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EVALUATING THE STATIC AND DYNAMIC IMPACT PROPERTIES OF LDPE FILM: INSIGHTS INTO MECHANICAL ENERGY CONSUMPTION

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Abstract: Plastics, or more precisely, polymers, have been utilized as construction materials for numerous decades. The broad range of plastic types results in a vast array of physical properties, consequently yielding a wide spectrum of practical applications. Significant advancements in materials engineering, manufacturing technology, and structural design call for the continuous enhancement of experimental research methods and the exploration of domains that are often regarded as conventional or standardized. The prevailing method for evaluating the mechanical properties of plastics is the static tensile test, which is conducted in accordance with established standards that meticulously delineate the test conditions and specimen preparation methodologies. While static tensile test results furnish valuable information, integrating them with dynamic test results facilitates a more precise evaluation of the structural material under examination. The objective of this study was to conduct a comprehensive investigation of the mechanical properties of film made of low-density polyethylene (LDPE) subjected to static and dynamic loads, thereby enabling the formulation of more comprehensive conclusions about the tested plastic. The methodology entailed conducting experimental static and dynamic tests on samples of recycled LDPE film from this plastic. The experimental results obtained were used to develop a series of mechanical characteristics based on energy relationships. The integration of the outcomes from static tests with impact tests at varying strain rates and impact energies resulted in the identification of several pivotal indices and characteristics. The developed material and structure diagnostic indicators are imperative for future endeavors involving the utilization of LDPE and other unconventional materials as structural materials, particularly in structures designed for controlled mechanical energy dissipation. In summary, a comprehensive understanding of the mechanical properties of materials such as plastics is essential for optimizing their use in specific engineering applications. One critical area where static and dynamic material properties are essential is human safety. Protective measures, including helmets, harnesses, safety belts, and energy-absorbing mats, depend on precise knowledge of material properties.

Key words: LDPE polymer, Low Density Polyethylene, static mechanical properties, force pulse, LDPE dynamic properties, mechanical energy dissipation, LDPE mechanical properties, mechanical state of the LDPE

1. INTRODUCTION

From the perspective of their applications in mechanical structures, polymers exhibit a broad spectrum of mechanical properties, which undoubtedly contributes to their widespread use in engineering practice. A plethora of standards exist that specify mechanical testing methods for polymers. These include standards for foil testing (PN-EN ISO 527-3:2019-01), static testing of polymers (PN-EN ISO 527-1:2020-01), bending tests (PN-EN ISO 178:2019-06), and impact testing of thermoplastic pipes (PN-EN ISO 3127:2017-12). These standards detail the preparation of specimens and the procedures for conducting tests under various loading, deformation, and environmental conditions. Notwithstanding substantial progress in the domain of testing apparatus and methodologies, the pursuit of novel quantitative indicators remains imperative to facilitate a more objective evaluation of a material's mechanical properties. The present study offers the results of tests conducted on films fabricated from Low-Density Polyethylene (LDPE), a material derived from recycled resources. LDPE boasts a wide range of applications and is frequently utilized in various products, particularly in the food industry and transportation sectors. Examples of such products include bags, containers, pipes, hoses, ropes, bottles, tools, and toys. A notable advantage of LDPE is its recyclability, although it should be noted that indefinite reprocessing is not feasible. Moreover, LDPE's capacity for energy absorption, which is a consequence of its mechanical properties, renders it a valuable material in the design and manufacture of equipment intended to safeguard health and safety from shock loads (Drane et al. [22]). Such equipment includes bumpers, impact absorbers, helmet linings, and energy-absorbing mats, to name a few. LDPE polymer is extensively utilized in the packaging industry, where its impact-resistance is crucial for safeguarding fragile products during storage. Additionally, LDPE polymer is a plastic that can be efficiently processed via automated methods, making it well-suited for high-volume production scenarios. This characteristic contributes to a reduction in unit production costs. LDPE Polymer is distinguished by its favorable elastic properties and capacity for energy storage. The advantages of LDPE also include favorable properties related to the release of strain energy stored during deformation. However, it is important to note that the LDPE polymer exhibits a lack of resistance to high temperatures and shear loads. A substantial body of literature exists that details the modification of LDPE plastics through the addition of various substances, aiming to tailor the final product's properties. Research is ongoing into the development of composites with LDPE and their mechanical properties. In a related study, Sailaja et al. [10] examined the mechanical properties of biodegradable blends of LDPE and cellulose acetate phthalate. The researchers conducted a series of fundamental mechanical property tests to assess parameters such as tensile strength and longitudinal modulus of elasticity.

Barbosa and Catelli de Souza [1] performed tests on plastic formed from Surlyn® industrial waste ionomer mixed with LDPE, evaluating mixtures with varying percentages of the two components. The researchers assessed the melt flow index (MFI) and morphology (SEM), in addition to mechanical properties through tensile, bending, and impact tests. Furthermore, thermal tests of the prepared mixtures were conducted, encompassing DSC, TGA, and HDT analyses. It was observed that the incorporation of ionomer, in conjunction with LDPE, led to an enhancement in tensile and flexural strength, as well as tensile and flexural modulus values and strain at break. Conversely, an increase in ionomer concentration has been observed to result in a decline in impact strength.

It is evident that plastic waste management is a pressing issue. The potential for creating new plastics from recycled materials presents a promising avenue. However, it is imperative to conduct extensive testing to ascertain the properties of these novel materials, as they have the potential to fulfill a wide range of applications. A more profound comprehension of the mechanical properties of these materials can facilitate more precise material selection for specific operational conditions.

In a study by Kismet et al. [2], three distinct electrostatic waste thermosetting powder coatings were utilized as fillers in low-density polyethylene (LDPE). Subsequent to the fabrication of the composite material, a series of evaluations were conducted to ascertain its mechanical, thermal, and morphological properties. The composite compositions included powder waste coatings in the proportions of 10%, 20%, and 30%, respectively. The injection molding method was employed to create rod specimens for tensile tests, with plate-shaped specimens also utilized. An energy intensity study of the prepared composite specimens was conducted, and the results were compared with those of pure LDPE specimens. For pure LDPE, the highest energy absorption occurred during low-speed impacts. Efforts were made to enhance the impact and flexural strength of LDPE composites containing deactivated powder paint waste.

Sirin et al. [3] investigated the effects of various organic peroxides on selected types of LDPE, including F2-21T, F5-21T, and I22-19T, mixed in varying percentages with dialkyl, dibenzoyl, and dilauroyl peroxides. The experimental tests conducted in this study yielded critical insights into the mechanical properties of the resulting plastics, encompassing stress-strain characteristics, tensile strength at break, and elongation at break.

Peršić et al. [4] prepared composites of LDPE with iron oxide hematite particles, demonstrating superior physical properties compared to pure LDPE. Mechanical property tests were conducted under static conditions to evaluate tensile strength and elongation at break. Dwivedi et al. [5] proposed a composite with sisal fiber coated in LDPE. The coated fibers were utilized as the material for composites with varying weight percentages of sisal fibers. Significant increases in strength and abrasion resistance were observed based on strength tests. Dynamic properties were assessed through three-point bending tests, revealing that the elastic modulus (E') and loss modulus (E") values were lower for the tested composites compared to pure LDPE and sisal fibers alone.

Barabaszová et al. [6] presented results on an LDPE nanocomposite with ZnO/V and ZnO/V_CH nanofillers, indicating its potential application as a medical material. Mechanical properties such as hardness and Vickers microhardness were determined, alongside friction coefficient tests that demonstrated reduced wear. Antimicrobial tests further suggested beneficial medical properties of both fillers used.

In preparation for the extrusion process, Janik [7] developed a composite of polymer blends of poly(butylene terephthalate) (PBT) and LDPE. Subsequent testing on the mechanical properties of the PBT/LDPE composite demonstrated enhancements in tensile strength, flexural strength, and alterations in both Young's tensile modulus and flexural modulus when compared to unmodified LDPE. Additionally, an enhancement in elongation ranging from 10% to 20% was observed in comparison to unmodified LDPE.

Ono and Yamaguchi [9] conducted research on the effects of the extrusion process on the structure and mechanical properties of low-density polyethylene (LDPE). Their analysis focused on the outcomes of rheological tests, which revealed that linear viscoelastic properties exhibit reduced sensitivity to alterations in polyethylene structure. However, an enhanced sensitivity was observed in specimens subjected to extrusion temperatures of 350°C. Czarnecka-Komorowska et al. [8] presented the findings of a study on the thermomechanical, rheological, and structural properties of films made from recycled polyethylene. The authors observed that recycled rLDPE/rLDPE blends possess qualities that render them suitable for thin film production. Mechanical property tests demonstrated enhancements in tensile strength and elongation values. Furthermore, it was observed that films derived from rLDPE/rLDPE blends demonstrated superior puncture resistance in comparison to films fabricated from virgin materials.

Yao et al. [11] investigated the mechanical properties of LDPE composites with colored CBF filler, highlighting concerns about heavy metal contamination in plastics used to manufacture children's toys. The CBF-filled composite is posited as a potential solution to this issue. Preliminary investigations into the mechanical properties of the composite have indicated that the integration of CBF with LDPE can result in a substantial enhancement of tensile strength, Young's modulus, flexural strength, and the modulus of elasticity of the composite under consideration. Rana et al. [14] presented the results of an LDPE composite reinforced with jute. The fabrication of the composite involved the compression of LDPE film and jute into slab form. A series of fundamental mechanical property tests were conducted, encompassing bending, tensile, impact, DMA, and SEM analyses. The outcomes of these tests indicated that the LDPE-jute composite demonstrated enhanced impact strength in comparison to the pure polymer.

Yazdani et al. [15] investigated the mechanical properties of low-density (LDPE) and high-density polyethylene (HDPE) and their composites with carbon nanotubes (CNTs). The study identified four stages of deformation: linear elasticity, plasticity, softening deformation, and strengthening. The strain rate was found to have a significant impact on the mechanical properties of the polymers and their composites studied.

In a related study, Sahraeian et al. [16] examined the mechanical properties of nanocomposites based on low-density polyethylene (LDPE) with varying contents of nanoperlite. The researchers performed rheological tests, dynamic mechanical thermal analysis (DMTA), and thermogravimetric analysis (TGA).

In addition to static tests on various materials, including LDPE, dynamic tests at different impact speeds were also carried out. Kofi et al. [12] conducted impact resistance tests on birch fiber-reinforced HDPE composites obtained through injection molding. The authors noted that the dynamic properties of these composites are not fully characterized, and there is a paucity of studies on their

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impact resistance. The composite material that was the subject of this study was submitted to impact tests, hardness tests, tensile strength evaluations, and elastic modulus assessments. Impact tests were conducted at speeds of 1 m/s and 1.25 m/s using a system based on an inertially falling mass with a semicircular head for composite specimens with varying birch fiber content. The authors observed the tup bouncing after striking the test specimen and noted the minimal energy absorbed by the composite material.

Karthikeyan et al. [13] conducted a series of experiments on laminated beams composed of monolithic carbon-fiber-reinforced plastic (CFRP) and ultra-high molecular weight polyethylene (UHMWPE). The experimental design encompassed three-point bending of composite beams, with dynamic tests involving the use of a metal foam beater to simulate an explosion by striking the mid-span of the beam. The authors of the study examined the impact of the support method on the beam's response to the applied load, with a particular focus on the movement of so-called moving or shear hinges from the impact point toward the beam supports. Fiber cracking of the composite was observed in the proximity of the supports.

Xu et al. [17] subjected low-density polyethylene (LDPE) and ultra-high molecular weight polyethylene (UHMWPE) to static and dynamic tests, thereby determining the relationship between yield strength and strain rate. A comparison was made between the mechanical properties of the two polymers, with particular attention given to the impact of molecular structure on the tensile fracture behavior of polyethylene specimens.

Zhu et al. [18] developed experimental stress-strain characteristics for four types of polyethylene: low-density polyethylene (LDPE), linear low-density polyethylene (LLDPE), medium-density polyethylene (MDPE), and high- density polyethylene (HDPE), across strain rates ranging from 0.001 to 1000 s^{-1}. It was observed that the fracture characteristics of the specimens varied with the strain rate, as did the strain rate-dependent changes during yield stress analysis.

In a related study, Mohagheghian et al. [19] investigated the fracture characteristics of low-density polyethylene (LDPE), high-density polyethylene (HDPE), and ultra-high molecular weight polyethylene (UHMWPE) specimens, focusing on their capacity to absorb impact energy. The researchers explored the relationship between the shape of the bullet's contact surface and the energy absorbed by the polymer material. Plates fabricated from the materials under consideration were subjected to static loads and bullet impacts at a velocity of 100 meters per second. The increased strain rate resulted in softening, which in turn led to the destabilization of neck propagation during stretching in LDPE and HDPE. In contrast, UHMWPE exhibited notable stability. The study underscored discrepancies in energy absorption intensity among the materials under scrutiny, contingent on the morphology of the bullet contact surface. The findings for the examined polymers were then juxtaposed with those garnered from an aluminum alloy specimen, here designated as 6082.

Sandeep and Murali [20] conducted experimental tests on low-density polyethylene (LDPE) foams of five different densities under compressive loading at various strain rates. It was observed that the compressive strength of LDPE foam is more favorable at higher strain rates.

It is also imperative to acknowledge the prevalence of other composite materials that currently garner significant interest among researchers, particularly within the domains of aerospace and automotive engineering. In contemporary composite structures, natural fibers, including wool, silk, kenaf, and others, are frequently utilized as base materials. Additionally, composites incorporating carbon nanotubes have garnered significant attention. Sahu et al. [28] examined the mechanical and electrical properties of multi-walled carbon nanotubes (MWCNTs) filled with pineapple fibers and hybrid laminated composite structures based on kenaf fibers. The study highlighted the benefits of the electrical and mechanical properties of the composites to the aerospace industry. Similarly, Das et al. [27] conducted extensive research on a KF/epoxy composite whose electrical and mechanical properties are ideal for the automotive and aerospace industries. Antony et al. [26] evaluated composite structures designed to absorb radar waves. The composites tested utilized various fibers, including wool, silk, E-glass, aramid, and wave-absorbing foams such as balsa wood, PVC, and PM. The experimental and simulation methods are employed in the study of composite structures. Modal analysis and finite element simulation are popular methods [24,25]. Sahu et al. [23] conducted simulation and experimental tests of polymeric composite plates reinforced with natural fibers and polyethylene terephthalate (PET) foam cores for impact bending of polymeric composite plates reinforced with natural fibers.

This article presents the results of experimental static and impact tests on specimens made of low-density polyethylene (LDPE) in film form. The author observed the effects of strain rate and impact energy on the mechanical properties of the test material.

It was observed that the manufacturing process of the film appeared to induce anisotropy in its mechanical properties. This observation was based on a visual assessment of the examined material. The failure mechanism observed visually exhibited a dependence on the direction of the applied load; however, this variation had a negligible impact on the overall performance of the film, based solely on data obtained from static tests. The author also presents indices based on strain energy, the interpretation of which aids in a more precise evaluation of the plastic tested. The proposed methodology can be applied to evaluate and diagnose the mechanical properties of various materials and structures.

The study of the mechanical dynamic properties of polymers and composites is a vital and contemporary field of scientific inquiry. The findings from this research are directly applicable in engineering practice, particularly in the comprehensive analysis of polymeric materials, their composites, and structures made from them. Obst et al. [21] conducted experimental and analytical studies of the dynamic mechanical properties of pneumatic absorbers made from LDPE polymer. The tests results of pneumatic impact absorbers made of LDPE polymer [21] and the research results of LDPE film presented in this article are a continuation of dynamic tests aimed at the safety of people exposed to impact loads.

2. EXPERIMENTAL RESEARCH METHODOLOGY

LDPE film, precisely cut into strips measuring 210 millimeters in length, 25 millimeters in width, and with a thickness ranging from 0.36 to 0.39 millimeters, was utilized for the experimental procedure. The observed variation in foil thickness is attributable to the manufacturing process. Micrometric measurements were conducted at several points on the foil, and the thickness measurements obtained were within the specified dimensional range. The initial material used was a sheet of LDPE film, which was fabricated from a polymer blend of recycled materials. Strips were meticulously cut from this film in three distinct orientations relative to the manufacturing traces that were visible to the naked eye: parallel to the traces, perpendicular, and at a 45-degree angle. As previously mentioned in the introduction, the objective was to conduct a diagnostic study of the material's mechanical properties in relation to these manufacturing traces. To mitigate the risk of damage from flat test grips, the gripping sections of the test specimens were fortified. The section between grips measured 110 mm in length. The LDPE strip specimens, as illustrated in Figures 1-2 and 7, were subjected to static loading on a Zwick Z100 testing machine at a loading rate of 300 mm/s. Identical belt specimens were also subjected to impact tests using a drop tower. In this experiment, a 3.3-kilogram steel striker, falling freely under the influence of gravity, impacted a steel bumper, thereby generating an impact load on the LDPE film specimen. The striker was released from heights of 0.5 m, 1 m, and 1.5 m, resulting in varying velocities and kinetic energies at impact. The configuration of the impact test apparatus is illustrated in Figure 8. LDPE film specimens were meticulously extracted from a sheet in three distinct orientations, designated as 0°, 45°, and 90° relative to the visible structural lines of the film. The tested specimens are displayed in Figure 7. During the impact testing procedure, the LDPE film strips underwent tensile loading as the striker made contact with the rigid reversing plate. A Chronos 2.1-HD high-speed camera was employed to record the movement of the LDPE strip under dynamic stretching conditions. All tests were conducted at ambient temperature (23°C).

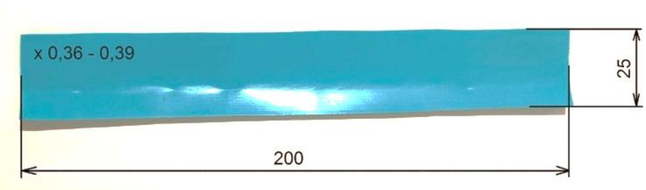

Fig. 1. Strip cut from a sheet of tested LDPE film

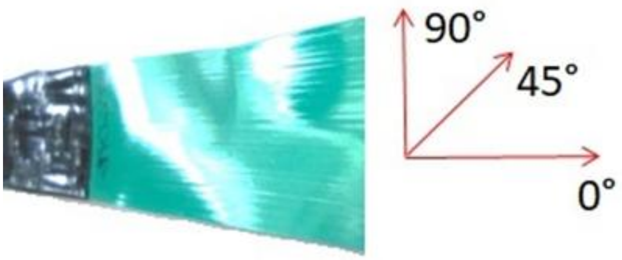

Fig. 2. Tested LDPE film. Visible technological straight lines and coordinates of cutting directions

2.1. Static testing of LDPE film

The findings from the static tensile test of LDPE film strips under uniaxial tension provided the foundation for the subsequent development of additional mechanical characteristics. Tensile plots for the three angular orientations of the strip specimens are shown in Figure 3a, b, and c. Upon examination of both LDPE film samples and pneumatic absorbers made of this plastic, some peculiarities were noted for some measurement results. The author attributes this phenomenon to the internal structure of plastics and the sensitivity of deformation mechanisms to the velocity of loading and other factors. The author intentionally left the measurement result labeled as specimen No. 6 to indicate that despite providing the same boundary conditions, plastics do not necessarily guarantee perfect repeatability of results.

The Young's modulus and the static strain energy density, expressed as the specific energy of deformation, were determined. The strain energy density was calculated using the following formula:

$$E_c\left[\frac{mJ}{mm^3}\right] = \int_{l_o}^{l_o+\Delta l} \frac{F}{V_o}\, dl = \int_0^{\varepsilon} \sigma d\varepsilon \tag{1}$$

where F and V_o are respectively the current value of tension force, and the initial value of sample volume.

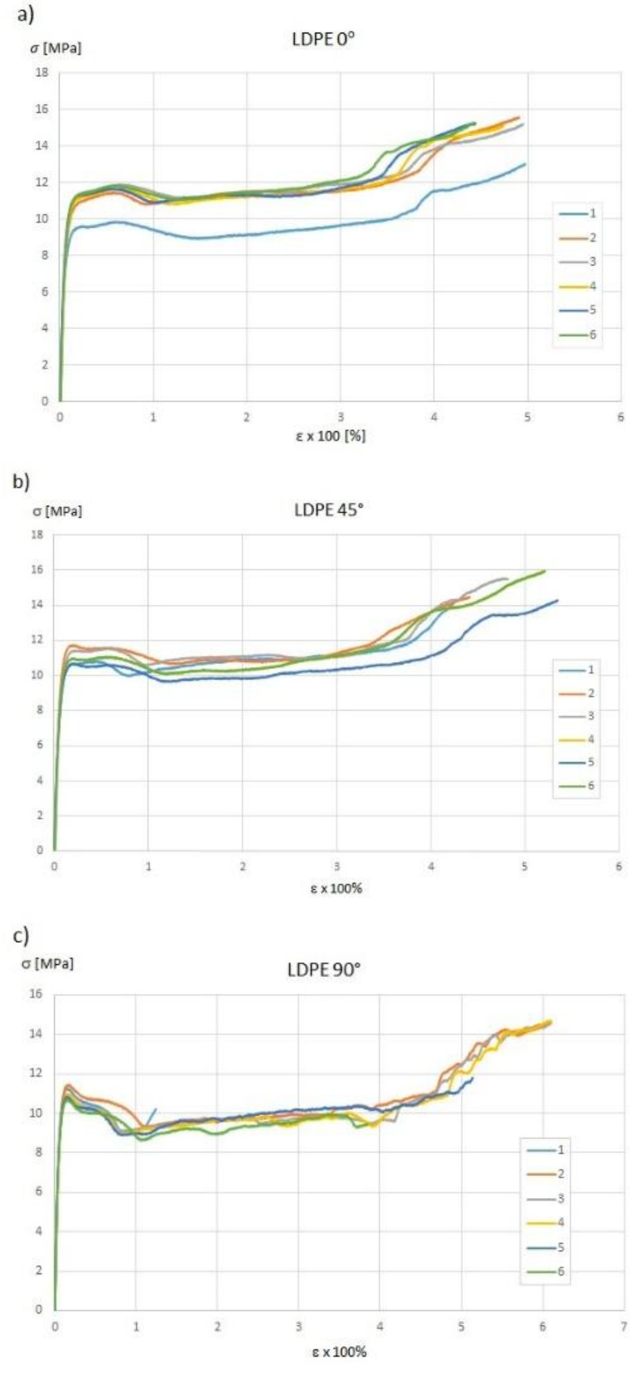

Fig. 3. Static stress σ on relative strain ε for angles: 0°, 45° and 90°

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As demonstrated in Figure 3, the fundamental mechanical characteristics, denoted by σ(ε), derived from tensile testing of LDPE film strips, reveal no substantial disparities among the selected angular orientations. However, it is noteworthy that substantial strain values for the 90° orientation (where the load is applied perpendicular to the lines visible to the naked eye in the film structure) are accompanied by local fluctuations in both load and strain.

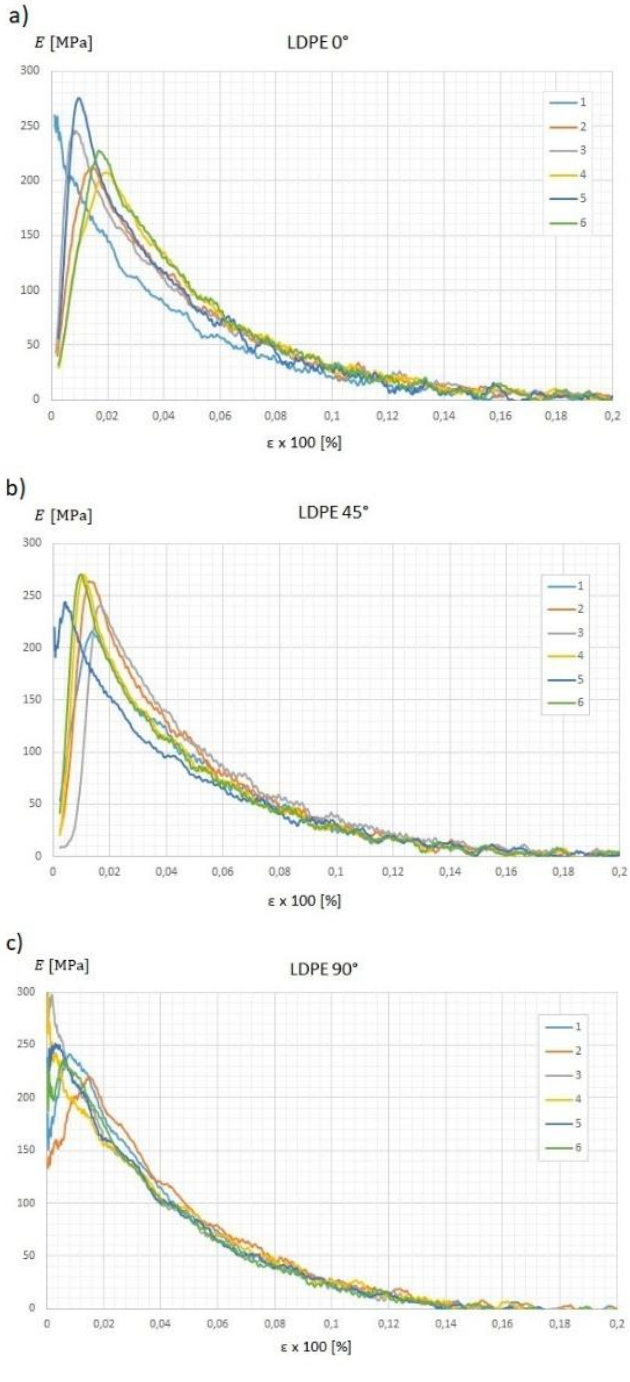

Fig. 4. Static Young's modulus *E* on relative strain ε for angles: 0°, 45° and 90°

The estimated value of the instantaneous Young's modulus This suggests a degree of dependence on the loading directions of the samples. However, the observed differences are of negligible practical significance. The total work expended in deforming the tested LDPE film specimens was calculated and is denoted as the total energy consumed in the deformation work, related to the unit volume of the tested material. The total strain energy index possesses the dimension of specific energy, otherwise known as strain energy density, a quantity frequently utilized in materials science. A thorough examination of the energy characteristics (Fig. 6) reveals that the energy intensity exhibited by the tested LDPE film displays a modest dependence on the selected loading directions. For the 90° orientation, the range varies from approximately 38 mJ/mm³ to approximately 65 mJ/mm³, indicating that the film in the 90° orientation relative to the load exhibits greater variability in specific energy limits.

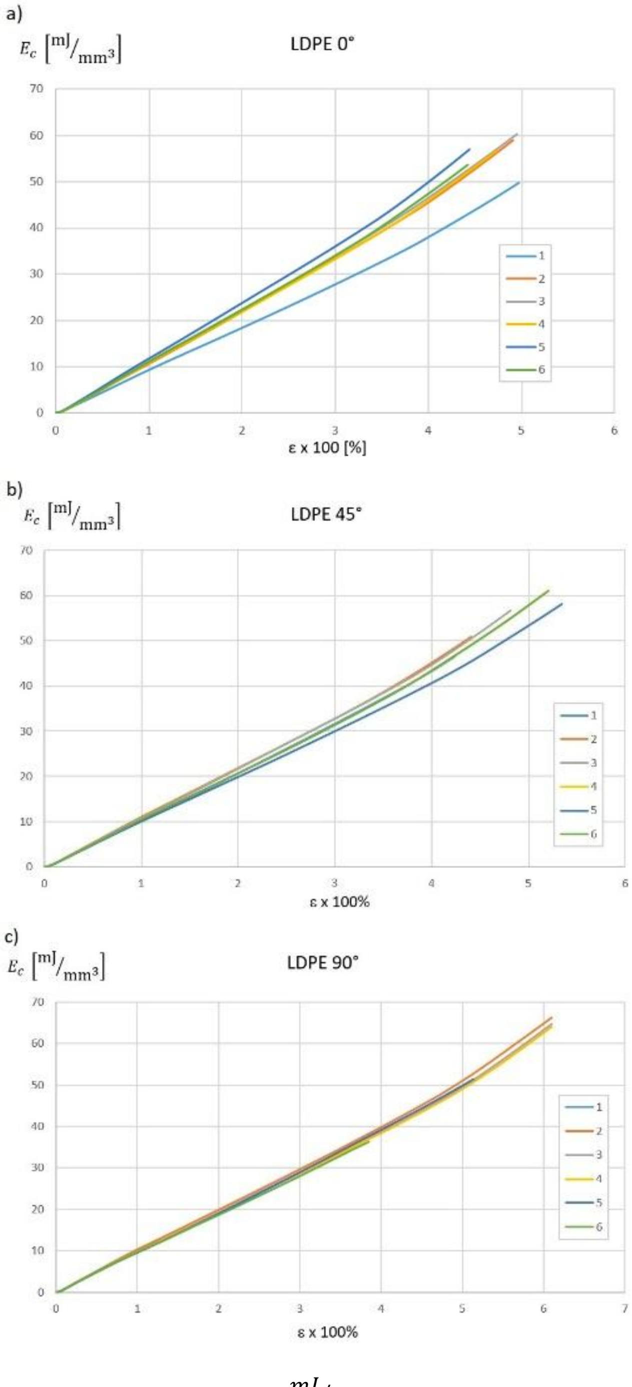

Fig. 5. Static energy density E_c [$^{mJ}/_{mm^3}$] on relative strain ε for angles: 0°, 45° and 90°

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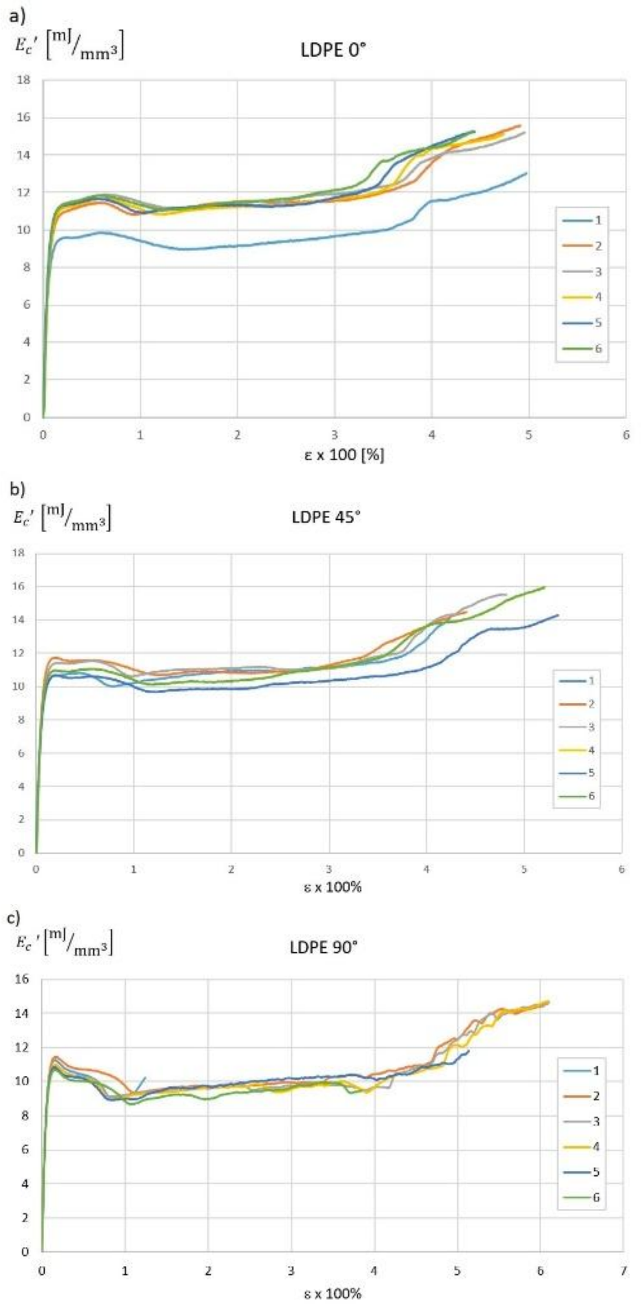

Fig. 6. Volumetric Energy change intensity E_c' $[^{mJ}/_{mm^3}]$ on relative strain ε for angles: 0°, 45° and 90°

2.2. Dynamicimpact testing of LDPE film

The dynamic mechanical properties of the tested foil specimens were determined based on the displacement of markers applied to the foil specimens (Fig. 7). The schematic of the test stand designed for impact load testing is shown in Fig. 8.

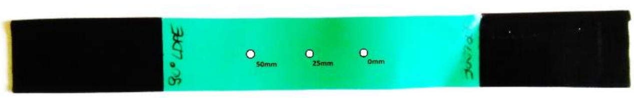

Fig. 7. Strip specimen with three displacement markers of the tested LDPE film

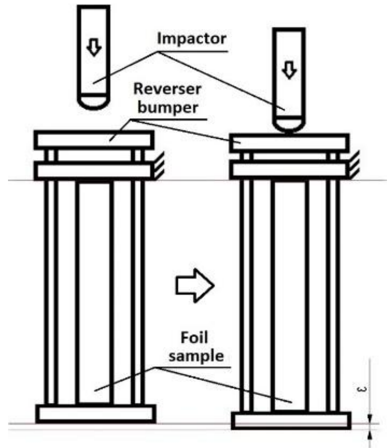

Fig. 8. Schematic of the impact load acting on the LDPE film strip specimen

The test stand employed during the impulse load tests, in conjunction with the drop tower, comprised two masses: the mass of the beater (3.3 kg) descending inertly from heights of 0.5 m, 1 m, and 1.5 m, as well as the mass of the bumper (the mass of the reverser), incorporating the guide rods and jaws that secure the specimen. It was hypothesized that the collision of the steel striker with the steel plate of the reversing bumper would be purely elastic. The kinetic energy of the beater was hypothesized to be transferred to the mass of the reverser, resulting in work done in deforming the tested LDPE tape specimens. The displacements of three markers along the survey section, labeled sequentially as 0 mm, 25 mm, and 50 mm, were recorded with a Chronos 2.1 HD high-speed camera. Subsequent to the aforementioned, a thorough deformation analysis was conducted, and mechanical characteristics were determined in relation to the previously mentioned reference points.

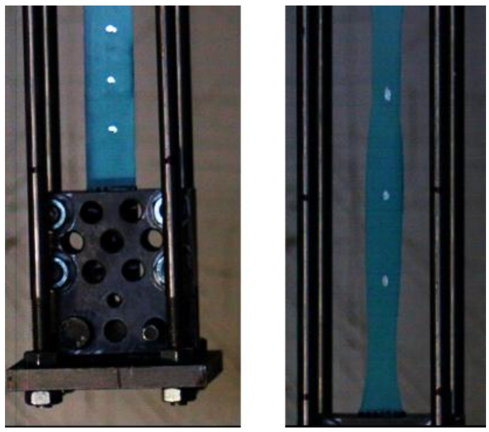

Fig. 9. LDPE film strip specimen under impact load. Initial and final elongation phase for angle 0°and flail drop height equal 1m

The characteristics of Δl(t) (see Figures 10-12) were developed for experimental data, and their approximation by a family of modified sinusoidal functions (2.1) was determined.

$$\Delta l(t) = a \cdot \sin^n(bt) \quad (2)$$

where *a,b,n* are approximation coefficients.

The objective of the approximation was twofold: first, to minimize measurement errors, and second, to provide an analytical representation of the collected results using a function that met the following conditions:

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– smoothness,
– differentiability up to the fourth order,
– simple analytical form.

The modified sine function meets these requirements, and the graphs resulting from the approximation are superimposed on those based on the experimental data. The legends on the graphs indicate the measurement segments between the reference points, with the subscript "A" denoting results obtained from the approximation using the modified sine function.

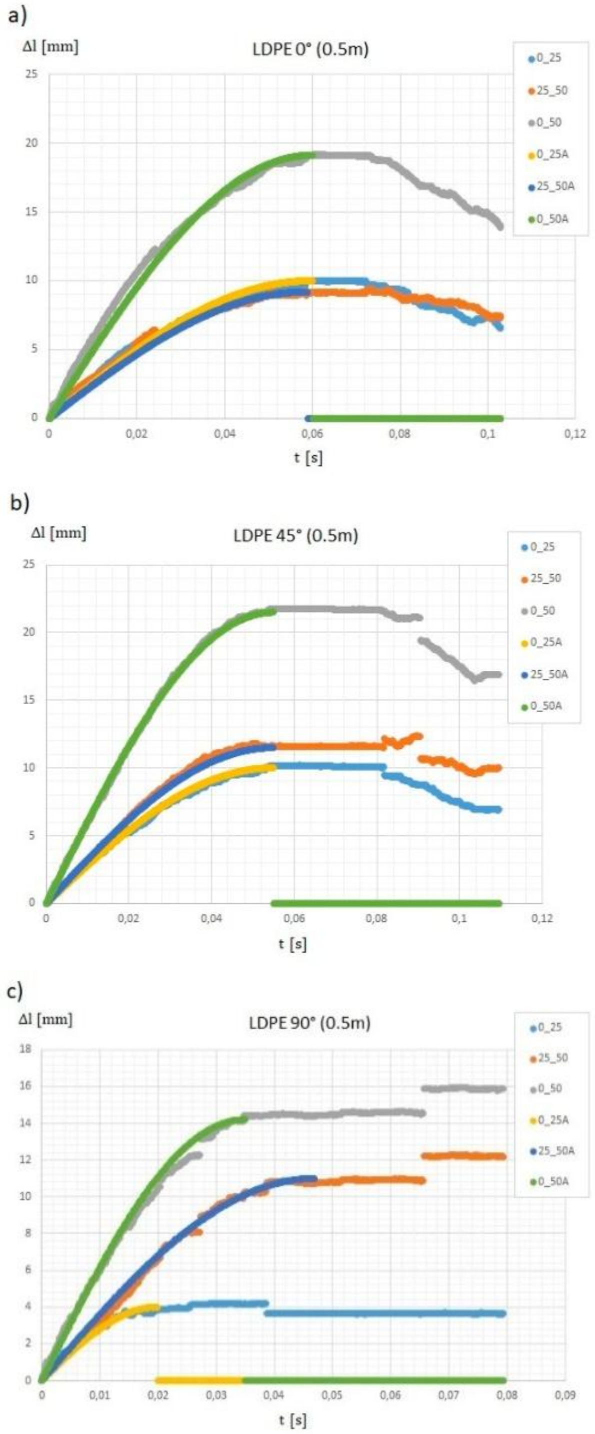


Fig. 10. Dynamic elongation Δl [mm] as a function of time for angles: 0°, 45° and 90° and 0.5m drop height

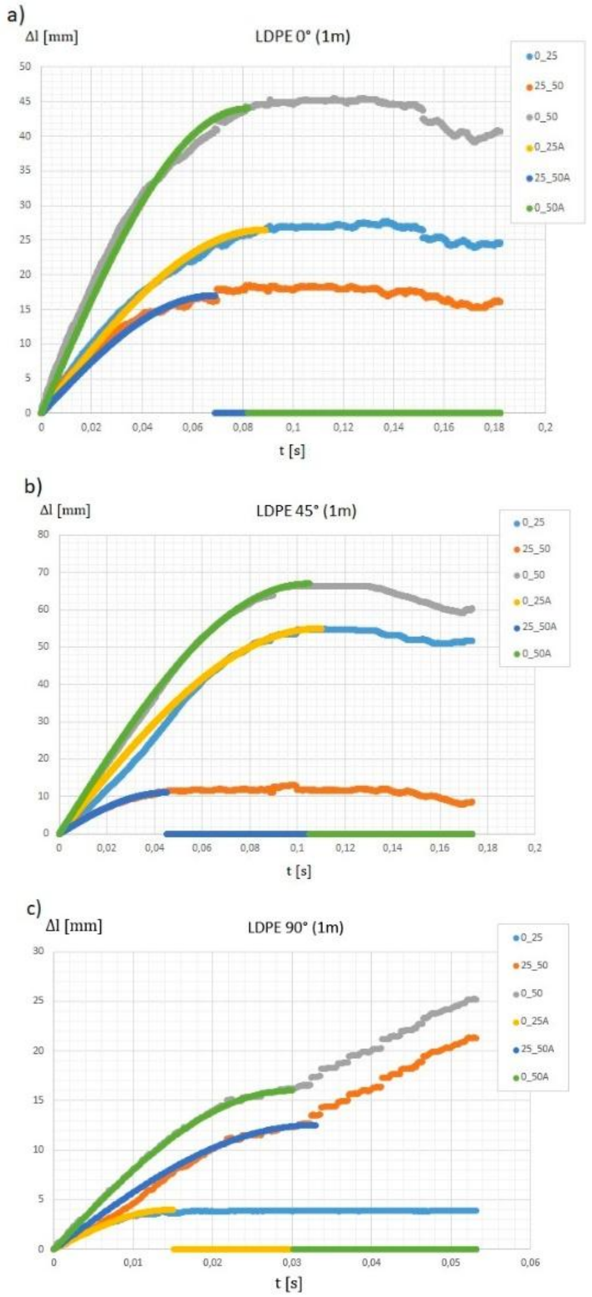
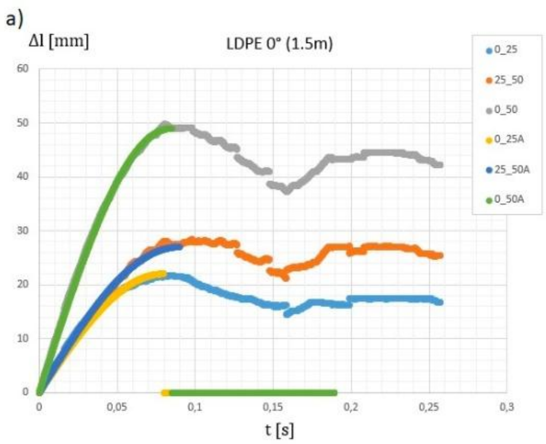


Fig. 11. Dynamic elongation Δl [mm] as a function of time for angles: 0°, 45° and 90° and 1m drop height



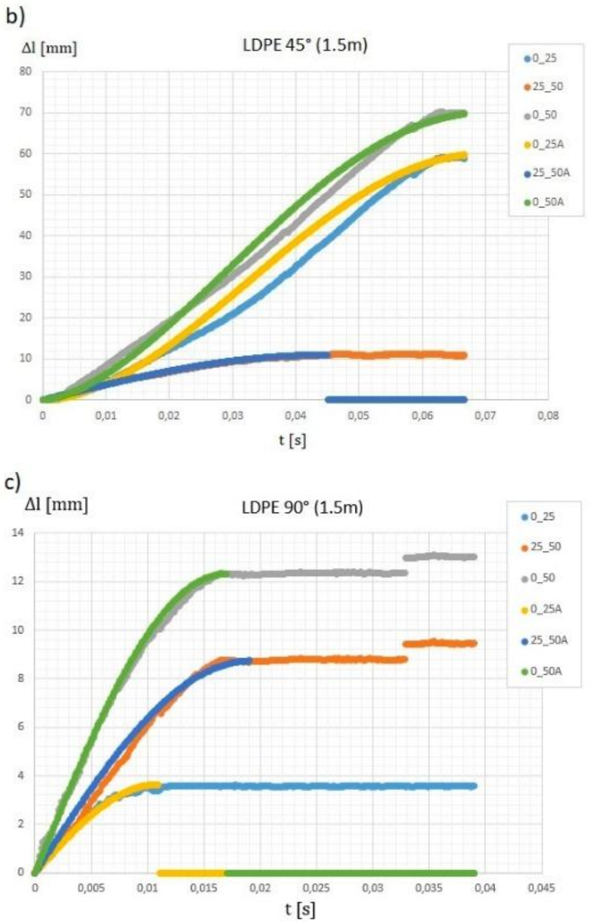
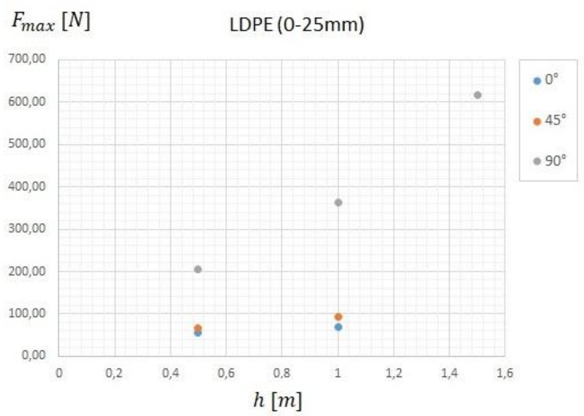
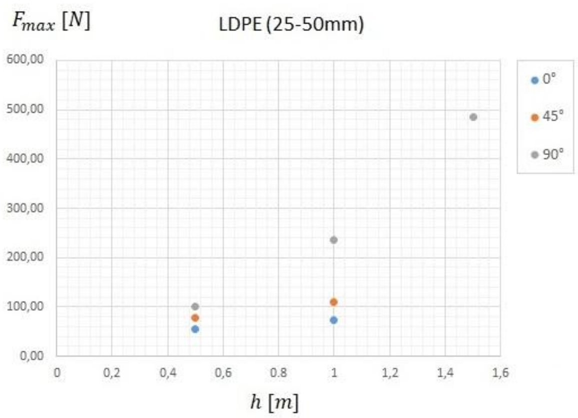


Fig. 12. Dynamic elongation Δl [mm] as a function of time for angles: 0°, 45° and 90° and 1.5m drop height





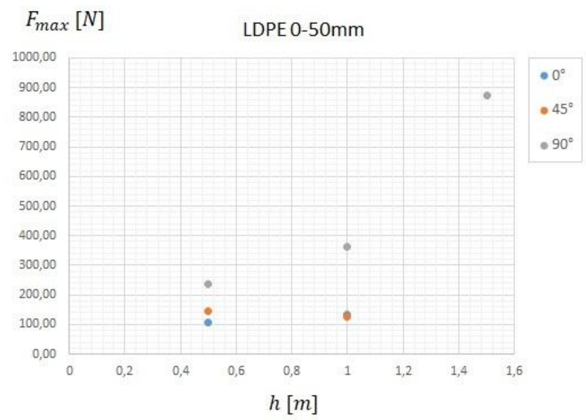


Fig. 13. Impact tension force F [N] as a function of flail drop heights h [m]. Results for angles: 0°, 45° and 90° and three measuring sections 0-25mm, 25-50mm and 0-50mm

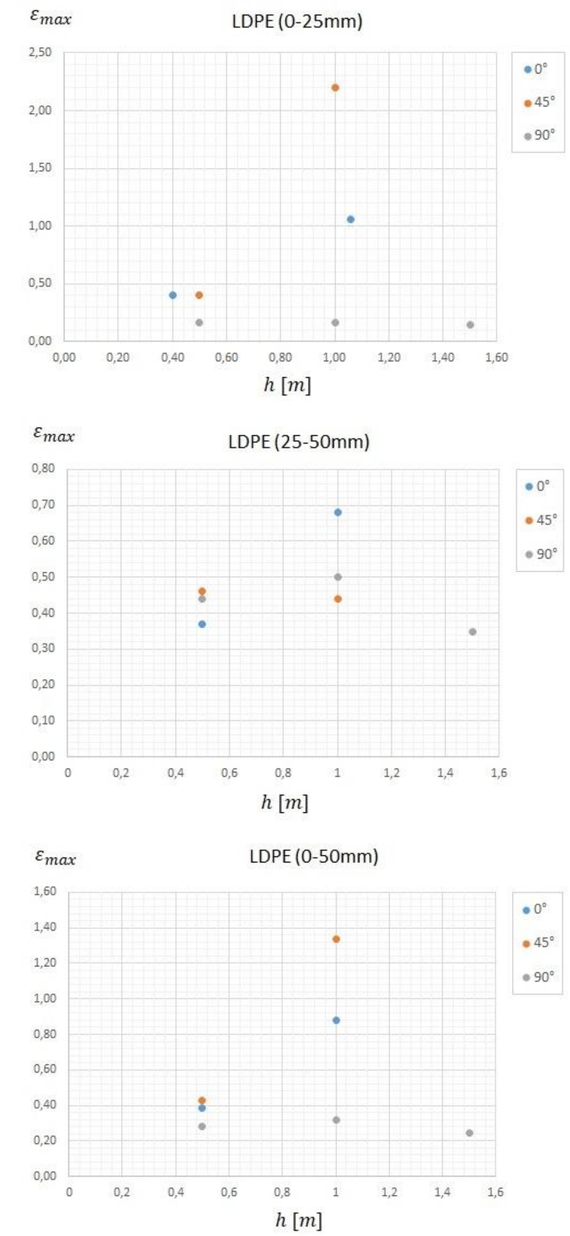


Fig. 14. Relative strain ε as a function of flail drop heights h [m]. Results for angles: 0°, 45° and 90° and three measuring sections 0-25mm, 25-50mm and 0-50mm

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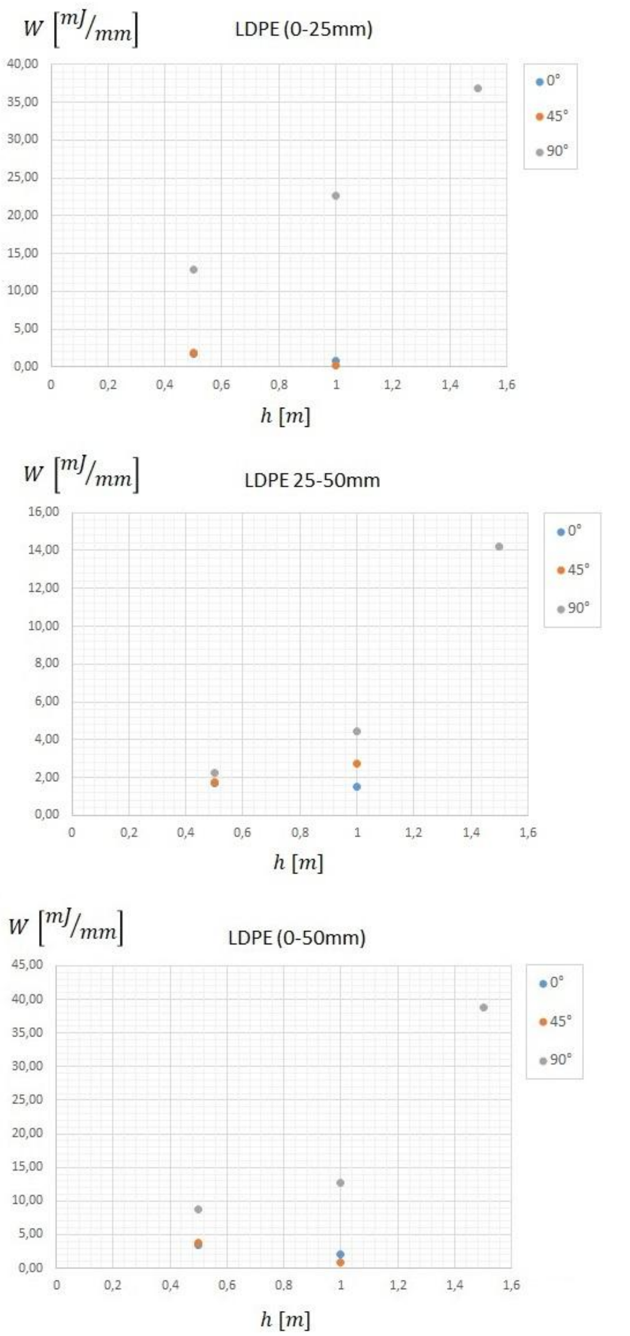

Fig. 15. Work of deformation per unit length W [mJ/mm] as a function of flail drop heights h [m] calculated for $\varepsilon = 0.15$. Results for angles: 0°, 45° and 90° and three measuring sections 0-25mm, 25-50mm and 0-50mm

3. CONCLUSIONS

An investigation was conducted into the static and dynamic characteristics of the mechanical properties of LDPE plastic. The mechanical properties of the tested LDPE film demonstrate a high capacity for deformation and energy absorption, which are used to permanently deform the material. During the static tensile testing of LDPE strips, a discernible local constriction shifted position as the load increased, and multiple zones of plastic flow appeared along the gauge length of the specimen. In impulse-loaded tensile tests, two to three zones of plastic deformation were also observed along the gauge length of the strip specimen.

In both static and impulse loading cases, the production process of the LDPE film influences its mechanical properties, as evidenced by the dynamic test results. Tests conducted in different orientations revealed differences in deformation mechanisms.

In summary, the following conclusions were derived:

- The production processes employed for plastic films have the capacity to exert an influence on both their static and dynamic properties.
- Testing the mechanical properties of LDPE film in different orientations, influenced by the production processes, can reveal discrepancies in the measured properties.
- A more precise assessment of the material can be achieved through the integration of static tests with impact tests.
- The dynamic properties of LDPE film are contingent upon orientation and impact velocity.
- The deformation work per unit length of the LDPE film varies based on these factors.

The impact strength of the tested LDPE film strips was also found to be relatively high. The obtained results of the mechanical properties of the tested material testify to its advantages and applicability in the area of protection of human security or transportation of sensitive goods. The proposed mechanical characteristics for static and impact loads can be used as diagnostic tools when testing materials and structures. Furthermore, the proposed experimental characterizations can facilitate more precise assessments of the suitability of the tested material or structure for specific practical applications. The author is currently investigating pneumatic absorbers, which are made of LDPE plastic, exhibit exceptional impact energy absorption properties. Research is currently underway on the use of LDPE pneumatic shock absorbers with controlled air flow as inserts for protective helmets. The objective of the present study is to develop a methodology that enables quantitative assessment of the mechanical response of the protective helmet and the human head to impact, with consideration for the mechanical properties of the neck. That is to say, the elements of the system that are in a cause-and-effect correlation with each other. Additionally, the results of rheological tests on both LDPE plastic in the form of films and LDPE pneumatic absorbers are of interest. Rheological studies employing LDPE film samples are currently underway.

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