability, low hardness, high creep, impact resistance, excellent electrical insulator. PE is used as medical implants, packaging, pipes, bottles, ropes, etc. [10]. Products made of polyethylene are recyclable. The samples for testing have dimensions of thickness - 1.4 ± 0.01 mm, width 100 ± 1 mm, length 210 ± 1 mm. One sample has 26 open holes with a diameter of 10 ± 1 mm, and the other with 8 holes with a diameter of 20 ± 1 mm(Fig2,Fig.3). The samples have technological holes of 8mm for installment(Fig. 4).

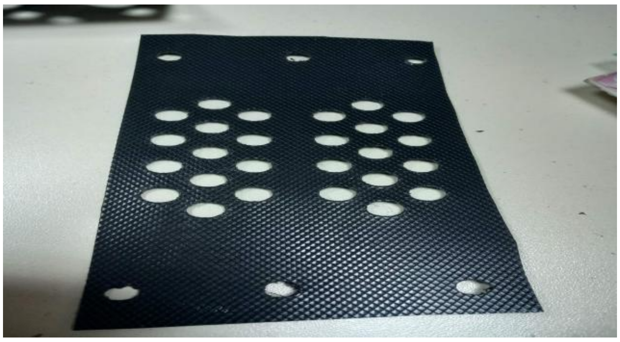


Fig.2 *Sample with 26 open holes*

Fig. 3. *Sample with 8 holes*

The area of the holes of the first and second samples is:

$$S_1=26(\pi.r^2)=2041mm^2 \quad (1)$$

$$S_2=8(\pi.r^2)=2512mm^2 \quad (2)$$

The area of the holes of the second sample is 23% larger. The samples were tested on a calibrated two-slot universal machine for creeping materials with appropriate jaws and scope. The test parameters are incremental temperatures $23,30,37,44,51,58^0$

degrees, dwell time at each step - 240 minutes - total test duration - 24 hours{fig. 5). the requirement that the test be longer than 60,000 seconds(app. 16.66 hours) has been met. The atmospheric conditions were observed according to the standard..The loading was carried out by weights of 50 kg, i.e. the force is equal to 490.5 N(Fig. 6).

Fig. 4 *Installment of the samples in the chamber*

Fig, 5 ***Parameters*** *of the creep testing*

Fig.6 *Dead weight system*

The test was performed on a calibrated creep machine. The test conditions specified in the standard were met. The temperature during the test was within the standard limits of ±1°C. The selected incremental temperatures correspond to test conditions for heavily loaded structures. For the purposes of this article, only the elongation in mm after the test is considered, ignoring the elongation obtained at the different temperature steps. Both sockets of the testing machine are used to ensure that both specimens are subjected to the same test conditions.

.3. Results and discussion

The results of the accelerated creep test are presented in a table 1.

Table 1: *Accelerated tensile creep results*

Sample No	Elongation mm	Elongation %
1	14.06	6.69
2	9.06	4.31

The results show significant deformation of specimen 1, even though it is the specimen with the smaller hole area. The reason is that the linear force lines are denser in specimen 1 due to the selected hole configuration,fig. 7.

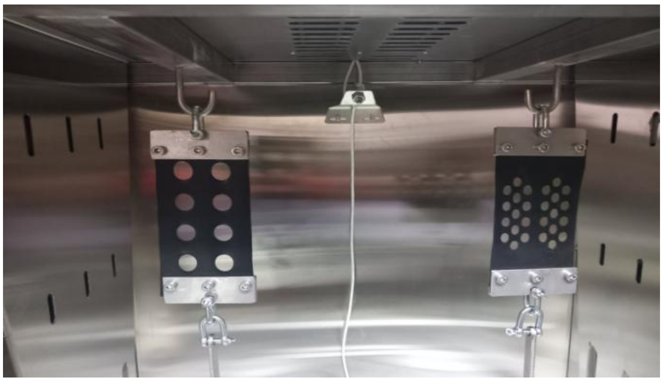
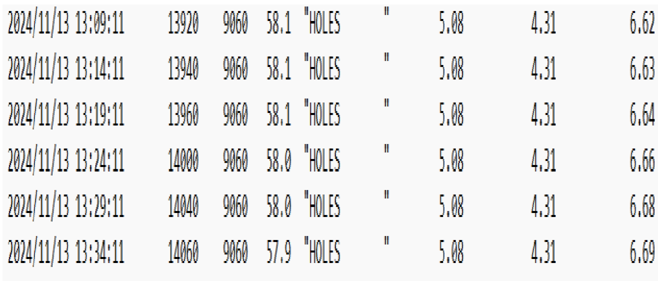


Fig. 7 *Tested samples*

The software of the universal creep machine records every 5 minutes and in the logs with the results there are no visible shock strains, which would compromise the test results(fig. 8) slippage or displacement of the test specimens is observed.No strain is observed in the gripping area. The strain is characterized by thinning around the horizontal axis of symmetry, forming an arc on both sides of the samples.



2024/11/13 13:09:11	13920	9060	58.1	"HOLES	"	5.08	4.31	6.62
2024/11/13 13:14:11	13940	9060	58.1	"HOLES	"	5.08	4.31	6.63
2024/11/13 13:19:11	13960	9060	58.1	"HOLES	"	5.08	4.31	6.64
2024/11/13 13:24:11	14000	9060	58.0	"HOLES	"	5.08	4.31	6.66
2024/11/13 13:29:11	14040	9060	58.0	"HOLES	"	5.08	4.31	6.68
2024/11/13 13:34:11	14060	9060	57.9	"HOLES	"	5.08	4.31	6.69

Fig. 8 *Log file*

The test results are significant, as plastics are increasingly used as a structural materials. Such tests can serve for more optimal designs of similar types of products with open holes[11].

4.Conclusions

. After testing the accelerated creep of the PE films blend with 2 different hole configurations, the following conclusions can be made:

• Sample 1, which has a smaller hole area, strains 55% more than sample 2

• The test conditions fully comply with the accelerated creep standard D6992

• No significant deviations were observed that would affect the test results

• The test results can be used for plastic films with a similar open hole configurations.

5.References

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