EFFECT OF PROCESSING TECHNIQUES ON THE MECHANICAL PROPERTIES OF OIL PALM EMPTY FRUIT BUNCH COMPOSITE

By

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4648
Mechanical Engineering Programme

submitted in partial fulfilment of
the requirements for the
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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
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Approved by,

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TRONOH, PERAK

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CERTIFICATION OF ORIGINALITY

This is certify that I am responsible for the work submitted in this project, that the original work of my own except as specified in the references and acknowledgement, and that the original work contained here in have not been undertaken or done by un specified sources or persons.

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(MOHD YUSNIMAN YUSOF)

ABSTRACT

Oil palm fibers have been extensively studied for the production of various composites, such as thermoplastic composites, particleboard, medium-density fibreboard, polymer-impregnated oil palm trunk, and thermoset composites. The empty fruit bunch of oil palm can be included as a reinforcement fiber due to availability, cost, and its properties. High-density polyethylene (HDPE) is chosen because it has low degree of branching and stronger intermolecular forces and tensile strength. The filler acted as reinforcement on strength and stiffness of composites while the plastic matrix serves as the adhesive to hold the filler in the place so that the suitable structures components can be made. Two different processing techniques were used for this works which are Extrusion process (EX) and Internal mixer process (IM). These two processes will produce two composites in different form and with different mechanical properties. The result revealed that IM composites yielded a relatively higher strength than EX composites. The IM composites also showed better results in their tensile modulus, flexure strength, and hardness compared with EX composites.

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LIST OF ABBREVIATIONS

EFB	Oil palm empty fruit bunch
HDPE	High-density polyethylene
IM	Internal Mixer
EX	Extrusion Process
SEM	Scanning Electron Microscope
MOR	Modulus of Rupture

CHAPTER 1
INTRODUCTION

1.1 Background of Study

Over the past few years, there has been a growing interest in using natural fibers as reinforcement in composites materials. These composites have already been used in various applications such as in automobile parts, building materials and furniture. The advantages of using these natural fibers are their high strength to weight ratio, low specific gravity, low cost and a renewable resource.

One of the natural fibers that can be used is oil palm empty fruit bunch (EFB). This fiber can be obtained from oil palm and for this study, the high density polyethylene is used as the matrix material. The composite will be produces using two different processes which is extrusion process and internal mixer process.

These two processes are totally different method and as a result the composites produced are also in a different shapes for example in extrusion process the composites will be produced in a small pallets form while in internal mixer process the composite will be produced as a big agglomerate. For extrusion process, it required more stages in processing the composites compared to the internal mixer process. The problems that always occur during the extrusion process are melt fracture, surging, degradation, poor mixing, contamination and bubbles in the extruder. The internal mixer process only requires a few stages of processing compare with the extrusion process but it also have it own problems such as poor mixing and the over high temperatures. These types of problems may happen during compounding the composites and could affect the mechanical properties of the composites.

1.2 Problem statement

Mechanical properties of any materials, including composites, are very important especially in ensuring full performance of component and part during their service life. These mechanical properties of composites including tensile strength, elastic modulus, flexural strength and flexural modulus are influence by the microstructure resulted from the processing techniques used to produce the composites materials. Therefore, it is important to investigate and study the effect of processing techniques on the mechanical properties of the EFB-HDPE composites.

1.3 Objective

The objective of this study is to investigate the effects of extrusion and internal mixer processes on the mechanical properties of oil palm empty fruit-bunch (EFB)-HDPE composite.

1.4 Scope of Study

Samples of the EFB-HDPE composites at varying EFB content 10%wt, 20%wt, 30%wt and 40%wt will be prepared using both extrusion and internal mixer techniques. The samples will be subjected to injection molding process in order to obtain the necessary test samples for tensile and flexural tests.

Three types mechanical testing will be done which are tensile, flexural and micro-hardness tests. The result obtained will be analyzed and compared between the two processing routes.

CHAPTER 2

LITERATURE REVIEW

2.1 Extrusion process

The extrusion process utilizes a screw plasticizer. The screw melt the plastic granules introduced through a hopper and forces the molten plastic through to the end of the barrel under high pressure, through a series meshes to remove dirt, and out through a shapes die to produce a continuous product of constant cross-sectional dimension. Thermoplastic melt have very high viscosities, the material can leaves the extruder above the melting point. After extrusion, the material must be cool below it melting point to crystalline polymers, or below the glass transition temperature for amorphous materials, before it can be roughly handled. This is performing by passing the extrudate into a water tank or by water or cool air sprays. After extrusion, the strength can be increase in the extrusion direction by applying an external tensile stress with the pulling device. The extrude product may be drawn down considerably, and extrude may be reduced as mush 30% in stretching process. Due to this orientation, properties vary considerably between the extrusion and transverse direction.

Although the extrudate is fairly uniform in dimension on leaving the die, it can be distorted during the cooling and stretching process, and for dimensional accuracy it can be resized after sufficient cooling. The size and shape of the extrusion die and the postextrusion devices depend on the characteristics of the extrusion screw and barrel.

Figure 2.1: Extrusion Machine

2.2 Problems in Extrusion Process

2.2.1 Melt Fracture

The phenomenon a melt fracture occurred when the extrudate has a rough surface, especially with short cracks or ridges that are oriented in the machine direction or helically around the extrudate. This materials defect occurred because of the tensile forces on the extrudate exceed the critical shear stress and the shear rate of the melt so the materials would experiences random fractures. The turbulent flow in the die that often present when the die is not properly streamlined also can also caused the melt fracture. Another principles that may caused the melt fracture are low temperatures of the melt and high molecular weight of the filler that being used in the extrusion process.

2.2.2 Poor Mixing

Streak or particles in the extrudate could also result from poor mixing, usually from running the extruder faster than it can mix the materials. Slowing the extruder speed is the most obvious remedy. Increasing the back pressure will improve mixing and may be advantageous because output will not be reduced as much. The back pressure could be increased by using more of finer screens and by cooling the metering section and die. Heating farther back in the extruder and adding special mixing devices inside the extruder barrel are other methods that could also improve mixing process.

2.2.3 Degradation

Discolorations and lower physical or mechanical properties of the part indicate degradation. There are two types of degradation which are general and nonuniform degradations. The general degradation happen when entire extrudate is affected as shown by discoloration throughout, although darker streak may also be present. This most likely caused by that the heat is too high for the speed of extrusion. The nonuniform degradation happen when there is shown up as specks of dark material in the extrudate. The material that is trapped or adhering to the surface inside the extruder and therefore degraded by the long residence times at high temperatures.

2.2.4 Bubbles in the Extrudate

The bubbles occurred in the extrudate when excessive moisture or volatile that being absorbed by the resin and then vaporize at the melt exits. This resin will degrade severely when heated in the presence of moisture. Air entrapment can caused bubbles in the extrudate. These bubbles tend to be less regular and less numerous than the bubbles from moisture and volatiles. The air entrapment is usually the result of improper match between resin and screw.

2.3 Internal Mixer process

The internal mixer of the type including a mixing chamber rotatably accommodating mixing rotors there in, a hopper frame erected on the mixing chamber, a charge hopper provided on one lateral side of the hopper frame for charging a mixing material there through, and a floating weight provided in the hopper frame for upward and downward movements there in, the floating weight being held in an upper lifted position when charging a mixing material into the mixing chamber and then lowered into a pressing position in a mixing stage to apply pressure on the charged material in the mixing chamber, where in the floating weight is dimensioned to have an axial length sufficient for closing an inlet opening formed in the side wall of the hopper frame in communication with the charge hopper, when in the lower pressing position, and lift means for lifting the floating weight up and down in the hopper frame is provided separately from a pressing means with a function of pressing the floating weight resiliently against the mixing material, the lift means being constituted by a hydraulic cylinder formed internally of the floating weight.

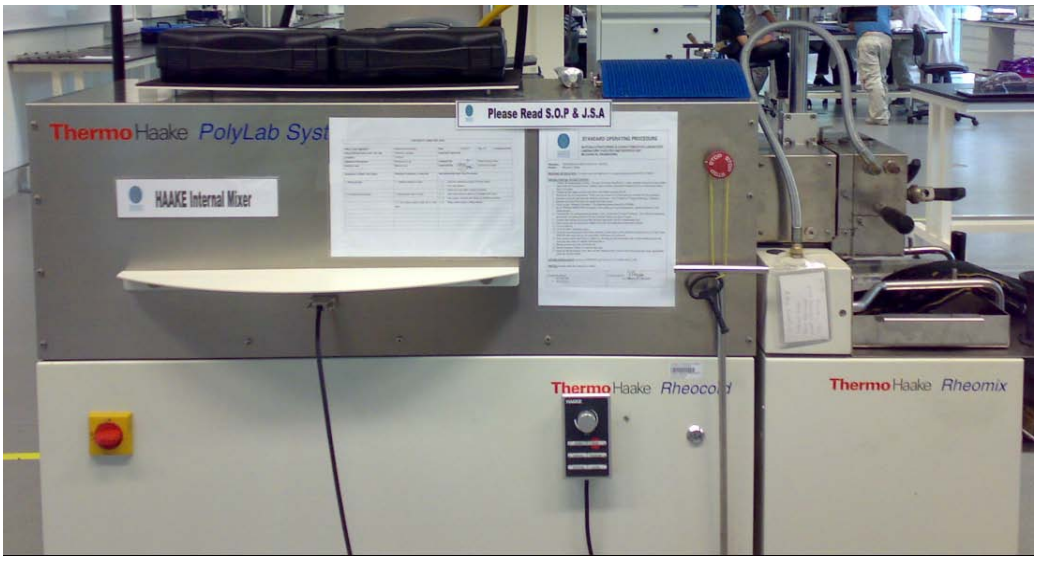

Figure 2.2: Internal Mixer Machine

2.4 Problems in Internal Mixer process

2.4.1 Bubbles in the Internal Mixer

Same problem as extrusion process, air traps also occur during this processes and it may lead the appearance of the bubbles in the composite. This maybe caused of the EFB and the HDPE did not dry first before mixing these materials together into the internal mixing machine. The specimens needed to be dried firsts using the oven at 100 ºC– 105 ºC so to make sure that there is no vapor occurs at the EFB and HDPE.

2.4.2 Contamination

This contamination are a common spots of problems and its happen in the internal mixer process and extrusion process. Small dimples or discoloration on an otherwise uniform surface are sometimes called ‘fish eyes’**.** The contaminants can be distinguished by examining the part under microscope, with solvent or by some chemical analysis technique. The contamination may be difficult to distinguish from complete mixing, as might be the case with incompletely mixed carbon black or other pigments. One sources of contamination which is the materials from a previous run that not fully purged.

2.5 Theory

2.5.1 High-Density Polyethylene (HDPE)

HDPE Figure 2.3 is a polyethylene thermoplastic made from petroleum. HDPE is defined by a density of greater or equal to the range 0.935g/ cm^3 - 0.960 g/cm^3 and it determined by a compression molded sheet that has been cooled at the rate of 27ºF. HDPE has a low degree of branching and thus stronger intermolecular forces and tensile strength. HDPE is used in products and packaging such as milk jugs, detergent bottles, margarine tubs, garbage containers and water pipes. The polymer chain in HDPE can easily pack tightly and form crystalline structure Figure 2.4.

Figure 2.3: Sample of High Density Polyethylene (HDPE**)**

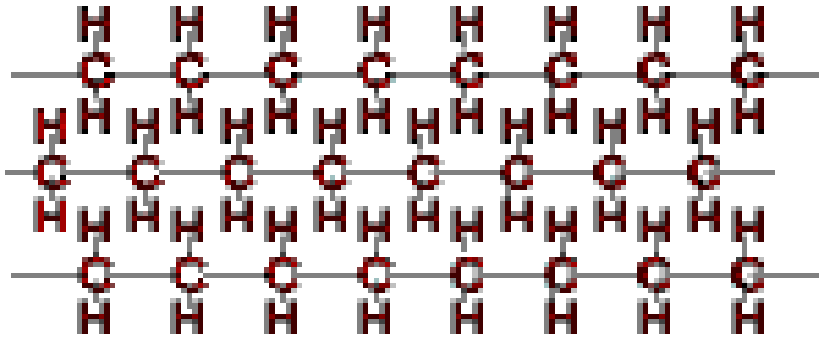

Figure 2.4: Polymer- chain in HDPE

HDPE has little branching, giving it stronger intermolecular forces and tensile strength than lower density polyethylene. It is also harder and more opaque and can withstand to high temperatures 120 °C for short periods, 110 °C continuously. High-density polyethylene, unlike polypropylene, cannot withstand normally at high temperature. The lack of branching is ensured by an appropriate choice of catalyst (*e.g.* Ziegler-Natta catalysts) and reaction conditions.

2.5.2 Tensile Strength

Tensile or Fracture strength is the stress needed to break a sample. It is expressed in Pascal or Psi (pounds per square inch) where MPa is equal to 145 psi. The tensile strength is an important property for polymers that are going to be stretched. Fibers, for instance, must have good tensile strength. Stress-strain diagrams Figure 2.5 show the tensile strength and the breaking point.

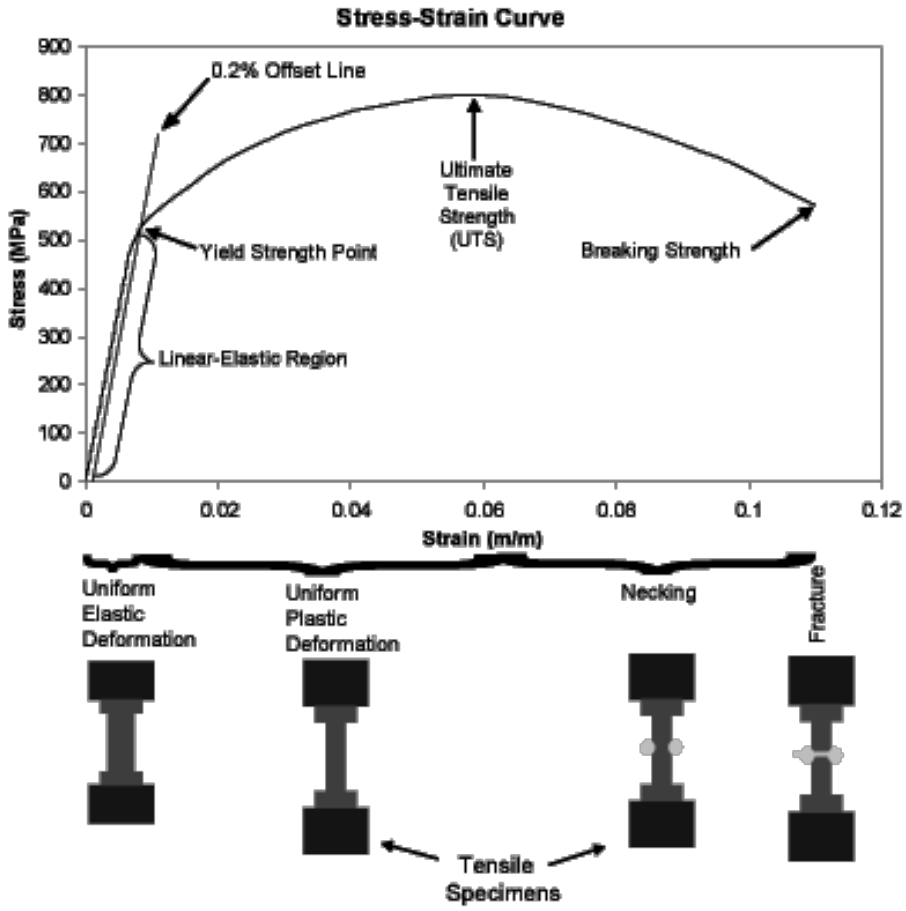

Figure 2.5: Stress-strain Diagram

As stated above, the tensile strength of a material is the maximum amount of tensile stress that it can be subjected to before failure. The definition of failure can vary according to material type and design methodology. This is an important concept in engineering, especially in the fields of material science, mechanical engineering and structural engineering.

There are three typical definitions of strengths which are yield strength, ultimate strength, breaking strength. Yield strength is the stress at which material strain changes from elastic deformation to plastic deformation, causing it to deform permanently meanwhile ultimate strength is the maximum stress a material can withstand. The third one which is breaking strength is the stress coordinates on the stress-strain curve at the point of rupture.

2.5.3 Flexural Strength

Flexural strength of a material is defined as its ability to resist deformation under load. For materials that deform significantly but do not break, the load at yield, typically measured at 5% deformation/strain of the outer surface, is reported as the flexural strength or flexural yield strength. The test beam is under compressive stress at the concave surface and tensile stress at the convex surface. Figure 2.6 shows the test geometry for ASTM D790.

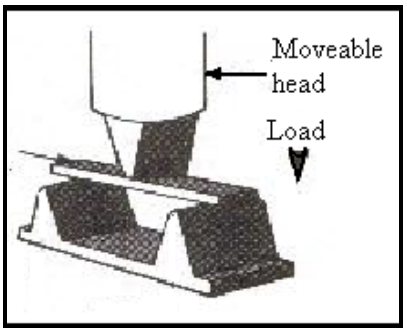

Figure 2.6: Support Span Arrangement for Flexural Testing (ASTM D790)

The analogous test to measure flexural strength in the ISO system is ISO 178. The values reported in the ASTM D790 and ISO 178 tests seldom differ significantly. These tests also give the procedure to measure a material's flexural modulus (the ratio of stress to strain in flexural deformation).

Table 2.1 lists average flexural strengths and flexural modulus values for some filled and unfilled polymers. These values are a measure of stiffness; flexible materials such as film grade polymers used have lower values than fiber reinforced engineering polymers used as metal substitutes such as polyimide or acetyls.

Table 2.1: Typical Flexural Strength and Flexural Modulus of Polymers

Polymer Type	**Flexural Strength (MPa)**	**Flexural Modulus (GPa)**
ABS	75	2.5
ABS + 30% Glass Fiber	120	7
Acetal Copolymer + 30% Glass Fiber	150	7.5
Acrylic	100	3
Nylon 6	85	2.3
Polyamide-Imide	175	5
Polycarbonate	90	2.3
Polyethylene, MDPE	40	0.7
Polyethylene Terephthalate (PET)	80	1
Polyimide	140	3
Polyimide + Glass Fiber	270	12
Polypropylene	40	1.5

2.5.4 Scanning Electron Microscopy (SEM)

The SEM will be used to obtain some information regarding filler dispersion and bonding quality between filler and matrix, and to correlate between fracture surface and energy absorbed. The good specimens which will be choose from every mesh sizes after the test. The fracture ends of the specimens were mounted on an aluminum stubs and sputter coating with a thin layer of gold to avoid electrostatic charging during examination. Philip XL 40 was used to examine the coated surface

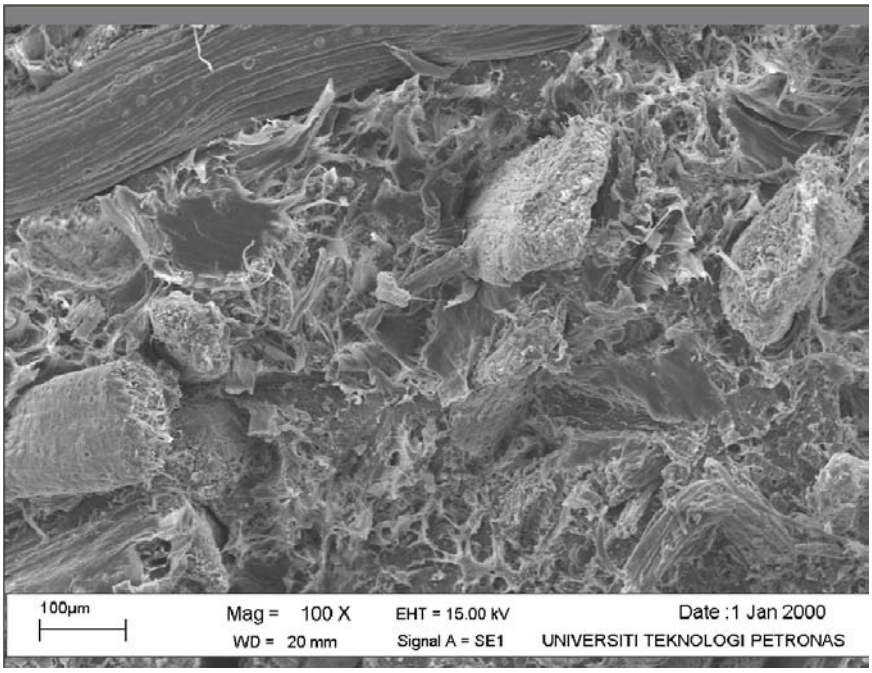

Figure 2.7: 30% filler loading from Extrusion process

CHAPTER 3
METHODOLOGY

3.1 Experimental Procedures

3.1.1 Materials

EFB materials need to be obtained first from source. The size of EFB that will be use for this experiment would be 300µm-450 µm. High density polyethylenes (HDPE) has been selected because it low degree of branching and stronger intermolecular forces.

3.1.2 Composites formula

For this experiment, the total weight of composites for each experiment would be 200 gram. From this 200 gram total weight of sample, the samples that can be prepares through injection molding process for mechanical testing are about 10-15 samples. For example, for 10 % filler of EFB, the total weight of 20 gram of EMB samples and 180 gram sample of HDPE were needed for the experiment. Sample calculation can be refers at the Appendix B**.**

The size of the EFB that will be used for this experiment is 300µm -450µm.The total weight of EFB which in size of 300µm -450µm from sieve process is 300 gram.

The total weights of composites that will be use for this 1st experiment (10% filler of EFB) are 200 gram. This 200 gram can produce 10-15 samples for material properties testing. So the weight of HDPE and EFB that must be obtained for the composite are 180 gram and 20 gram. These two materials need to be dry first in the oven in about 100 ºC-106 ºC in about 1 to 2 hour. This to make sure that there are no water that appear in this specimens. After that the specimens was kept in the bottle that seals from atmosphere.

Samples calculation using 10%, 20%, 30, 40 filler of EFB

Table 3.1: Weight of EFB fiber and HDPE for *300µm - 450µm* filler size

Sample % of filler	Weight of EFB fiber (g)	% of HDPE	Weight of HDPE (g)
300-450 µm			
0%	0	100%	200
10%	20	90%	180
20%	40	80%	160
30%	60	70%	140
40%	80	60%	120

.

Total weight of HDPE and EFB that must obtain during for this two process (extrusion and internal mixer):

HDPE = 800 gram x 2 process
= 1600 gram

EFB = 200 gram x 2 process
= 400 gram

3.1.3 Processes

Two different processes have been selected for this for this experiment, which are the extrusion process and internal mixer process. These processes will be used to produce the composites in the same percentages of fillers (0%, 10%, 20%, 30%, and 40%). The injection molding process will be use to prepare the sample for the mechanical testing.

Figure 3.1 and Figure 3.2 below show the composites of HDPE using 30% filler of EFB for Extrusion process and Internal Mixer process. During the process, if the % filler of EFB increases the composites become more brittle and easy to break into pieces. The color of composites of HDPE using 30% the color of composites become more different and dark compare using 10% and 20% filler of EFB. The final composites produced by extrusion and internal mixer processes were in pillet/die shape and irregular shape respectively.

Figure 3.1: 30% filler loading from Extrusion process

Figure 3.2: 30% filler loading from Internal Mixer process

3.2 Testing Techniques

3.2.1 Tensile Test

Filler dispersion, degree of filler adhesion and degree of degradation of polymer are the main factors which determine the tensile properties of composites during the processing period. Smaller or finer particles with larger specific area may impart greater interaction with the polymer matrix and can result in uniform filler dispersion in the composite. In this research the tensile test will be carried out according to ASTM D638 on a Lyold machine. Dumb-bell specimens 1mm thick was cut from the molded sheets. Tensile test procedure can be referred to in Appendix A.

3.2.2 Flexural Test

Flexural testing determines the strength of material when a force is applied perpendicular to the longitudinal axis sample. Flexural test was carried out using the Llyod machine according to the ASTM D790 standard, three point bending system. The flexural strength can calculate using:

$$\sigma_f = \frac{3PL}{2bd^2}$$

P - Force in Newton

L - Distance between support span (mm)

b - Specimen width (mm)

d - Specimen thickness (mm)

3.2.3 Water Absorption Test

The composite will be immersed in distilled water Figure 3.3 for certain days. The water absorption will be determined by weighting the specimen by irregular interval. The length of composites will always being update ever day and the change of weight of composites will calculate to determine the percentage of water absorbed of product.

$$M_t = \frac{W_w - W_d}{W_d}$$

M_t - Water absortion

W_w - Weight after exposure

W_d - Weight original before wet

W_d - Weight original before wet

Figure 3.3: Samples from Internal Mixer and Extrusion

CHAPTER 4

RESULT AND DISCUSSION

4.1 Tensile Strength Result

The results of the tensile strength from the experiment are shown in table below. By taken best three out of five samples test, the result of tensile test using 10%, 20%, 30%, 40% filler as shown in the Table 4.1 and Table 4.2. The average result and diagram are in shown in Table 4.3 and Figure 4.1.

Table 4.1: Result Tensile Strength from Extrusion Process

% Filler	Sample 1 (Mpa)	Sample 2 (Mpa)	Sample 3 (Mpa)	Average (Mpa)
10	23.25	23.15	22.85	23.08
20	22.21	22.38	23.01	22.53
30	21.85	22.12	21.75	21.91
40	18.07	17.21	18.85	18.71

Table 4.2: Result Tensile Strength from Internal Mixer Process

% Filler	Sample 1 (Mpa)	Sample 2 (Mpa)	Sample 3 (Mpa)	Average (Mpa)
10	33.31	35.72	31.73	33.87
20	30.75	30.15	31.75	30.88
30	30.25	29.17	27.3	28.91
40	25.63	26.35	25.17	25.72

The average of tensile strength from Extrusion process and Internal Mixer process will be taken as the final result for comparison in Table 4.3.

Table 4.3: Average Tensile Strength from Extrusion and Internal Mixer Process

% Filler	Average EX (Mpa)	Average IM (Mpa)
10	23.08	33.87
20	22.53	30.88
30	21.91	28.91
40	18.71	25.72

The chart in Figure 4.1 shown that the Internal Mixer process has produces a better tensile strength compare with Extrusion process. The tensile strength decreases while the percentages filler increases. This indicated that the mixing mode plays an important role in determine the tensile strength of composites. The extent of formation for interfacial region between matrix and filler are better in Internal mixer composite. The Internal Mixer composite performed a better transfer of stress compared with Extrusion composite. To get a better result, the filler need to be applies the treatment process first before the composite processes. But yet the result may still the same that the Internal Mixer process will produce the better tensile strength compare with Extrusion process.

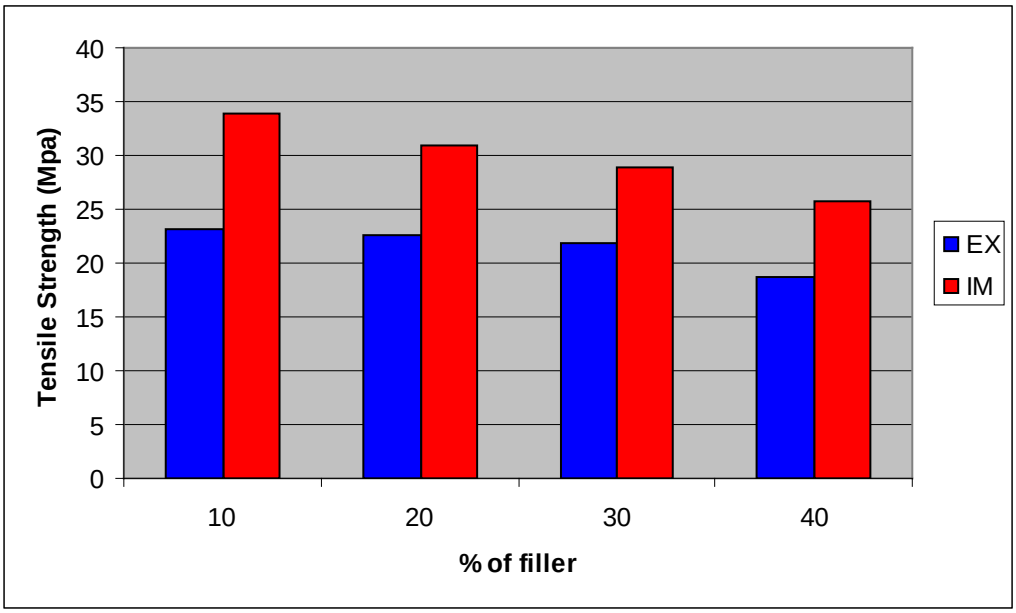

Figure 4.1: Tensile Strength (Mpa) vs % Filler loading

4.2 Tensile Modulus Result

The results of tensile modulus of composites are shown in table 4.4, Table 4.5 and Table 4.6. The slope from tensile test result from the graph during the testing represents the tensile modulus of the composites. The slope results for every three samples for different percentage filler loading using the Extrusion process and the Internal Mixer process are shown in Table 4.4 and Table 4.5. The average results of composites can be revealed in Table 4.6.

Base from diagram Figure 4.2, the tensile modulus of each composites are increasing when the percentage filler in that composites are increasing. The results prove that the Internal Mixer process yielded a higher strength than Extrusion process. This because a better stress transfer in Internal Mixer composites compare with Extrusion composites. This factor could bring the effect for higher tensile modulus displayed by Internal Mixer composites.

Table 4.4: Result Young Modulus from Extrusion Process

% Filler	Sample 1 (Mpa)	Sample 2 (Mpa)	Sample 3 (Mpa)	Avg (Mpa)
10	1987.651	2153.253	2049.591	2063.498
20	2036.968	2154.365	2092.644	2098.659
30	2298.794	2099.856	2248.702	2215.784
40	2356.958	2315.245	2382.573	2351.592

Table 4.5: Result Young Modulus from Internal Mixer Process

% Filler	Sample 1 (Mpa)	Sample 2 (Mpa)	Sample 3 (Mpa)	Avg (Mpa)
10	2257.632	2315.593	2518.505	2363.951
20	2396.911	2521.264	2398.541	2425.572
30	2604.187	2418.251	2356.521	2459.653
40	2698.530	2721.367	2738.666	2716.521

Table 4.6: Average Tensile Modulus from Extrusion and Internal Mixer Process

% filler	Avg Young Modulus EX (Mpa)	Avg Young Modulus IM (Mpa)
10	2063.498	2363.951
20	2098.659	2425.572
30	2215.784	2459.653
40	2351.592	2716.521

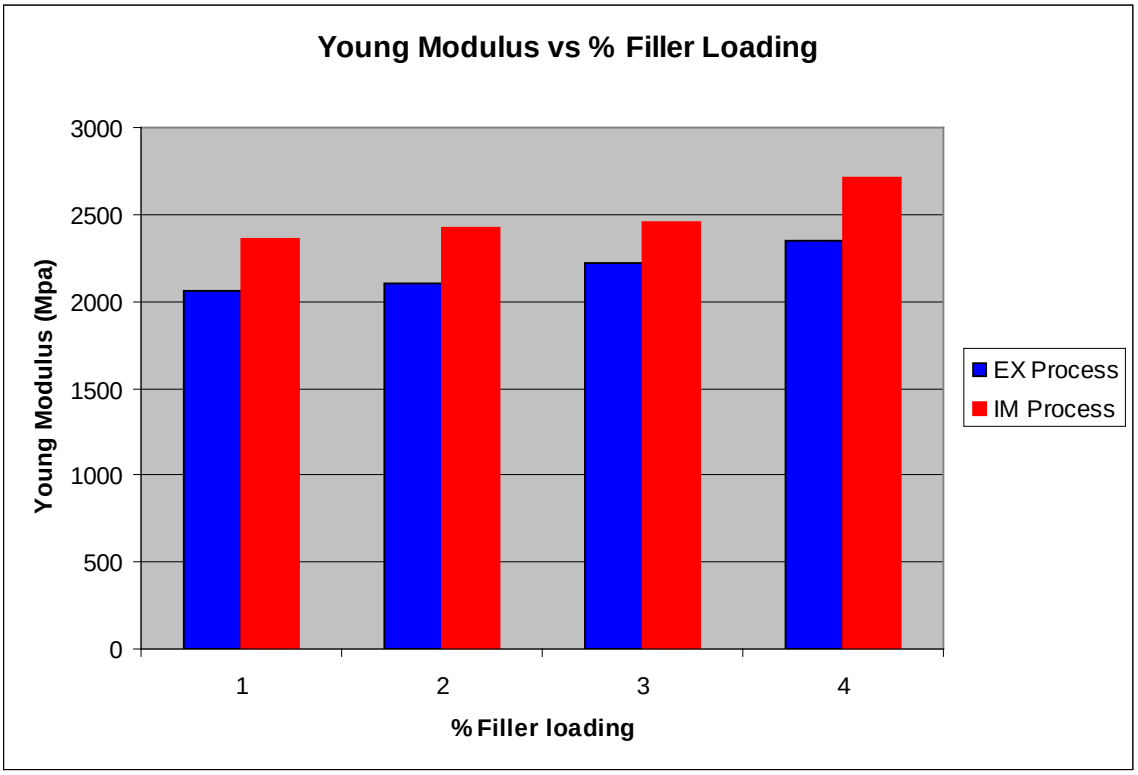

Figure 4.2: Young Modulus Extrusion (EX) and Internal Mixer process (IM).

4.3 Flexural Result

Result in Table 4.7 shown that the composites from Internal Mixer process have produce better results in flexural strength compare to Extrusion process.The strength of frexural is increasing while the percentage of filler is increases starting from 10% filler loading until it reach to 30% filler loading. After the percentages of filler loading reached at 40%, the value of flexural strength of composites from both processes decreases compare from the result at 30% filler composites in Figure 4.2. When the percentage of filler is too high, the samples will become easier to bend thus it will reduce maximum force compare with 30% filler loading maximum force.

From the SEM results also shown the contact between matrix and the filler are better in Internal Mixer process compare with Extrusion process. This could the better strength bounding between the matrix and filler in Internal Mixer process compare with Extrusion process.

Table 4.7: Modulus of Rupture from Extrusion and Internal Mixer Process

% Filler	MOR (Mpa) IM	MOR (Mpa) EX
10	36.64	39.35
20	36.99	41.87
30	37.54	45.53
40	30.1	45.17

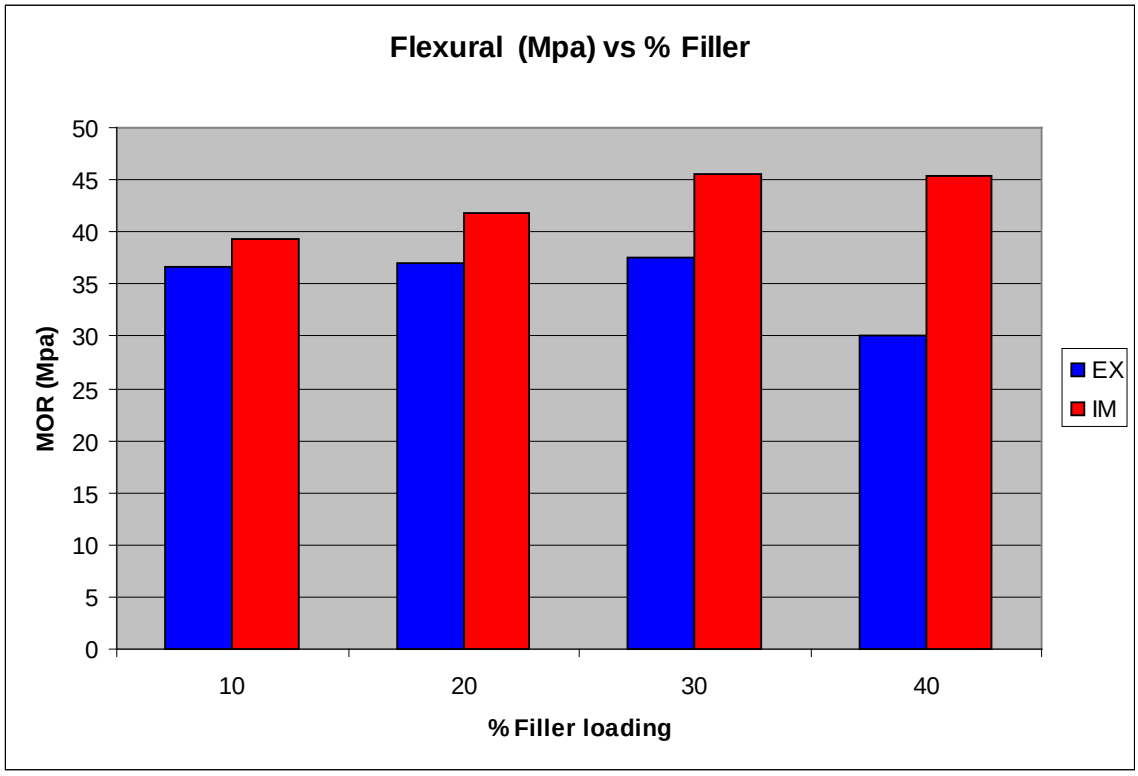

Figure 4.3: Modulus of Rupture vs % Filler loading

4.4 Water Absorption Result

From table 4.8 and Figure 4.4, the amount of water absorbed by composite (using 20% filler loading) that produced from both Extrusion process and Internal Mixer process are compared. It shown that composite from Extrusion process absorbed more water compare with composites from Internal Mixer Process. It also recorded that the amount of water increased because the water that being absorbed are propositional with the amount of percentage of filler loading.

The Internal Mixer process produced the better contact between matrix and filler in that composites compare with the Extrusion process. The space contact between the matrix and filler is bigger in Extrusion processes. Thus this composite water can absorbed more amount of water compared with in Internal Mixer composite.

Table 4.8: Water absorption from Extrusion and Internal mixer composite (20% filler)

Day	Internal Mixer p Weight (gram)	% Water Absorbed	Extrusion Weight (gram)	% Water Absorbed
0	13.333	0	13.333	0
2	13.382	0.42	13.352	0.18
6	13.548	1.61	13.583	1.91
8	13.554	1.66	13.586	1.92
14	13.668	2.51	13.669	2.52
19	13.776	3.32	13.828	3.71
22	13.939	4.55	13.977	4.83
28	14.134	6.01	14.228	6.71
30	14.201	6.51	14.281	7.11
33	14.208	6.56	14.297	7.23

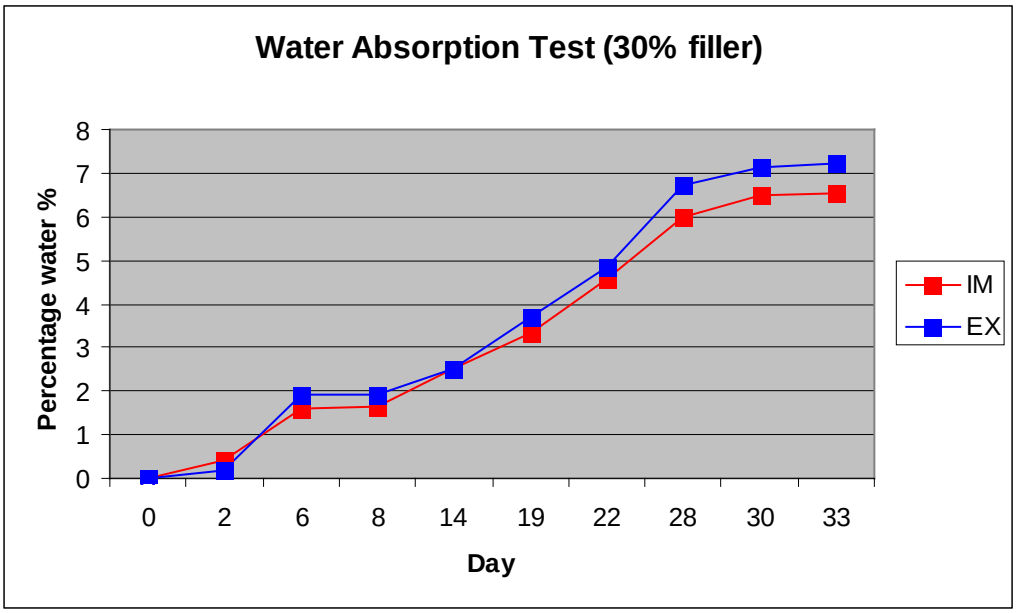

Figure 4.4: Graph water absorption Extrusion (EX) and Internal Mixer Process (IM)

4.5 Scanning Electron Microscope (SEM)

SEM micrograph in Figure 4.5 and Figure 4.6 shows that the interaction between the matrix and the filler in the composites. The composites from the Internal Mixer Figure 4.6, shows a better contact between the matrix and the filler which means that the less space between the matrix and the filler compare with the composites from Extrusion Process Figure 4.5.

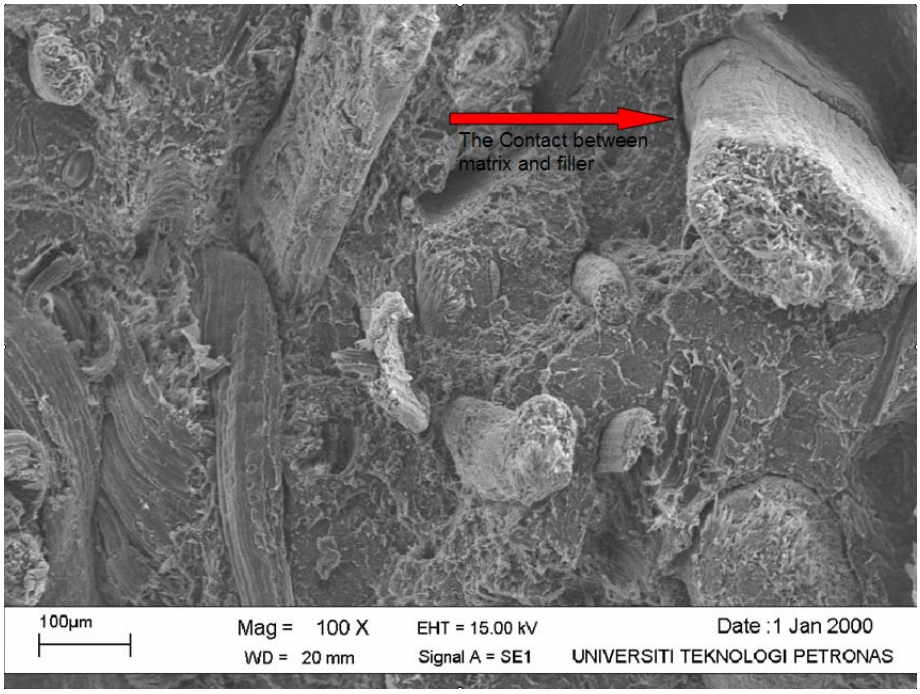

Figure 4.5: SEM picture from Extrusion process (20% filler loading)

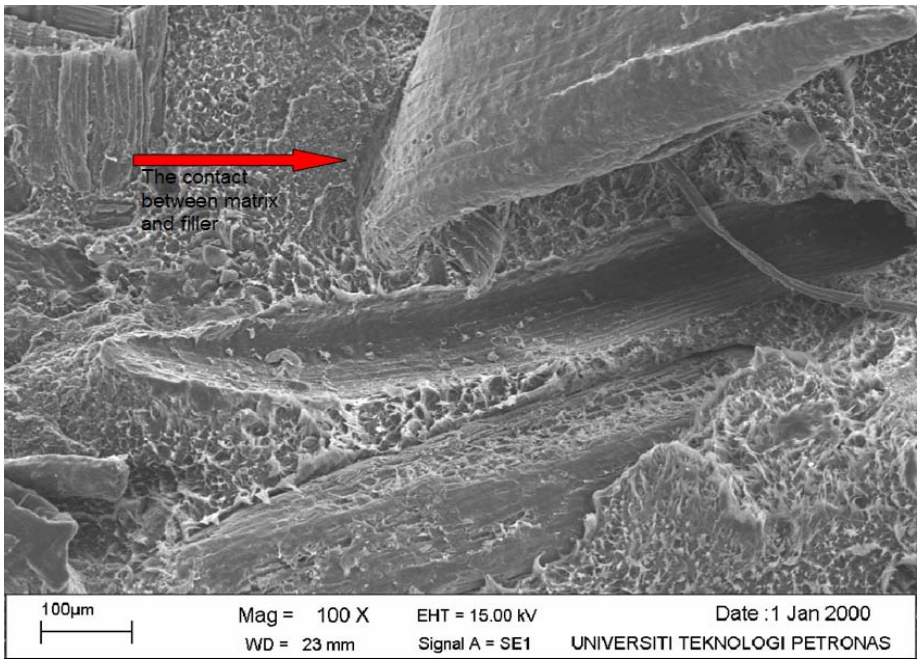

Figure 4.6: SEM picture from Internal Mixer Process (20% filler loading)

CHAPTER 5

CONCLUSION

It is important to study the effect of processing techniques on the mechanical properties of oil palm empty fruit bunch composites in order to produce a better composite for the future. Due to their mechanical properties result, a comparison of can be made between internal mixer composites and extrusion composites result. From that, which process can be proved have produce a better composites due to their yield strength, tensile strength, tensile modulus strength, elongation at break, and impact strength. From the study, the Internal Mixer process has shown a better result in their mechanical properties compare to Extrusion process. These comparisons can be referring on tensile test, Young Modulus test, Water Absorption test and SEM results. This may be during the processes producing composites using Extrusion process, a lot of problems occurs in that machine such as mechanical problems, polymer degradation, bubbles in the extrude, melt fracture, and poor mixing. These problems may effects the mechanical properties of the composites. As the conclusion, the mechanical properties of composites that being produces using the Internal Mixer process have better in mechanical properties result compare with the Extrusion process.

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APPENDIX

APPENDIX A: Tensile Test Procedure

Preparation of specimen

Test specimens are cut from designated areas of the welded assembly, the length and width, method of cutting (thermal or machine), and requirements for the removal or leaving of the weld reinforcement would be stated in the appropriate specification. In this particular experiment, the measurement of the cross sectional area of the samples will be 10mm x 10 mm and the method of cutting will be done by saw machine to reduce heat affects that can severely alter the specimens' microstructure. The edges should be made smooth – normally filed – and any corners in the test area radius slightly to reduce stress raisers.

Test Procedures

Two sets of vice jaws are used to clamp the test specimens at the top and at the bottom; hydraulic power is then applied to force the specimen apart. A dial usually calibrated in pounds, tonnes or newtons, records the load applied. As the load increases, the dial registers the amount until fracture occurs.

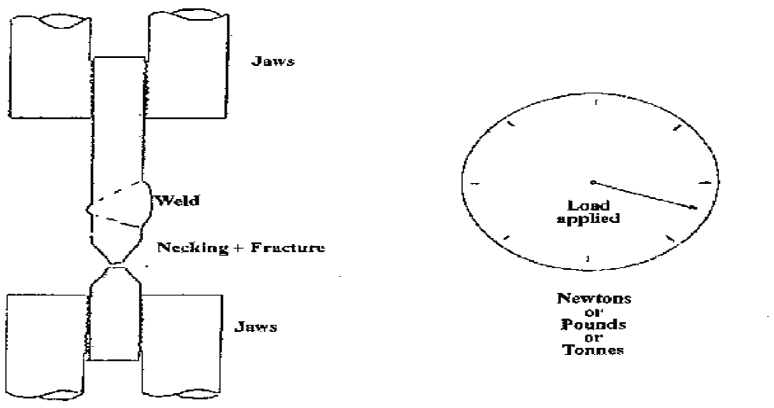


Figure A.1: Tensile Test Equipmen

In all cases, necking of the steel specimen prior to fracture should occur; the reduction in cross sectional area indicates a ductile fracture. Steel specimens which snap and do not exhibit any necking are usually caused for rejection.

Calculation for Tensile Strength (Maximum Load)

The ultimate tensile strength, σ, can be calculated by dividing the maximum load applied by the original cross sectional area of the specimens. The maximum load applied is obtained from the dial on the machine; the original cross sectional area is measured prior to testing with a micrometer

$$\sigma = F/A$$

APPENDIX B: Sample calculation

Using 10% filler of empty fruit bunch

(10/100) X 400 = 40 gram of empty fruit bunch

*so another 360 gram it would be HDPE

For this 400 gram total weights. We can form 10 samples through injection molding process for mechanical testing. So weight for 1 sample it would be

400/25 = 16 gram

- Assume totals of 400 gram = 250 pieces of samples

APPENDIX C: Internal Mixer Process

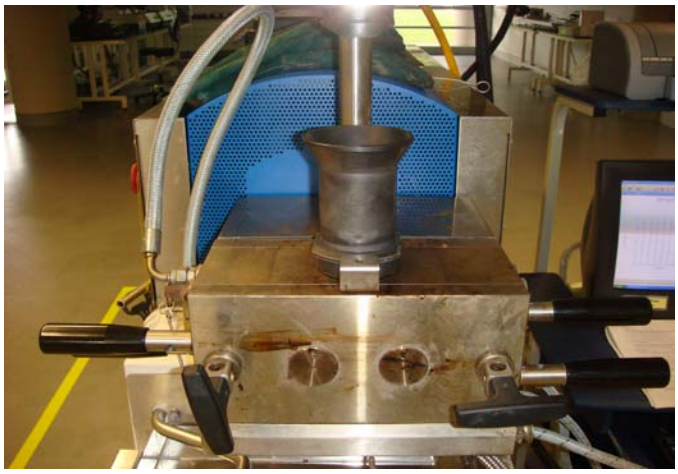


Figure C1: Internal Mixer Machine

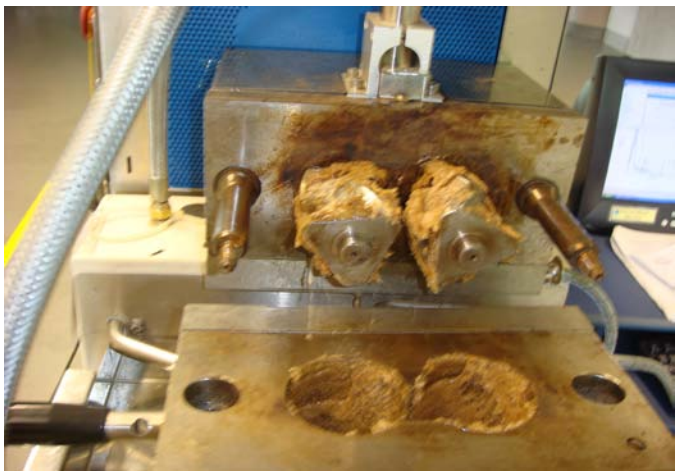
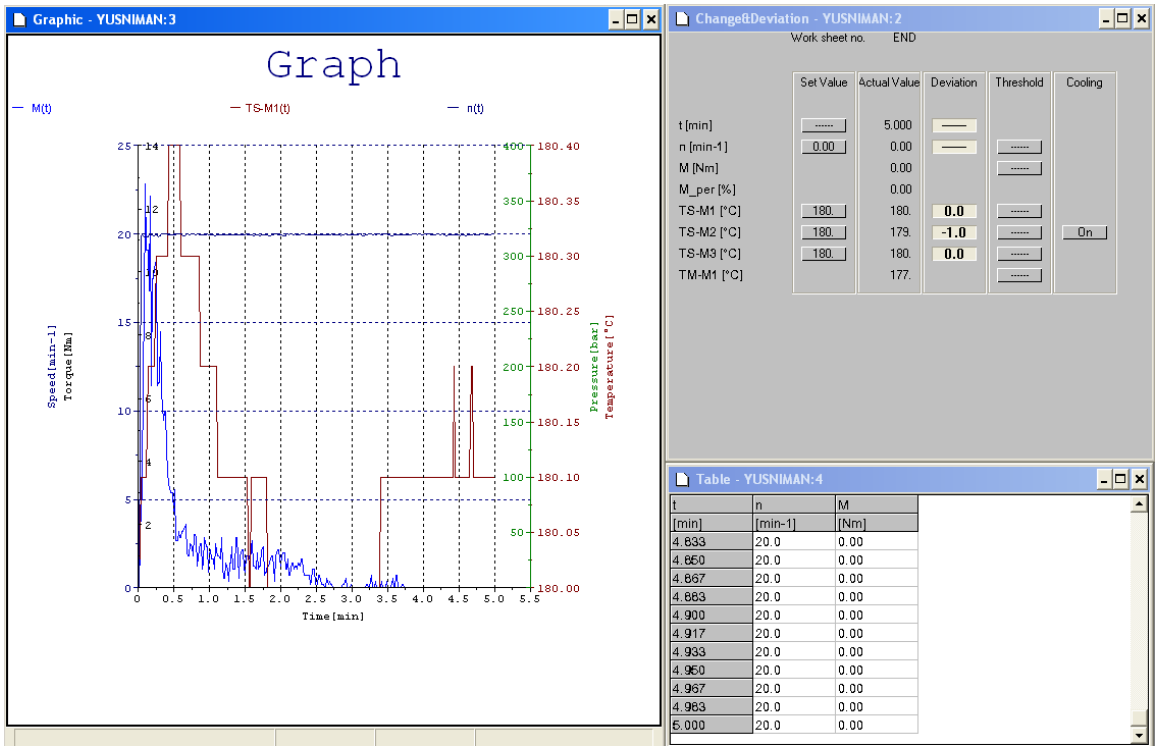


Figure C2: Composites after Internal Mixer process



t	n	M
[min]	[min-1]	[Nm]
4.833	20.0	0.00
4.850	20.0	0.00
4.867	20.0	0.00
4.883	20.0	0.00
4.900	20.0	0.00
4.917	20.0	0.00
4.933	20.0	0.00
4.950	20.0	0.00
4.967	20.0	0.00
4.983	20.0	0.00
5.000	20.0	0.00

Figure C3: Result Setting from Internal Mixer process using 180^0C

APPENDIX D: Tensile Test (Dog Bone)

The test was based on standard method according ASTM D638 – Standard Test Method for tensile properties of Plastics. Details of specimen dimensions are shown in the Figure D1.

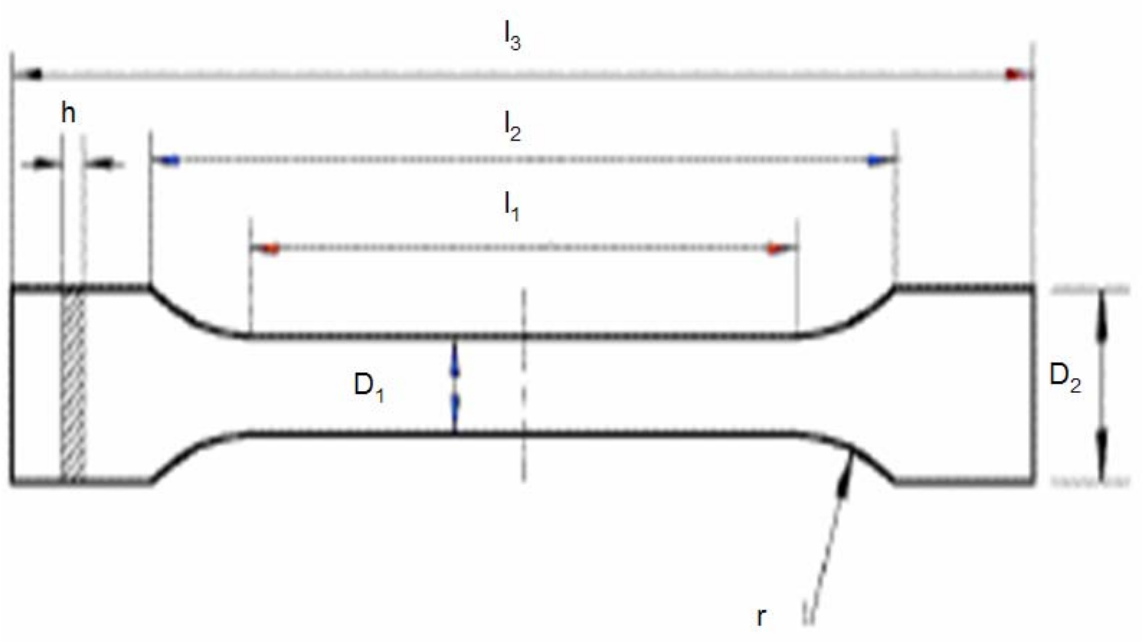


Figure D1: Tensile test specimen and Dimension (Dog Bone)

D_1	- Width of narrow section	10mm
D_2	- Width overall, min	19mm
l_1	- length of narrow section	57mm
l_2	- Distance between grips	115mm
l_3	- Length overall, min	165mm
r	- Radius of fillet	76mm
h	- Thickness	4mm

The specimens were conditioned at 27 ± 2 ºC for 30-40 hours prior to testing. The width and thickness of each specimen were measured using a digital screw micrometer gauge. The tests were performed on an Instron Universal Testing Machine. At least five specimens for every each differences % of filler were tested from extrusion and internal mixer composites.

The speeds of the machine need to be set up first based on what type of polymer that being used (HDPE). The best speed for the machine is 5 in/min based on the Tensile Yield Strength Table D1 and Tensile Yield Elongation Table D2 using HDPE polymer that being done by other research.

Table D1 Tensile Yield Strength, for Ten Laboratories, Eight Materials

Materials	Test Speed in/min	Value Expressed in psi Units				
		average	S_r	S_R	r	R
LDPE	20	1544	52.4	64	146.6	179.3
LDPE	20	1894	53.1	61.2	148.7	171.3
LLDPE	20	1879	74.2	99.9	207.8	279.7
LLDPE	20	1791	49.2	75.8	137.9	212.3
LLDPE	20	2900	55.5	87.9	155.4	246.1
LLDPE	20	1730	63.9	96	178.9	268.7
HDPE	5	4101	196.1	371.9	549.1	1041.3
HDPE	5	3523	175.5	478	492.4	1338.5

Table D2 Tensile Yield Elongation, for Eight Laboratories, Eight Materials

Materials	Test Speed in/min	Value Expressed in percents Units				
		average	S_r	S_R	r	R
LDPE	20	17	1.26	3.16	3.52	8.84
LDPE	20	14.6	1.02	2.38	2.86	6.67
LLDPE	20	15.7	1.37	2.85	3.85	7.97
LLDPE	20	16.6	1.59	3.3	4.46	9.24
LLDPE	20	11.7	1.27	2.88	3.56	8.08
LLDPE	20	15.2	1.27	2.59	3.55	7.25
HDPE	5	9.27	1.4	2.84	3.91	7.94
HDPE	5	9.63	1.23	2.75	3.45	7.71