Progress in Engineering Application and Technology Vol. 2 No. 1 (2021) 799–812
© Universiti Tun Hussein Onn Malaysia Publisher's Office

PEAT

Homepage: http://penerbit.uthm.edu.my/periodicals/index.php/peat
e-ISSN : 2773-5303

Evaluation of High Density Polyethylene Plastic Bag Performance towards Edge and Point Stresses Using Taguchi Method

Ng Si Jin[1], **Yong Tze Mi**[1]*

[1]Department of Mechanical Engineering Technology, Faculty of Engineering Technology,
Universiti Tun Hussein Onn Malaysia, 84600 Pagoh, Johor, MALAYSIA

*Corresponding Author Designation

DOI: https://doi.org/10.30880/peat.2021.02.01.076
Received 12 January 2021; Accepted 01 Month 2021; Available online 25 June 2021

Abstract: Plastic bag are widely used due to it is low cost and convenience for packaging items. The problem with the strength of the plastic bag tends to tear easily and perforated. This study aims to validate the simulation results of High Density Polyethylene (HDPE) plastic towards HDPE plastic bags manufactured in UTHM and thus to evaluate the performance of plastic bag towards mass, edge and point stresses. The tensile test simulation was conducted using Solidworks 2017 to validate the HDPE plastic material properties by comparing the tensile test performed according to ASTM D882-18. The real life application was conducted to validate the simulation result by comparing plastic film's displacement with different mass applied. Taguchi Method was used to arrange the edge and point stress test parameter with varied angle, mass, length and distance between the loads. The result showed that the error percentage for all loads was lower than 10.00 % for simulation compared to experimental tensile test. It also showed that error percentage was less than 5.00 % by comparing real life application and simulation results for displacement of plastic film. For mass stress test, the loads with 5.0 kg square base has the highest stress acted on the plastic film's surface which is 22.399 MPa. For edge stress test, sample D with 1.0 kg, 20 mm of edge's length and 20 ° of edge's angle have highest maximum stress and displacement acted on plastic film's surface which are 34.086 MPa and 84.94 mm respectively. For point stress test, sample G with 1.0 kg, 10 ° of angle and 30 mm of the distance between the point load have highest maximum stress and displacement acted on surface of plastic film which are 50.676 MPa and 63.64 mm accordingly. Both sample D and G were perforated since the maximum stress acted was exceed the tensile strength of HDPE plastic which is 28.4 MPa. The validation of HDPE plastic towards HDPE plastic bag manufactured in UTHM was proven from the result obtained. The plastic bag's performance towards mass, edge and point stresses was successfully evaluated by using Finite Element Analysis and Taguchi Method.

Keywords: Plastic bag, Finite Element Analysis, Taguchi Method

*Corresponding author: tmyong@uthm.edu.my

1. Introduction

The products that people use in daily life can be made from various type of materials. Plastic is one of the material that is widely used to produce a variety of products because it can be shaped and moulded. Thus, the demand and production of plastic bag are increasing gradually. It is estimated that trillion plastic bags are used as carrier bag everywhere in the world annually [1].

However, improper disposal and tremendous use of plastic bags can damage the ecosystem and natural environment. There are 19000 tonnes of solid waste produced by Malaysians annually, of which 24.00 % of total solid waste are plastic waste [2]. Moreover, the postal and courier business had consumed around 31 million packages in a single day and left 0.16 million tons of plastic packaging waste [3]. In order to reduce the impact on the environment, the No Plastic Bag Day program was introduced to discourage people from using a plastic bag to carry purchased items from the retail shop [2].

In order to overcome the problem, this project will mainly focus on validation of material properties of HDPE plastic and the simulation result that calculated by SolidWorks software. Using software SolidWorks 2017, the results of the simulation are evaluated and compared with the experimental result. The simulation result shows the performance of plastic bag with varied of mass, angle, length and distance between loads applied that acting on the plastic surface so that can determine whether the plastic film are perforated based on the strength of HDPE plastic. From the results obtained, the plastic bag manufacturer can have better understanding the performance of plastic bag towards mass, edge and point stresses. Other than these factors, there are others factors also can conducted using simulation analysis. Thus, the plastic bag with optimal strength can be design regarding the test conducted. Usage of plastic bag decreased because people are not essential to use doubled layered plastic bag to avoid the plastic bag from tearing if the sharp items were filled into plastic bag. The environmental pollution problem can be decrease since the usage of plastic bag decreased.

This study aims to validate the simulation results of HDPE plastic towards HDPE plastic bags manufactured in UTHM and thus to evaluate the performance of plastic bag towards mass, edge and point stresses by using Finite Element Analysis and Taguchi Method.

The scope of this study is limited to plastic bag and its production, Taguchi method, Finite Element Analysis and the size and sharpness of dorsal fish fin. The simulation software used in this project is SolidWorks 2017. Validation of simulation material properties of HDPE plastic results limited to tensile test and real life application. The properties of HDPE plastic and the plastic bag samples used in this project was produced by the machine Hyplas Machinery (HP-35HD) at Universiti Tun Hussein Onn Malaysia, Pagoh, Johor, Malaysia [4]. The type of analysis used in simulation is Static and the material of plastic film used was HDPE plastic. Evaluation of stress analysis are limited to the analysis of mass, edge and point stresses on plastic bag. Parameter studies for edge stresses test are limited to mass, angle, length of edge load using Taguchi Method. Parameter studies for point stresses test are limited to mass, angle, the distance between the point loads using Taguchi Method. Taguchi Method applied is limited to L_4 orthogonal array.

1.1 Usage of plastic bag in Malaysia.

There are 18000 metric tons of plastic a day produced by Malaysia, and it is 24.00 % of the overall daily national production output. The Penang's state deals with 1500 to 1600 tons of plastics waste every day and averages the disposal of 1 kg of plastic per person [5].

A study was carried out mentioned that out of 192 coastal countries globally, Malaysia ranked eighth in the largest producer of plastic waste that could not be disposed [6]. The study estimated that Malaysia had generated a total of 0.94 million metric tons of mismanaged plastic waste in 2010, of which whopping 0.14 to 0.37 million metric tons of plastic waste was dumped into oceans [6]. All 27 countries in the European Union, with a combined population of almost 500 million, used 86 billion plastic shopping bags in 2010 but Malaysia's population is only 6.00 % of EU's. From the year 2010 to 2015, Malaysians had used 3 billion plastic shopping bags which means that almost 1 billion per year by using the linear regression equation and Malaysia's mean GDP [7].

1.2 Finite Element Analysis

FEA is used to determine the force and pressure that acting on wall of plastic bag for algae growth [8]. A cylindrical shape plastic bag was designed and the most suitable material was chosen for algae cultivation. The physical properties of plastic can affect the cost of algae production. For example, the durability, toughness and price of the plastic bag produced are needed to be considered. With SolidWorks FEA's aid, the maximum stress and displacement of the plastic bag are evaluated [8].

The three-dimensional stress-strain relations in both free standing and adherent thin film are studied using FEA. The tensile testing simulation was conducted and the stress on thin film's surface were determined using FEA. Comparison with experimental data and simulation results prove that FEA have better accuracy because the FEA results shown are closer to the theoretical results [9]. During testing, the elastic necking of thin film is determined using FEA and it is shown that the plastic deformation of thin-film occurs. The shearing, fracture and delamination of thin-film are identified using FEA [9].

Incompatible polymer particles can significantly impact the processing behavior of Polyethylene Terephthalate (PET) films. The PET film model was constructed to simulate void formation due to interfacial delamination between PET and other types of dispersed incompatible polymer. The interfacial delamination in a polymer can be evaluated by using FEA. The result of simulation can be obtained and it can be compared between the types of polymer used. Based on the simulation result, the difference in surface energy of PET are increasing and the incompatible polymer is associated with the formation of larger voids during stretching [10].

2. Materials and Methods

2.1 HDPE plastic bag

HDPE plastic properties and the plastic film samples used in this study was produced by the machine Hyplas Machinery (HP-35HD) at Universiti Tun Hussein Onn Malaysia, Pagoh, Johor, Malaysia [4]. Tensile strength test performed according to ASTM D882-18 showed that the HDPE plastic have the properties of 100.74 MPa of Elastic Modulus, 33.56 N/mm^2 of tensile strength and 899 kg/m^3 of density [4].

2.2 Parameter studies

2.2.1 Validation of HDPE plastic material properties through tensile test

The plastic film dimension used in the previous experimental study was 250 mm × 30 mm and its thickness was 0.03 mm [4]. The validity of HDPE material properties was identified by comparing the previous experimental results and simulation result. The parameter of applied load for simulation as shown in Table 1.

Table 1: Parameter of applied load for simulation

Sample	Applied Load (N)
1	15
2	17
3	19
4	22

2.2.2 Validation of simulation result

The dimension of plastic film used in this test was fixed as 250 mm × 250 mm. The loads were acted on the plastic film's surface and the plastic film's displacement will be recorded. Comparison between simulation and real life application result by comparing the displacement of plastic film. The parameter of loads used as shown in Table 2. The stress on the surface of plastic film can be identified with different loads applied.

Table 2: The parameter for the applied load

Sample	Loads
1	0.5 kg square base
2	1.0 kg square base
3	2.0 kg square base
4	5.0 kg square base
5	5.0 kg cylinder base

2.2.3 Simulation for the edge stress test

For the simulation of edge stresses test is to evaluate the quality of plastic bag towards edge stresses with varying angle and length and the mass of the edge load. Taguchi Method was used to classify the number of factors and levels so that different analysis results were obtained as shown in Table 3 and 4.

Table 3: Selected factors and their levels for simulation of edge stresses test

Factor	Level	
	1	2
Mass (kg)	0.5	1.0
Angle (°)	10	20
Length (mm)	20	60

Table 4: Orthogonal Array (OA) with control factors for simulation of edge stresses test.

Sample	Control factor		
	1	2	3
A	1	1	1
B	1	2	2
C	2	1	2
D	2	2	1

2.2.4 Simulation for point stress test

The simulation of point stresses test is to evaluate the performance of plastic bag towards point stresses with the varying angle and mass of point load and distance between point loads. Taguchi Method was used to classify the number of factors and levels so that different analysis results were obtained as shown in Table 5 and 6.

Table 5: Selected factor and level for simulation of point stresses test

Factor	Level	
	1	2
Mass (kg)	0.5	1.0
Angle (°)	10	20
Distance between point loads (mm)	20	30

Table 6: Orthogonal Array (OA) with control factors for simulation of point stresses test

Sample	Control factor		
	1	2	3
E	1	1	1
F	1	2	2
G	2	1	2
H	2	2	1

2.3 Procedure of real life application

All the plastic film specimens have been cut to the 250 mm × 250 mm dimension as shown in Figure 1.

Figure 1: The specimen of plastic film

Before the loads acting on the plastic film, the initial point is 9.0 cm on ruler as shown in Figure 2. The loads inclusive the empty box's weight were weighted on a weight scale with 0.5 kg, 1.0 kg, 2.0 kg and 5.0 kg. The load with 2.0 kg was weighted on weight scale as shown in Figure 3. Due to the limitation of weight scale, the 5.0 kg of load were weighted with added on two 2.0 kg of load and one 1.0 kg of load. The adhesive method was applied on the both side of the plastic film's edge was to prevent the plastic film from slipping.

Figure 2: Initial point on the ruler

Figure 3: The load with 2.0 kg

2.4 Procedure of Finite Element Analysis

Software Solidworks 2017 was used to construct all the CAD model of plastic film and the loads. The plastic film and loads was mated and assembled together. To operate simulation analysis, the type of analysis used was Static. The material for plastic film was assigned which is HDPE plastic. The left and right sides of plastic film was fixed as fixture geometry. The force was applied on top of the load and the meshing both parts before start the simulation analysis.

3. Results and Discussion

The result of simulation will be discussed based on the data obtained from varying of test which are validation through tensile strength test, mass stresses test, simulation of edge stresses test and simulation of point stresses test.

3.1 Validation of HDPE plastic material properties through tensile strength test

Figure 4 shows the simulation of tensile strength test for the displacement of the plastic film with 22N of applied load. The displacement type used in SolidWorks was URES which means resultant displacement.

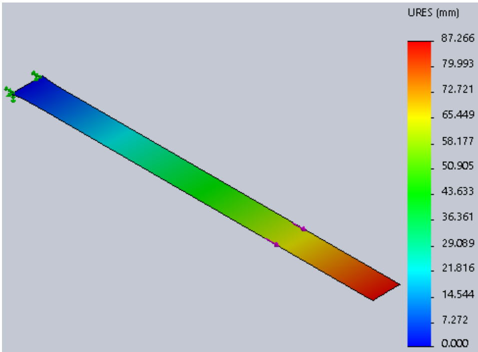


Figure 4: The simulation result with 22 N of applied load

Table 7 shows the experiment result of the previous study compared with the simulation result for plastic film's displacement. The maximum load applied was 22 N and the maximum displacement of the plastic film at maximum load was in between 77.32 mm and 98.91 mm but its average displacement was 90.26 mm [10]. For the simulation, the same maximum load was applied and the maximum displacement of the plastic film for tensile strength test was 87.27 mm. There were slightly differences between the previous experimental results and simulation results and it was a 3.31 % error.

Table 7: The percentage of error between experiment and simulation results

Loads (N)	Displacement of plastic film (mm)		Error (mm)	Error (%)
	Experiment [4]	Simulation		
15	44.87	48.23	3.36	7.49
17	51.61	54.73	3.12	6.05
19	61.25	64.50	3.25	5.31
22	90.26	87.27	-2.99	3.31

From Figure 5, there were slight differences between the experimental and simulation results. The percentage of error for all loads was lower than 10.00 % after compared the experimental and simulation results of tensile test. Since the simulation results were compared with the experimental data of previous study, the validity of the material properties of HDPE plastic was proven.

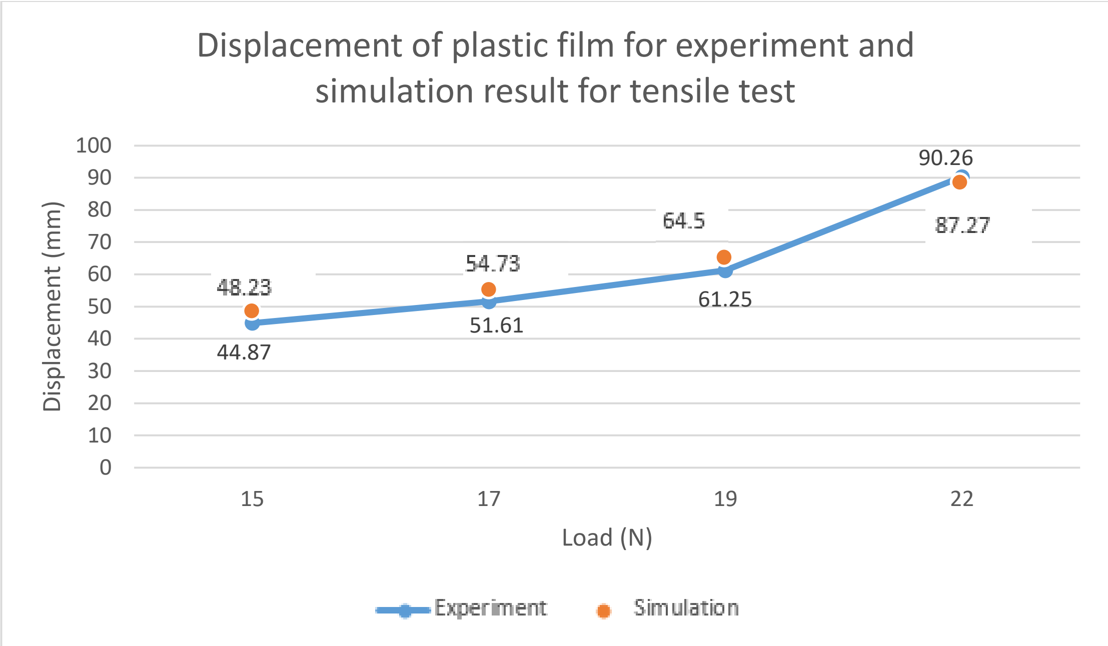
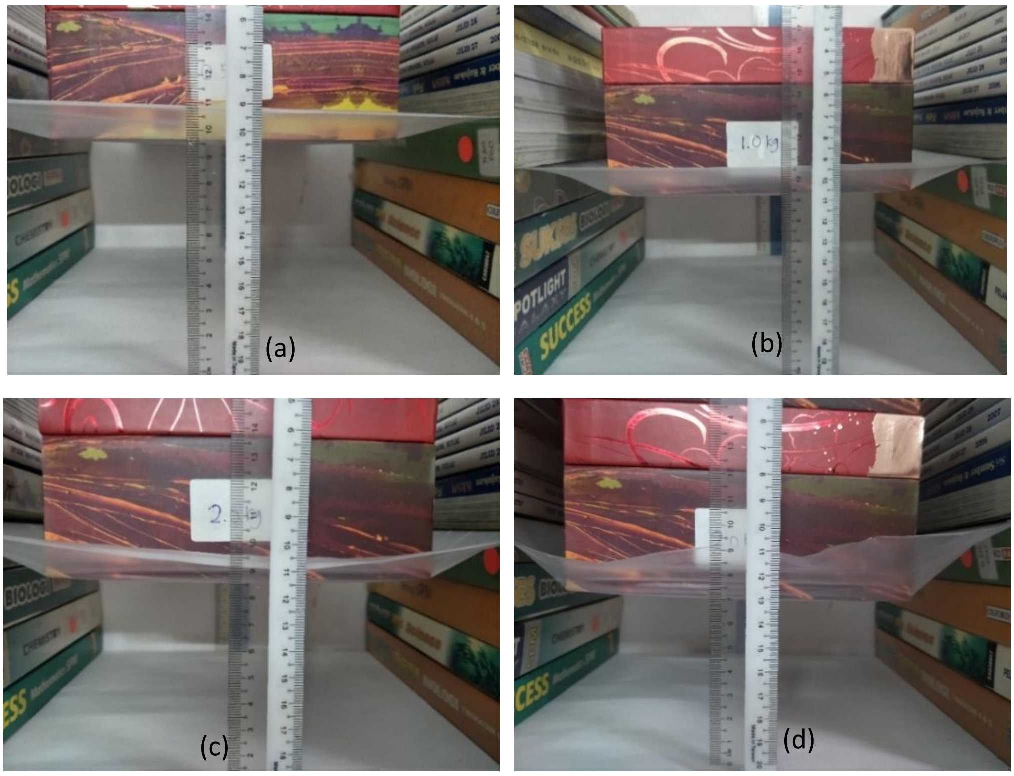


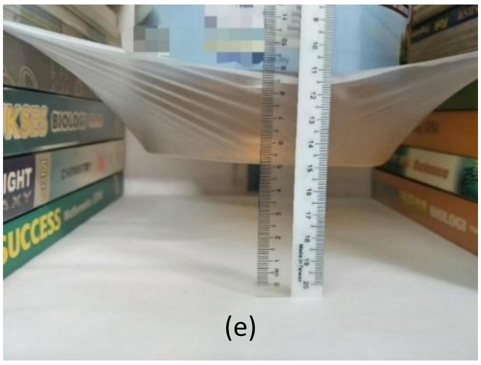
Figure 5: Displacement of plastic film for experiment and simulation results for the tensile test

3.2 Mass test

3.2.1 Real life application

The displacement of the plastic film for each parameter of loads which are 0.5 kg, 1.0 kg, 2.0 kg and 5.0 kg were measured from the bottom part of the loads as shown in Figure 6 (a), (b), (c), (d) and (e).





(e)

Figure 6: The loads with (a) 0.5 kg, (b) 1.0 kg, (c) 2.0 kg, (d) 5.0 kg (square base) and (e) 5.0 kg (cylinder base) acted on the plastic film

Plastic deformation occurred on the plastic film because the plastic film not able to return to its original shape after the load is unloaded as shown in Figure 7. The deformed shape of the plastic film experienced necking before fracture because of strain hardening. It is because the occurring of strain hardening for some distance on the specimen acted by the 5.0 kg.

Figure 7: The plastic film was deformed after the 5.0 kg of load unloaded

Table 8 shows the displacement of the plastic film after the loads are acting on the plastic film. The results shows that the displacement of three specimens have slightly different for the load with 0.5 kg, 1.0 kg and 2.0 kg square base. The differences in the displacement between these two specimens due to the uneven load distribution on plastic film's surface. Hence the average value for the load with 0.5 kg, 1.0 kg and 2.0 kg square base were 13.67 mm, 17.67 mm and 23.33 mm.

Table 8: The displacement of the plastic film after the loads are acting on the plastic film

Loads	Displacement of the plastic film (mm)			
	1	2	3	Average
0.5 kg square base	14.0	12.0	15.0	13.67
1.0 kg square base	18.0	17.0	18.0	17.67
2.0 kg square base	24.0	23.0	23.0	23.33
5.0 kg square base	41.0	42.0	41.0	41.33
5.0 kg cylinder base	56.0	60.0	57.0	57.67

For the load with a 5.0 kg square base, the average displacement value was 41.33 mm. For the load with a 5.0 kg cylinder base, it has the largest average displacement value of 57.67 mm among the parameter of loads that were acting on the plastic film. The first specimen have the displacement with 56.0 mm while the third specimen have the displacement with 57.0 mm and the second specimen have the largest displacement among the parameter of loads that were acting on plastic film which is 60.0 mm.

3.2.2 Simulation results for stress and displacement of the plastic film for different mass applied

Figure 8 (a) and (b) showed the results of simulations for the plastic film's displacement when loads of 5.0 kg square base and cylinder base were acted on the plastic film. For the load of 5.0 kg of cylinder base, the 10 mm of fillet was constructed at the bottom edge of the cylinder since the experiment object has the 10 mm of the fillet at the bottom edge of cylinder base.

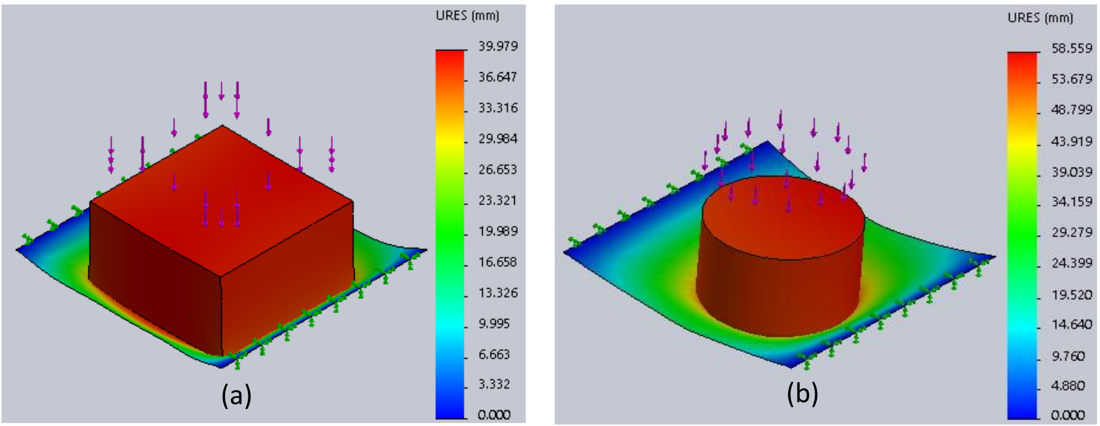


Figure 8: Displacement of plastic film with (a) 5.0 kg (square base) and (b) 5.0 kg of load (cylinder base)

The stresses on the plastic film acted by different loads were determined from results of simulations as shown in Figure 9 (a) and (b).

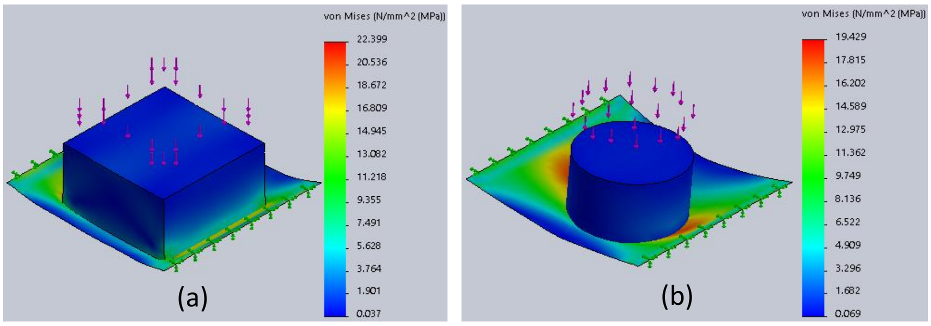


Figure 9: Stress on plastic film after acted on (a) 5.0 kg (square base) and (b) 5.0 kg of load (cylinder base)

Table 9 below shows the simulation results after loads of 0.5 kg, 1.0 kg, 2.0 kg and 5.0 kg were acted on the plastic film and the displacement of the plastic film under loading. The displacement of the plastic film that loaded with 0.5 kg square base and 1.0 kg square base are 13.99 mm and 18.23 mm. The displacement of the plastic film that loaded with 2.0 kg square base and 5.0 kg cylinder base are 24.30 mm and 58.56 mm.

Based on Table 9, the stresses on the surface of plastic film is gradually increased for the loads with a square base. The higher the weight of the loads, the larger the stress on the plastic film's surface. The loads of 5.0 kg with square base have the highest stress on the surface of plastic film which is 22.399 MPa among the parameter of loads.

The stress on the surface of plastic film that acted by the loads of 5.0 kg with cylinder base have lesser stress compared with the stress on the surface of plastic film that acted by the loads of 5.0 kg with a square base. It is because there are four sharp points on every corner of the bottom base of loads. The larger stress on the plastic film's surface occurred due to the sharp corner on the base of the loads. However, the plastic film was not fractured since the stresses on the plastic film's surface were not exceed the maximum tensile strength of the HDPE plastic properties which is 28.4 MPa.

Table 9: The result of simulations for the displacement of plastic film with different loads acted on

Loads	Displacement of plastic film (mm)	Maximum Stress (MPa)
0.5 kg square base	13.99	8.689
1.0 kg square base	18.23	11.652
2.0 kg square base	24.30	15.457
5.0 kg square base	39.98	22.399
5.0 kg cylinder base	58.56	19.429

3.2.3 Comparison between real life application and simulation result

The experimental data and result of the simulations for the displacement of plastic film that loaded with 0.5 kg, 1.0 kg, 2.0 kg and 5.0 kg were compared as shown in Table 10. There are slight differences between the experiment and simulation data and the error occurred due to the parallax error during the experiment. The eyes must be perpendicular to the ruler when reading the scale. Inaccuracy was due to using a ruler as a measurement tool with a minimal reading of 1 mm displacement. Since the experimental results were compared with the simulation results for the displacement of the plastic film, the validity of the result of simulation that calculated by the Solidwork software was proven.

Table 10: The percentage of the error between experiment and simulation data

Loads	Displacement of plastic film (mm)		Error (mm)	Error (%)
	Experiment	Simulation		
0.5 kg square base	13.67	13.99	0.32	2.34
1.0 kg square base	17.67	18.23	0.56	3.17
2.0 kg square base	23.33	24.30	0.97	4.16
5.0 kg square base	41.33	39.98	0.35	3.27
5.0 kg cylinder base	57.67	58.56	0.89	1.54

3.3 Simulation for the edge stress test

The simulation was conducted with varied angle, length and weight of the edge load using Taguchi Method. The edge load sample A, B, C and D was represented the edge model constructed with the corresponding control factor and levels as shown in Table 11. Figure 10 (a) and (b) shows the plastic film towards edge stresses and displacement of the plastic film after acted by sample D.

Table 11: Parameters for edge load for simulation

Sample	Control factor		
	Mass (kg)	Angle (°)	Length (mm)
A	0.5	10	20
B	0.5	20	60
C	1.0	10	60
D	1.0	20	20

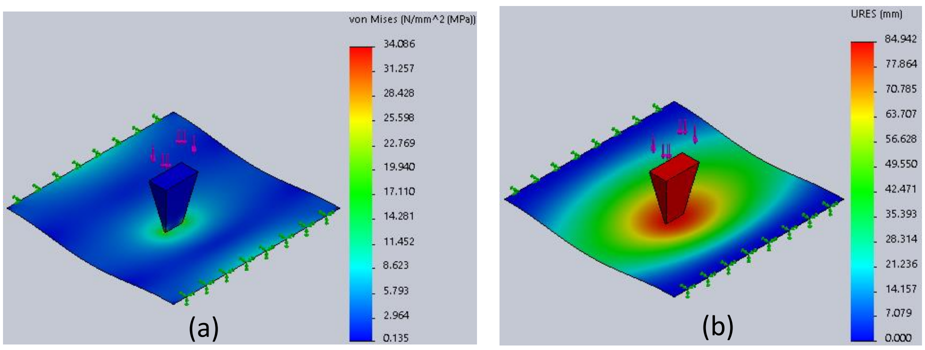


Figure 10: (a) The plastic film towards edge stresses (b) displacement of the plastic film after acted by sample D

Based on Table 12 showed that the sample D with 1.0 kg of weight of the load, 20 mm of edge's length and 20 ° of edge's angle has the highest stress towards the surface of plastic film which is 34.086 MPa and the largest displacement of plastic film which is 84.94 mm. Hence the sample D was perforated since the maximum stress on the surface of the plastic film was exceeded the maximum tensile strength of the HDPE plastic properties which is 28.4 MPa. While sample A, B and C were not perforated since the maximum stresses on the surface of the plastic film was not exceed the tensile strength of the HDPE plastic properties.

Table 12: Maximum stresses and displacement of plastic film acted by edge loads

Sample	Maximum stress (MPa)	Displacement (mm)	Perforated
A	21.518	53.30	No
B	15.987	44.97	No
C	26.850	72.31	No
D	34.086	84.94	Yes

The stress on the surface of plastic film can be affected by the sample acting on it with varied weight, angle and length of the edge. The stress on the surface of plastic film and displacement of the plastic film increased as the weight of the loads acting increased. For the control factor of angle and length of edge load, it was not seen that the factors and levels could directly affect the simulation result.

In this edge stresses test, the control factor of weight of load was a more significant factor that directly affected to the stresses acted on plastic film followed by length and angle of edge load. This is because the weight of load have created larger stress on the plastic film's surface when the larger load applied. Sample D has a larger angle and shorter edge load than sample C, but it created larger stress on the surface of plastic film although sample C has a smaller angle of the edge.

3.4 Simulation for the point stress test

The simulation was conducted with varied angles, weight of the load and distance between the point loads by using Taguchi Method. The point load sample E, F, G and H was represented the point load model constructed with the corresponding control factor and levels as shown in Table 13. Figure 11 (a) and (b) shows the plastic film towards point stresses and displacement of the plastic film after acted by sample G.

Table 13: Parameters for point load for simulation

Sample	Control factor		
	Mass (kg)	Angle (°)	Distance between point load (mm)
E	0.5	10	20
F	0.5	20	30
G	1.0	10	30
H	1.0	20	20

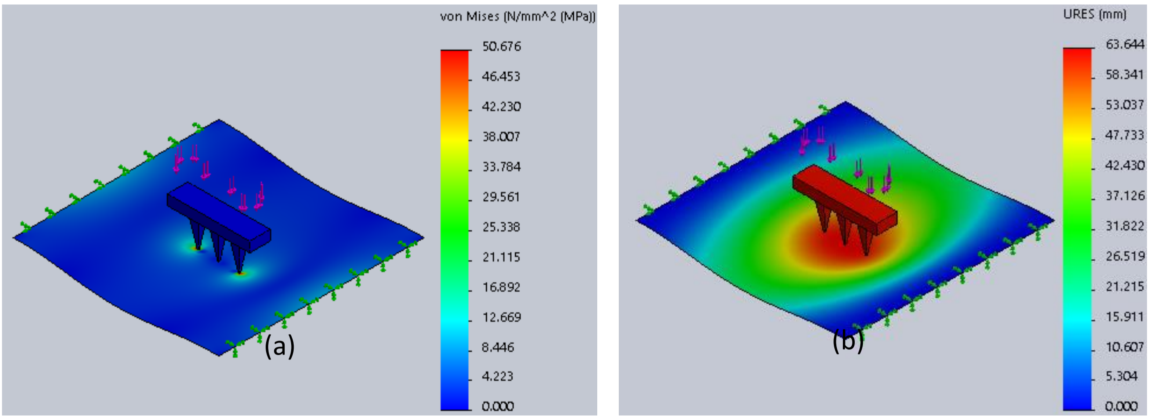


Figure 11: (a) The plastic film towards point stresses (b) displacement of the plastic film after acted by sample G

From the data tabulated in Table 14, the sample G with 1.0 kg of weight, 10 ° of point load and 30 mm of the distance between the point load have the highest stress towards the surface of plastic film which is 50.676 MPa and the largest displacement of plastic film which is 63.64 mm

Table 14: Maximum stresses and displacement of plastic film acted by point loads

Sample	Maximum stress (MPa)	Displacement (mm)	Perforated
E	22.778	35.74	No
F	21.135	32.37	No
G	50.676	63.64	Yes
H	35.318	51.18	Yes

Sample G and H were perforated since the maximum stress on the surface of the plastic film was exceed the maximum tensile strength of the HDPE plastic properties which is 28.4 MPa. While sample E and F were not perforated since the maximum stresses on the surface of the plastic film was not exceed the tensile strength of the HDPE plastic properties. From the simulation results, it was seen that the stresses on the surface of plastic film are higher at the left and right sides of point loads applied compared to the middle point load for every parameter. For sample G and H, the surface of plastic film was perforated by the left and right sides of the point loads.

The stress on the surface of plastic film can be significant impact by the varied of weight, angle and distance between the point loads applied. From the data obtained, the heavier the weight of the point load, the larger the stress and displacement of the plastic film. For the control factor of the angle of point load and distance between the point loads, it was not clearly seen that the factors and levels can directly affect the simulation result. However, the angle of point load can also affect the diameter of the hole that was perforated by the point load. The diameter of the hole can be increased as the angle of point load increased.

From the result of simulations with different control factors and levels applied, it was shown that the weight of point load was a more significant factor that will directly affect the stresses acted on plastic film followed by the angle of point load and distance between the point load. It is because the stresses on the surface of plastic film were tremendously increased if the heavier load applied.

4. Conclusion

The validity of the simulation of HDPE plastic material properties was proven by comparing with the tensile test according to ASTM D882 [4]. The percentage of error was lower than 10.00 % based on the result obtained. The validity of the simulation result was proven again with a comparison of real life application and simulation by comparing the displacement of plastic film with different mass applied on the surface of plastic film. It is because the percentage of error for all loads was less than 5.00 %. The mass stresses test was conducted with different loads applied. The loads with 5.0 kg square base have the highest maximum stress on the surface of plastic film and the largest displacement of plastic film. Using Taguchi Method on the edge stress test, sample D have the highest maximum stress on surface of plastic film and the largest displacement of plastic film. The sample D was perforated since the maximum stress on the surface of the plastic film was exceed the maximum tensile strength of the HDPE plastic. For point stress test, sample G have the highest maximum stress on surface of plastic film and the largest displacement of plastic film. The sample G was perforated since the maximum stress on the surface of the plastic film was exceed the maximum tensile strength of the HDPE plastic.

As a recommendation for further research, it is suggested that the Taguchi Method with larger size orthogonal array used for control factors and levels. The larger levels for angle and length of edge load and angle and distance between the point loads can be studied to determine whether which factors are more significant and directly affect the stress on the surface of plastic film. Other than that, simulation analysis can be conducted for other application. For example, consideration the factors for durian. This is because durian have a lot of thorn covered on the shell. Irregular shape and arrangement of thorn on durian are the main reasons that can cause the plastic bag being tear easily and perforated. The control factors are the shape of the durian, mass of the durian, angle of the thorn and irregular distance between the thorns. Throughout the tests, the optimal strength of plastic bag can be design and produce which used to carry the durian. When the specific plastic bag that design for carry the durian, the usage of plastic bag can be decrease because the fruit seller are not essential to use doubled or more layered plastic bag to prevent the plastic bag from tearing. The cost for usage of plastic bag that used by fruit seller can be minimize and the environmental impact of plastic bag can be decreased.Besides, the thickness of the plastic film used in the simulation can be changed by increasing the thickness of plastic film to identify the strength of a plastic bag that can withstand. The load distribution on the surface of plastic film can be observed and determined whether the plastic bag will be perforated with lower or higher thickness of the plastic bag. The optimum thickness of the plastic bag can be manufactured and the quality of plastic bag can be improved.

Acknowledgement

The authors would like to thank the Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia for its support. Cooperation from the Wahdah Plastic Industries management also highly appreciated.

References

[1] S. J. Kulkarni, "Plastic Bags- Review on Problems and Remedies," *International Journal of Advanced Research in Chemical Science*, vol. 5, no. 1, pp. 1–3, 2018.

[2] S. Asmuni, N. B. Hussin, J. Mhd. Khalili, and Z. M. Zain, "Public Participation and Effectiveness of the no Plastic Bag Day Program in Malaysia," *Procedia - Social and Behavioral Sciences*, vol. 168, pp. 328–340, 2015.

[3] O. Alam, M. Billah and D. Yajie, "Characteristics of plastic bags and their potential environmental hazards," *Resources, Conservation and Recycling*, vol. 132, pp. 121–129, 2018.

[4] C. W. San, "Effects of Winder Speed Variation on Production of High Density Polyethylene Plastic Bag," Undergraduate Dissertation, Universiti Tun Hussein Onn Malaysia, Pagoh, 2019.

[5] K. Jayaraman, H. Haron, G. B. Sung, and S. K. Lin, "Consumer reflections on the usage of plastic bags to parcel hot edible items: an empirical study in Malaysia," *Journal of Cleaner Production*, vol. 19, no. 13, pp. 1527–1535, 2011.

[6] J. R. Jambeck *et al.*, “Plastic waste inputs from land into the ocean,” *Science*, vol. 347, no. 6223, pp. 768–771, 2015.

[7] C. Teh, “Malaysian uses 3 billion plastic shopping bags per year, so why is limiting or even banning their use still a grossly inadequate strategy?,” *Science*, vol. 3, no. 9, pp. 330–334, 2015.

[8] C. Thein, N. Razali, M. Shamel, and S. Phang, “Optimization of Plastic Bag for Algae Growth,’ *Journal of Engineering Science and Technology*, vol. 5 no. 1, pp. 1–3, 2018.

[9] D. Krus, G. Mearini, K. Chaffee, and R. W. Hoffman, “Three-dimensional finite element analysis of thin-film stresses using algor personal-computer-based software,” *Journal of Vacuum Science & Technology A: Vacuum, Surfaces, and Films*, vol. 9, no. 4, pp. 2488–2493, 2019.

[10] K.Ito, K.Yamashita, C. Nonomura, and T. Yamada, “Analysis of interfacial delamination in stretched PET film containing incompatible polymer particles,” *Plastic, Rubber and Composites*, vol. 31, no.4, pp. 151–157, 2002.