Research Article

Handgrip Automotive Prototype of Polypropylene Reinforced Benzoyl Treated Kenaf and Sugar Palm Fibers: A Facile Flexural Strength and Hardness Studies

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Abstract
Combining two or more different types of fibers within a polymer matrix is defined as hybrid composites. The requirements for an impressive hybrid composites include compatible weight ratio, good compressive strength, low-cost production and ease of fabrication. Moreover, hybrid composites provide a combination of remarkable mechanical properties including tensile modulus, compression, impact strength, flexural and hardness, which are comparable with the metal-based product materials. Recently, hybrid composites have been established due to their remarkable performance and efficiency. This study presents a facile analysis of polypropylene (PP) reinforced benzoyl treated kenaf and sugar palm fibers for handgrip prototype application. The materials were further analyzed for their materials molding modeling, and facile mechanical behavior including flexural strength, flexural modulus, Rockwell hardness (HRF), and also weight reduction percentage test. Hybrid composite T-SP7K3 shows higher flexural strength and flexural modulus compared to the ABS (Perodua Axia) at 339.5 MPa and 17.19 MPa, respectively. In addition, the HRF testing shows a higher value of hybrid composite (at 92.96 N/mm^2) compared with the ABS handgrip with. Furthermore, the weight reduction percentage also recorded hybrid composite T-SP7K3 with the highest value at 22.7%.

Keywords: Kenaf, Sugar palm, Fiber, Handgrip, Prototype, Polypropylene, Flexural, Hardness, Weight reduction

1 Introduction

On the microscopic scale, materials, which having dual or more phases surface, heterogeneously merged with each other known as hybrid composite. A flowchart depicted the classification of composite is shown in Figure 1. Natural fibers have emerged as a potential alternative to synthetic fibers due to their greener benefits. Moreover, natural fibers are often picked by researchers because of their abundance, low density and cost, ecosystem friendly, non-hazardous, flexible, renewable, biodegradable, relatively non-abrasive, impeccable specific modulus strength, and simplest processing [1]–[8]. Throughout human civilization the innovations in the field of materials have been realized mainly due to the technological changes happened in terms of lifestyles, depleting man-made resources, and ever increasing global ecological problems [2]. Some disadvantages, such as non-uniform dimensions and heterogeneous properties and incompatibility with a hydrophobic polymer matrix, reduce their potential to be used as composite reinforcement [3], [4]. Despite many promising pros, natural fibers tend to be constrained due to their hydrophilicity behavior, extremes moistures absorption, and low impact strength properties. Fortunately, all these limitations could lessen by using hybridization techniques.

Hybridization is the system where fibers are introduced into the polymer matrix. Two fibers must have the same length but are still compatible with different diameters. However, for effective adhesion between fibers and polymer matrix, different diameters of fibers are believed to widen the effective area so that uniform transfer of stress could take place in the system [9]. These reasons induce efficient fiber stress transfer within its polymeric matrix thus increasing mechanical properties [10]. In composite fabrication, the structure of fiber emerged as a vital factor in the mechanical properties. Formerly, natural plant fibers were known to exist as cellulose, which consists of many helically cellulose microfibrils. The amorphous lignin matrix also was reported to be bound together within microfibril. In addition, lignin provides water retention in the fibers nerve [11]. These schemes help in protection against microbial invasion and provide sturdy stems for resisting the winds and gravity forces. Furthermore, hemicelluloses contain naturally in natural fibers, especially in plants act as compatible barriers between lignin and celluloses. The details in fibers structures define why natural fibers contribute to enhancement of the mechanical properties of hybrid composites.

The challenges faced by hybrid thermoset polymer composites are due to the main standpoint, which is natural fiber reinforcement quality. This article was specifically discussed sugar palm and kenaf fibers composite. In the last two decades, the plantations of kenaf plants were introduced in Malaysia. Unfortunately, it was produced very less kenaf composite products amid shallow research and technology locally. However, in recent years, kenaf fiber products have been highly demanded by domestic utilization [12]. The natural

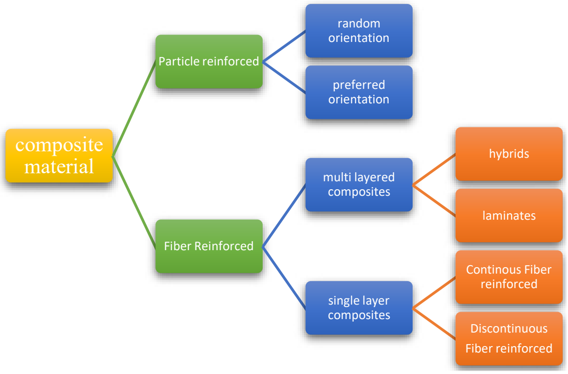


Figure 1: Classification of general biocomposites.

fibers enhance the thermoset composites to be the better quality materials compared to the metal-based products, especially to the compressive and impact resistance. From these studies, it could be concluded that plant fibers act as potential replacements for synthetic fibers for land transport applications, as these fibers demand less consumption of energy during production and emit a lower amount of greenhouse gas, such as low CO_2 emission involved in their productions [5], [6].

In recent years, fibers, such as kenaf and sugar palm fiber have been employed in hybrid composites for automotive applications, yet they are surprisingly far from commercialization [13]. Commonly, thermosetting matrixes were fabricated by two or more components, such as polymer resin, monomer and co-monomer, filler, and compatibilizer. The incorporation of a crosslinking agent in thermoset systems manages to provide outstanding mechanical properties performance. On the other hand, thermoset possessed the limitation of being unable to be restructured after the curing process might bring down the expectation [14]. Resins thermosets, such as polycarbonate, epoxy resins, polyester, polyamines, and vinyl ester are very flexible and provide advantageous assets, such as thermal stability, outstanding modulus, and ambient processibility [15]. End product biodegradability could be enhanced by bio-based fillers reinforcement such as natural fibers [16].

In advanced applications, global collaborations in the fields of research and advanced technology are seeking for bio-based thermoset resins to replace synthetic epoxies. Researchers believe that thermoset composites recently meet a hike in usage in the applications, such as automotive domestics, aircraft spare components, and sporting goods, In addition, they also diminish overall cost [16]. The fiber reinforcement gives thermoset composites excellent structural properties, while also making them inherently complex to manufacture. The compression molding process is a composite manufacturing process normally used to produce composite components in high production volumes [17]. The compression molding process usually allows long fiber reinforcements in complex composite structures. The compression molding process enables flexibility in design, as well as features inserts, ribs, bosses, and attachments [18]. Hot compression molding is utilized for thermoplastic polymer composite production, where heat is needed to melt the polymer [19]. However, for some thermoset composites, heat is applied to accelerate the curing process and enhance the fabrication including its mechanical properties [20]. However, one of the major difficulties in processing fast-cure thermoset resins is their extremely strong exothermic heat during the process of curing. This phenomenon will overshoot the temperature and large temperature gradients may cause shrinkage and residual stresses towards the importance of the resin injection strategy. For polymer composite manufacturing, the longer pressing period could reduce the porosity of the polymer composites. In addition, stickiness to the mold halves (mold sticking) is another problem that emerges. Less cure time, high amounts of the charge weight, insufficient mold temperature, and inappropriate mold surface may be the limitation and cause the composite to stick within the mold.

Polypropylene (PP) is unique among other thermoplastic polymers because of its physical and mechanical properties, which had been potentially for applications apprentice in polymers manufacturing. PP in general, presents a high melting temperature (160–166 °C for isotactic PP), low density (0.898–0.908 g/cm^3 for isotactic PP), high chemical inertness, the capability to be produced in different structures and properties, via various processes, and it can be modified by adding reinforcing agents, fillers, or other polymers and it can be grafted with various functional groups [21]–[23]. PP has a higher diversity in its applications, among all thermoplastics. It has versatility in nature and easily blends with other materials along with natural fibers. Recycling of PP had achieved highly potential along with easy and remarkable mechanical, physical properties and chemical properties in the end-user products. Due to its extra features, the global market consumption is 2/3 as compared to other materials. In addition, its low-density features attract the automotive manufacturer for using PP widely. Its easiness in processing, compounding, and reinforcement shows a market demand of 19%, which is higher than other materials [24]–[27]. The physical properties and their modifications of kenaf and sugar palm fiber reinforced (PP) polypropylene were investigated in our previous studies [28], [29].

Both treated and untreated composites that have 10 wt% of fiber loading with different fiber weight proportion ratios (7:3, 5:5, 3:7) kenaf: sugar palm were previously analyzed and confirmed. Physical and mechanical properties, such as tensile, flexural, and impact strength were also determined in the study [28]. Morphological properties were obtained using scanning electron microscopy (SEM). It was found that sugar palm/kenaf-reinforced polypropylene hybrid composites were enhanced with benzoylation treatment and recorded a tensile strength of 19.41 MPa [28]. In addition, hybrid composite with treated sugar palm and kenaf fiber T-SP3K7 recorded the highest impact and flexural strength of 19.4 MPa and 18.4 MPa, respectively. Diffraction scanning calorimetry (DSC) and thermogravimetry analysis (TGA) were carried out for the thermal stability test [29]. In addition, T-SP3K7 was the specimen that exhibited the lowest average burning rate and the best flammability properties. The damping factor (Tan δ), loss modulus (E”), and storage modulus (E’), were examined by using dynamic mechanical analysis (DMA). The hybrid composite with the best ratio (PP/SPF/KF), showed a good loss modulus and damping factor (E”). In addition, T-SP5K5 achieving the highest dimensional coefficient of thermomechanical analysis (TMA) was successfully recorded [29]. Grab handles are mainly developed so people can climb in and out of cars with ease. If users are getting into a large vehicle, for example, users might use the handle to hoist themselves up into the car, and then again to lower back down onto the step or sidewalk without having to jump. In order to save weight, reduce cost and improve safety, car door handles are usually made of plastics, such as PBT, fiber-reinforced PA, reinforced PP with filler, or ABS. These plastic parts then need to be painted to achieve an optimal look and feel. In general, softer rubbery, higher hysteresis rubber and stiffer cord configurations were employed to increase accommodation, comfort, and improve handling. Nevertheless, the problem is that those rubbery part of the handgrip handle cannot hold the retardancy towards higher heat. Thus, a closed molding technique for fabrication of handgrip prototype composite fabricate from polypropylene reinforced benzoyl treated kenaf and sugar palm fibers was developed. The best ratio of SPF/KF/PP hybrid composite T-SP7K3 was chosen as the testing specimen due to its mechanical potential [29]. In addition, this research highlights the comparison of mechanical instrumentation between the hybrid composite (SPF/KF/PP) specimen with neat PP and established Perodua Axia Acrylonitrile Butadiene Styrene (ABS) handgrip sample. Interestingly, the compounding and prototype mold was exposed in detail. It was also revealed evaluation results of products, in terms of mechanical reinforcement, such as flexural strength, hardness, and weight reduction of the prototype sample.

2 Materials and Methods

2.1 *Materials*

All solvents, monomer and chemicals used are 99% purity. Polypropylene pellet and benzoyl chloride were supplied by MechaSolve Engineering Sdn Bhd. Polypropylene pellet crystals with 0.95 g/cm^3 density were utilized. Kenaf plant, Arenga pinnata, and the sugar palm tree, Hibiscus cannabinus, were purchased and utilized. The sugar palm fiber (SPF) was obtained from Jempol, Negeri Sembilan, whereby kenaf fiber (KF) was purchased from Lembaga Kenaf and Tembakau Negara (LKTN) in Kelantan, Malaysia. Further the process, raw kenaf and palm fibers were first soaked and rinsed with deionized water. The fibers were then chopped, cleaned, and dried in the oven at 70 °C. Resin used were milky grayish, oval shape, and 3–5 mm diameter, respectively. The Perodua Axia, acrylonitrile butadiene styrene (ABS) index GRIP-AXIA14 was purchased from the local supplier (marvelecommerce) with 98% purity.

2.2 *Chemical treatment of kenaf and sugar palm fiber (KF/SPF)*

The treatment process was thoroughly discussed in our previous study [28], [29]. Firstly, the clean dried kenaf and sugar palm fibers were soaked and rinsed. An amount of the fibers was immersed in 18 percent concentration of sodium hydroxide solution for alkali treatment for 30 min. Next, partially treated kenaf and sugar palm fibers were purified with deionized water. The treated fibers were then dried in the oven with a maximum temperature of 70 °C [30], [31] and soaked in 10 percent concentration NaOH solution [32] stirred well with 50 mL benzoyl chloride for 15 min. The treated fibers were then immersed in ethanol for 1 h and rinsed with filtered water for excess chemical and dirt removal (benzoyl chloride). Treated KF and SPF were then dried at 60 °C for 24 h. Fibers were performed alkali treatment beforehand to remove impurities and benzoylation was performed to enhance the melting point of the samples [28]–[33].

2.3 *Thermoset compounding*

The compounding process of sugar palm (SPF), kenaf fiber (KF) and polypropylene (PP) matrix were carried out using a melt mixer (Brabender Plastograph, Model 815651, Brabender GmbH & Co. KG, Duisburg, Germany). They were mixed in ratios 7:3:90, 10% fiber loading with 90% of PP. For each compound, a total weight of 20 g was prepared for all compositions of hybrid composites as presented in Table 1 [28], [29]. As mentioned earlier, T-SP7K3 was chosen as the specimen because it was analyzed as the best proportion ratio for astounding physical, morphology and mechanical properties of (SPF/KF/PP) hybrid composite as discussed [28], [29].

Table 1: The compositions of sugar palm fiber, kenaf fiber and polypropylene hybrid composite (SPF/KF/PP) [29]

Hybrid Composites	SPF (g)	KF (g)	PP (g)	Total Weight (g)
U-SP3K7	0.6	1.4	18	20
U-SP5K5	1	1	18	20
U-SP7K3	1.4	0.6	18	20
T-SP3K7	0.6	1.4	18	20
T-SP5K5	1	1	18	20
T-SP7K3	1.4	0.6	18	20

The blending temperature was set at 180 °C while the speed of the rotating screw was set at 50 rpm. Polypropylene was discharged and melted for 3 min

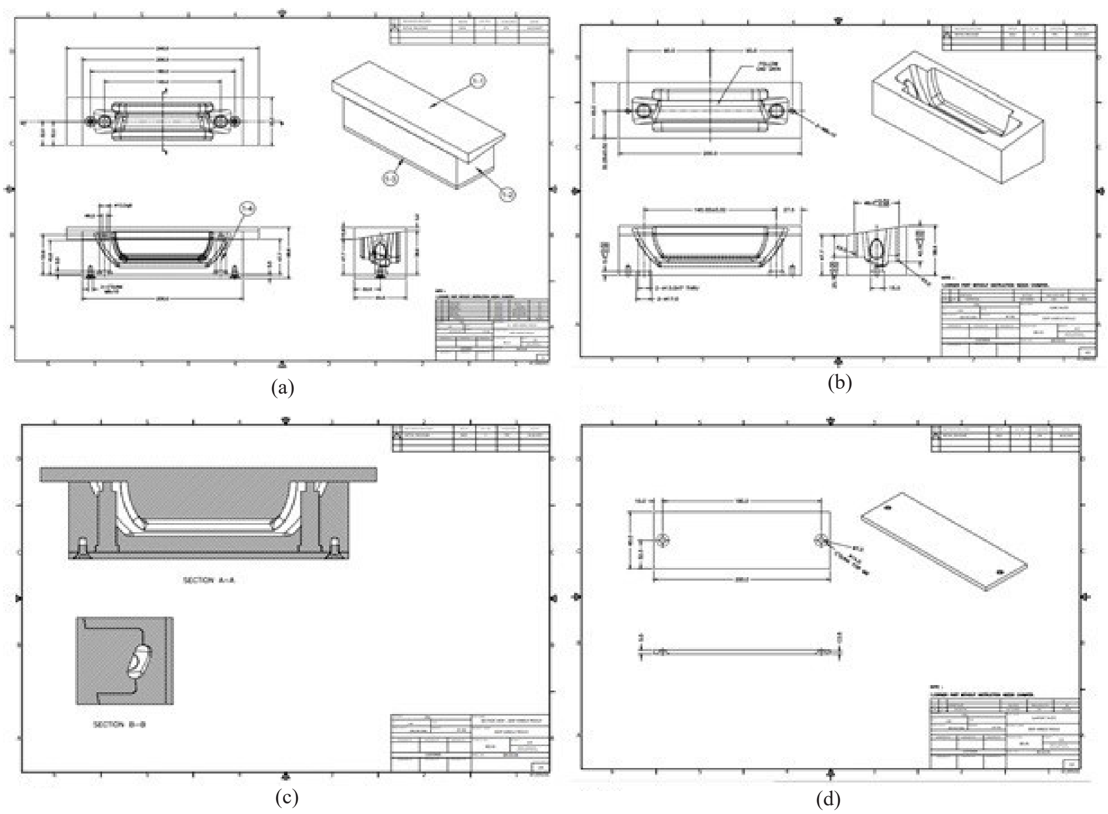


Figure 2: The dimensional drawing of (a) core plate hand grip (b) cavity plate mold (c) cross-sectional of handgrip mold (d) toppers plate.

before the polymer compounding took place. The extrusion process of KF and SPF particle fibers with polymer matrix were extruded holistically at 10 min. Thermoset composites of (SPF/KF/PP) T-SP7K3 were crushed into granular size pellets. After that, it was followed by handgrip casting using a hot mold pressing. The prototype molding was detailed as in Figure 2. Next, the customized samples of hybrid composites were then pre-heated at 180 °C for 5 min and pressed at 190 °C for 7 min by using a hot press machine. After that, the composite sample was cold pressed at 25 °C for 5 min. All specimens were examined for their mechanical properties including hardness, flexural strength, and weight reduction [28], [29].

The mold was fabricated as a dimensional drawing presented in Figure 2. It was shown in section (a) the isometric drawing of handgrip assist, (b) the cavity plate (c) cross-sectional handgrip mold and (d) the toppers plate. The mold was made of pure steel 98% with an overall mass of mold 61.69 grams. The volume of handgrip assist mold is 693.09 cm^3, while the surface area presented at 171.8 cm^2.

2.4 *Mechanical testing*

Two types of analysis were conducted to identify the facile mechanical properties of the hybrid composites prototype handgrip specimen: flexural, and Rockwell hardness tests. The tests were conducted using an Instron Universal Testing Machine (model 3366, USA) with a load cell of 10 kN and a crosshead speed of 5 mm/min. An average value was calculated from the total of six handgrip samples for each PP, ABS Perodua axia handgrip and hybrid composite (SPF/KF/PP) with Instron 8801 UTM that is employed to carry out the 3-point flexural test to calculate the flexural strength of the specimens, where the process is carried out under normal room temperature. The sample preparations were carried out as per the ASTM D7264: Standard Test Method for Flexural Properties of Polymer Matrix Composite Materials. The specimen was in the handgrip shape with the dimension explained in Table 2. Rockwell hardness standard was adopted on the specimens. The hardness of the samples was measured using a Rockwell hardness tester and test specimens were made according to ASTM D 2240-86. The diameter of the ball indenter used was 0.25 inches and the maximum load applied was 60 kg as per the standard of L-scale of the tester. This test was carried out at room conditions. The readings were taken 10 s after the indenter made a firm contact with the specimen ISO 2039-2: Plastics Determination of hardness-Part 2: Rockwell hardness. for Rockwell hardness test. All mechanical testings were done with a minimum of six samples.

3 Results and Discussion

3.1 *Sugar palm and kenaf fiber reinforced polypropylene composite (SPF/KF/PP) handgrip molding*

The main purpose of this work is to investigate the properties of handgrip fabrication mechanical performance of sugar palm/kenaf fiber-reinforced polypropylene hybrid composites. Physical, morphology and dynamic mechanical analysis were carried out to confirm the effect of benzoylation treatment toward fabricating a more hydrophobic behavior of the hybrid composites [28], [29]. Both treated and untreated composites that have 10 wt% of fiber loading with three different fiber ratios between sugar palm and kenaf with blend ratios were analyzed and recorded previously. The best ratio chosen for further analysis is T-SP7K3, 7:3 with 10% and 90% of fiber and matrix weight proportion, respectively. The handgrip molding schematic was presented as in the schematic diagram in Table 2. Generally, the molding plates are made from mild steel and divided into two segments. The first segment is the core plate, and the second segment is the cavity plate. In addition, the casting measurement is also presented as shown in Table 2. The measurement for core plate width is fabricated at 75 mm while the height is 40.7 mm respectively. In addition, the cavity plate length and height are developed at 170 mm and 45 mm, respectively. Furthermore, the finger grip cavity is 85 mm while its width was stated at 55 mm. The thermoset differs from any established automotive spare part made of ABS or polyurethane in terms of physicality, morphology, and appearance. Sugar palm/kenaf fiber-reinforced polypropylene hybrid composites were indeed less rubbery so that they would sustain their retardancy towards higher heat. Moreover, benzoyl treatment ensures that the thermostability of thermoset (sugar palm/kenaf fiber-reinforced polypropylene hybrid composites) was increased.

Table 2: The handgrip molding schematic modeling with the specific dimensions

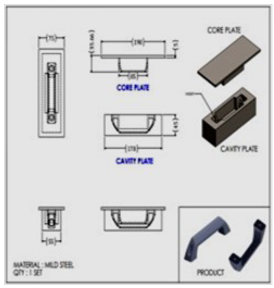
The Schematic Modelling	Segment	Measurement (mm)
	core plate width	75 mm
	core plate height	40.7 mm
	cavity plate length	170 mm
	finger grip length	85 mm
	cavity height	45 mm
	cavity width	55 mm

Figure 3(a) shows the actual empty cavity plate and core plate molding, while Figure 3(b) shows the sugar palm, kenaf, and polypropylene (SPF/KF/PP) composite pellet filled inside the cavity plate molding. Next, customized samples of hybrid composites were then pre-heated at 180 °C for 5 min and pressed at 190 °C for 7 min by using a hot press machine. After that, the composite sample was cold pressed at 25 °C for 5 min and examined its mechanical instrumentation, such as hardness, flexural strength, and weight reduction. Figure 3(d), shows a brown color handgrip specimen indicating T-SP7K3, the grey color is ABS Perodua Axia handgrip and the white color is the neat PP.

3.2 *Flexural analysis*

Flexural strength, also known as modulus of rupture, bend strength, or transverse rupture strength is a material property, defined as the stress in a material just before it yields in a flexure test [34]. The transverse bending test is most frequently employed, in which a specimen having either a circular or rectangular cross-section is bent until fracture or yielding using a three-point

Figure 3: Pictures of final products (a) cavity plate and core plate molding (b) composite pellet inside cavity plate (c) sugar palm/kenaf/polypropylene handgrip prototype (d) specimen (brown: sugar palm/kenaf/polypropylene handgrip prototype, constant (white: polypropylene and grey: acrylonitrile butadiene styrene (ABS) hand grip).

flexural test technique. The flexural strength represents the highest stress experienced within the material at its moment of yield. In mechanics, the flexural modulus or bending modulus [35] is an intensive property that was computed as the ratio of stress to strain in flexural deformation, or the tendency for a material to resist bending. It was determined from the slope of a stress-strain curve produced by a flexural test.

Table 3: Flexural strength (MPa) and flexural modulus (MPa) of various handgrip specimens

Handgrip Specimen	Neat PP	ABS (Perodua Axia)	Hybrid Composite
Flexural strength (MPa)	409.46	268.71	339.5
Flexural modulus (MPa)	18.54	10.23	17.19

Table 3 shows the handgrip specimen fabrication neat PP, ABS (Perodua axia) and hybrid composite (T-SP7K3) flexural strength (MPa) and also its flexural modulus. The flexural strength of neat PP, ABS (Perodua axia), and hybrid composite was recorded at 409.46, 268.71 and 339.5 (MPa), respectively. On the other hand, the specimen flexural modulus was displayed at 18.54, 10.23, and 17.19 (MPa), respectively. Whereas the relationship trend of flexural strength and flexural modulus was exposed in Figure 4. Comparing the established acrylonitrile butadiene styrene (ABS) and hybrid composite T-SP7K3 hand grip specimen, the composite hybrid displays a higher flexural strength (MPa) and flexural modulus (MPa). It is suggested that the treatment process gave no significant benefit to the hybrid fiber in the PP matrix at this ratio number, thus showing no enforcement effects in the composites [36]. It should be noted that the hybrid ratios in this study were up to 7% out of 10% of the total composite composition. Therefore, it is believed that the hybrid ratio of 7:3 is a promising value of flexural strength and flexural modulus, perhaps comparable to the pure PP. These flexural properties result also could be attributed to the better homogeneity and firm bonding of fibers towards its polymer matrix.

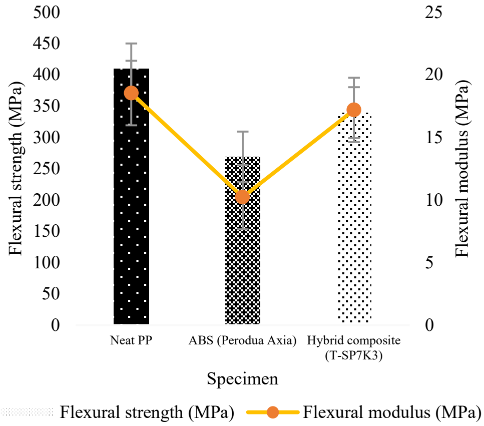


Figure 4: Relationship of flexural strength (MPa) and flexural modulus (MPa) for various handgrip specimens.

3.3 *Rockwell hardness*

The Rockwell scale is a hardness scale based on the indentation hardness of a material [37]. The Rockwell test measures the depth of penetration of an indenter under a large load (major load) compared to the penetration made by a preload (minor load) [38]. Rockwell hardness also explains a general method for measuring the bulk hardness of metallic and polymer materials. Although hardness testing does not give a direct measurement of any performance properties, the hardness of material correlates directly with its strength, wear resistance, and other properties [39]. Figure 5 shows the effect of various specimens of handgrip on its Rockwell hardness (HRF). The hardness data in Table 4 are plotted as displayed in Figure 5. The hardness value of neat PP, ABS, and hybrid composites T-SP7K3 handgrip was recorded at 99.1, 90.96 and 92.96 N/mm^2, respectively. Meanwhile, the trend of hardness (HRF) can be seen in Figure 5. It shows that the highest hardness value is neat pp with 99.17 N/mm^2, while the lowest value of HRF was

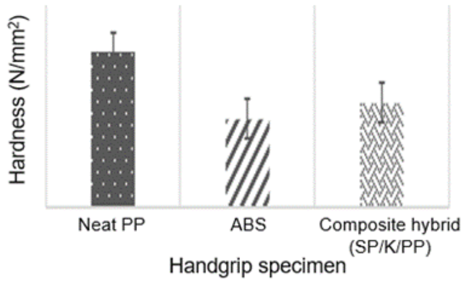


Figure 5: Neat polypropylene (PP), ABS PP, ABS, and hybrid composites T-SP7K3 handgrip hardness (HRF) trend.

recorded for ABS (Perodua axia) with 90.96 N/mm^2. It shows that the trend was not having a very distinct difference towards each specimen. Neat polypropylene, Acrylonitrile butadiene styrene, and hybrid composites T-SP7K3 handgrip have a comparable value of HRF hardness.

Table 4: Hardness value (N/mm^2) of neat PP, ABS, and hybrid composites T-SP7K3 handgrip

Handgrip	Neat PP	ABS (Perodua Axia)	Hybrid Composite
Hardness (N/mm^2)	99.17	90.96	92.96

3.4 *Weight reduction*

The primary goal of this research was to identify and evaluate the safety benefits of structural polymer and composites applications in future lighter, efficient mechanical and environmentally sustainable vehicles parts [40]–[42]. The research objectives of this analysis were to evaluate the neat weight (g) for neat PP, ABS (Perodua axia) and hybrid composite (SP/K/PP) composite materials. It was displayed in Table 5, that the neat weight for varied handgrip specimens is 53.25, 71.29, and 48.50 g, respectively. The highest handgrip weight was recorded for ABS (Perodua Axia) while (SP/K/PP) hybrid composite recorded the least neat weight. Comparing the percentage of weight reduction between neat PP and ABS (Perodua Axia) with neat PP and Hybrid composites, it was displayed the value of 4.66% and 22.7%, respectively (Figure 6). It means the hybrid composite (T-SP7K3) weight was 22.7% lighter compared to the domestic hand grip ABS (Perodua Axia).

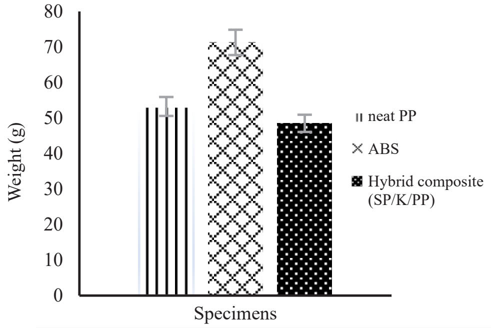


Figure 6: Neat weight (g) for neat PP, ABS (Perodua Axia) and hybrid composite (SP/K/PP) composite materials.

Table 5: Neat weight and percentage reduction of neat polypropylene, ABS (Perodua axia), and hybrid composite (SP/K/PP)

Polymer	Neat PP	ABS (Perodua Axia)	Hybrid Composite (SP/K/PP)
Neat weight (g)	53.25 ± 0.94	71.29 ± 0.15	48.50 ± 0.79
Percentage reduction compared to ABS (Perodua Axia) (%)	4.66	-	22.76

4 Conclusions

The best ratio chosen for facile mechanical testing is T-SP7K3, 7:3 with 10% and 90% of fiber and matrix weight proportion, respectively. The molding fabrication was thoroughly explained in the experimental and composite material parts. Flexural, hardness and weight reduction studies were explored towards neat polypropylene (PP), acrylonitrile butadiene styrene (ABS), Perodua axia, and hybrid composite T-SP7K3. Hybrid composite T-SP7K3 shows higher flexural strength and flexural modulus compared to ABS (Perodua axia) handgrip at 339.5 and 17.19 (MPa), respectively. In addition, the Rockwell hardness testing (HRF) shows a higher value compared with ABS (Perodua axia) handgrip with 92.96 N/mm^2. Furthermore, the weight reduction percentage also recorded hybrid composite T-SP7K3 value the highest at 22.7%.

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