Acta Tecnología – International Scientific Journal about Technologies
Volume: 4 2018 Issue: 2 Pages: 21-24 ISSN 2453-675X

doi:10.22306/atec.v4i2.32
Received: 07 Feb. 2018
Accepted: 07 May 2018

STIRLING ENGINE AND RENEWABLE ENERGY SOURCES

Ján Koščo
Institute of Earth Resources, Faculty BERG, Technical University of Košice, Park Komenského 19, 042 00 Košice, Slovakia, jan.kosco@tuke.sk

Keywords: stirling engine, renewable energy sources (RES), biomass
Abstract: The paper introduces the image of the functioning of fundamental thermodynamic processes that are required for the gas working action. It systematizes the application forms of renewable energy resources and also their potential for objective topic. The application of the objective technology is developed by various technical devices that demand their further development in order to improve the utilization. The major attention is paid especially to the solar radiation which represents the renewable resource of energy as well as it becomes the supporting element of other forms, for instance biomass, the wind energy, etc. The paper is at the place of biomass potential valuation, as well. There would be possible to start the revolution in the scope of the individual electrical industry in Slovak republic by partial biomass application on the objective technology.

1 Introduction, the principle of Stirling engine operation

"The Stirling engine is an example of an engine with an external fuel burning. Invented and patented in 1816 by Robert Stirling. The principle of the Stirling engine is based on four cyclically-recurring thermodynamic behaviors, which are graphically displayed in Picture nr.2 in the p-v and T-s diagrams.

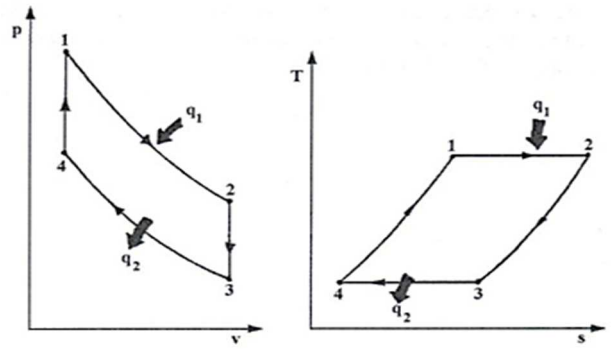

Figure 1 Thermodynamic events occurring during the Stirling cycle in the p-v and T-s diagrams

A first run running from 1 to 2 is an **isothermal expansion**, in which the working gas is heated by the continuously heated walls of the engine's hot chamber.

A second run from point 2 to point 3 is **isochoric regeneration**, which involves the internal transfer of heat from the working gas to the regenerator.

A third run running from point 3 to point 4 is **isothermal compression** in which the heat from the working gas is fed to the heat sink.

The fourth run from point 4 to point 1 is **isochoric regeneration**, in which the working gas is heated by heat from the regenerator "[1-3].

2 Piston movement in the Stirling engine

"The Stirling engine operates with an indeterminate hermetically sealed volume of working gas, which does not change with the surroundings but flows between the engine rollers and the heat exchanger, condenser and regenerator" as shown graphically in Picture nr. 2 [1,4,5].

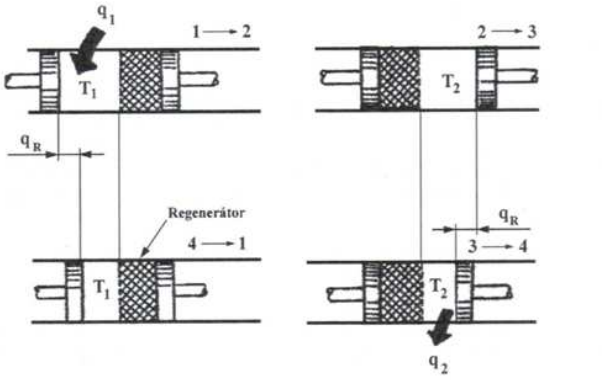

Figure 2 Piston movement in the Stirling engine

"As a regenerator, a wire or ceramic grid can be used which has high heat capacity and low thermal conductivity and serves for the temporary storage of thermal energy.
At the start of the first altimeter, running from point 1 to point 2, all the working gas is at the temperature T1 and the pressure p1 in the left chamber of the piston. With the heat supplied from the temperature source T1, the working gas heats up and thus the left piston is moved outward as a result of isothermal expansion, and a useful work is done when the pressure drops.

During the second one, running from point 2 to point 3, the two pistons in the isochoric regeneration move at the same speed to the right while the working gas is forced through the regenerator into the right cylinder chamber. During extrusion through the regenerator, the gas is cooled from T1 to T2 with T2 <T1.

During the third act, running from point 3 to point 4, the right piston moves inwards and compresses the working gas whose pressure is increased as a result of isothermal compression, while the heat from the working gas is drawn through the cooler to the surroundings.

Eventually, during the fourth act, running from point 4 to point 1, the pistons move at the same speed at the same time to the left while the working gas is forced through the regenerator where it is heated from T2 to T1.

This closes the cycle, whereby the total heat energy (qr) that the working gas passes in the regenerator during the second 2-3 is the same as during the act 4-1 when the gas is heated.

The performance and efficiency of the Stirling engine depends on the ratio of the size and stroke volume of both pistons, expansion and compression over a cycle, as well as the design of heat exchangers and regenerators" [1,6].

"With the development of the Stirling engines, the engine has fallen into oblivion, but a better knowledge of the thermodynamic events taking place in the Stirling cycle, as well as the possibility of using new materials in its design, suggest that Stirling's new engine will be able to compete very well with the classic spark ignition engine. The great advantage of the Stirling engine is its high efficiency, which is stated above 40% in top engines. It is not necessary to use noble fuels for its drive, but less valuable fuels, renewable energy sources or waste heat from different plants can also be used. Stirling's engine is less loud than spark-ignition engines. It is easy to maintain and is characterized by long-term reliability. Its shortcomings are bigger dimensions, bigger weight and a longer start time that moves in a few minutes. Despite these shortcomings, Stirling engines of the new generation can be expected to find wider application, especially in relation to the use of renewable energy sources" [1,7].

3 Means of renewable energy applications for the Stirling engine

Applying heat from renewable energy sources or waste heat that would not be used at all means driving the Stirling engine and producing energy without producing other greenhouse gases.

3.1 Application of solar energy

The application of solar energy requires in the technology in question certain technical equipment which must be ensured for continuity of operation.

The concentration of sunlight is divided into two groups:

1. concentration of sunlight using mirrors,
2. concentration of sunlight using lenses.

1. using mirrors :
   a) parabolic (hollow mirror),
   b) a set of planar mirrors.
2. using lenses:
   a) lenses-coupling.

3.1.1 Parabolic mirrors concentration

The principle of beam concentration in reflection in a parabolic mirror is as follows.

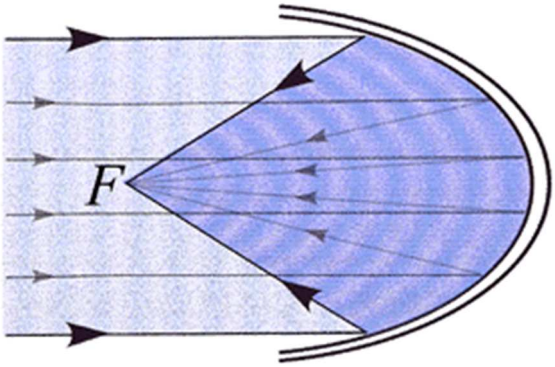

Figure 3 Parabolic mirror reflection

Picture nr. 3 shows how the light rays coming from the left reflect the hollow sphere and concentrate to a single point marked F, the focus of the mirror. In this focus of the mirror, a Stirling engine heater is located, where concentrated sunshine reflected from the mirror has a diameter of up to 17 meters in some types. Radiation is densified to one point [8].

At this point temperatures of 600 to 1200 degrees Celsius are achieved. The efficiency of sunlight conversion to electrical energy when applying the Stirling engine in the parabolic focus is 31.25%. When using photovoltaic panels made of polycrystalline silica, the efficiency is between 12 and 14%.

Figure 4 Grouping of planar mirrors into a parabolic shape

In Picture nr. 4, a group of 82 mirrors is concentrated into 1 focus. Each of these devices can produce up to 60,000 kW of electricity annually. Over the next few years, more than 70,000 Sun Catchers will be exposed in sunny

California, which can produce electricity for up to 1 million high-energy US households [9].

3.1.2 Concentration using clutch lens

The flow of light rays through the clutch lens is directed from left to right (Fig. 5). On the right, after the lens passage, the beam is grouped in a focal point marked F.

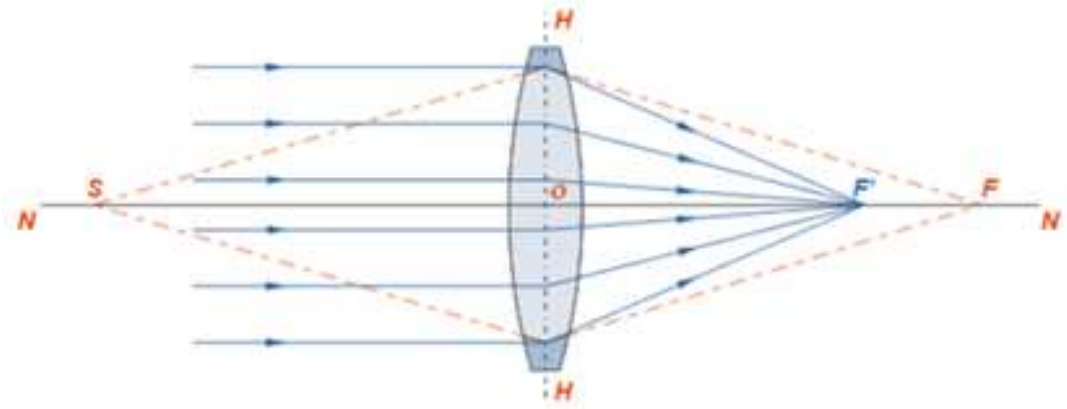

Figure 5 Flow of light rays through clutch lens

Figure 6 Lightening the light flow to 1 point by the lens coupling

In the Fig. 5 and Fig. 6 we can observe the condensation of the heat flux of the solar radiation centered in the focus by the clutch lens. This system is still very little used in the production of electricity by Stirling engines, as a considerable amount of money is needed to produce such a lens [10]. The mirror is the much cheaper form.

3.2 Utilization of thermal energy by combustion of biomass

"Because of the different forms of biomass, the energy contained in it is different. The energy content of dry plants (moisture content 15-20%) is about 14 MJ / kg. Fully dry biomass can be compared to coal with a calorific value of 10 to 20 MJ / kg for brown coal and about 30 MJ / kg for black coal. At the time of collection, however, the biomass contains a considerable amount of water ranging from 8 to 20% for straw, 30 to 60% for wood. The water content of the manure from which biogas is obtained is 75 to 90% and in some aquatic plants, hyacinth up to 95%. On the other hand, the water content of coal is between 2 and 12%. For this reason, the biomass energy at the time of collection is usually lower than that of coal. However, the chemical composition of biomass makes it a substantially more environmentally friendly fuel than coal. This is related to the fact that biomass has a lower sulfur content than coal. The ash incineration content is also lower than coal, and the ash does not contain toxic metals and other contaminants and can be used as a fertilizer for its nutrient content"[11]. From our experience, we can conclude that biomass derivatives have the greatest potential in terms of calorific value and water content of straw, whose water content reaches only 15% and energy gain up to 4 kW / kg. Interesting fuel, but the product of plant production is rape oil, whose energy gain is 10.3 kW / kg.

3.2.1 Stirling's engine powered by biomass fuel

Compared with traditional fuels that heat the Stirling engine heater, they are on the other hand, the more often biomass products. In this context, biomass products can be understood in particular as: wood sawdust, wood chips, straw, wood waste, bio oils.

A unique and successful cluster of scientists and engineers in Stirling engine powered by biomass would find up to 1,600 km towards North in the capital of Denmark, Copenhagen, at Stirling DK, a Danish Technical University. Their interest is mainly in the Stirling engine, which could operate in separate buildings and on the principle of cogeneration would provide energy self-sufficiency in the field of heat and power generation.

4 Conclusion

The engine was designed for low maintenance and long service life. The engine is rated at 100,000 working hours,

which means approximately 4166 days, ie over 11 years, with service intervals every 4000 to 8000 hours, i.e. every 166 to 333 days.

The original proposal was based on 15 years of R & D at the Technical University of Denmark, Copenhagen. 9 engines have been designed and tested for over 30,000 hours. Research and development is currently geared towards increasing efficiency and implementing new ideas. In Chapter 3.2 and in Chapter 3.2.1, I present applications that are addressed by scientists and students at the Technical University of Copenhagen, Denmark.

References

[1] BRANDHORST, H.W., RODIEK, J.A.: *A 25 kW Solar Stirling Concept for Lunar Surface Exploration*, In International Astronautics Federation. Proceedings of the 56th International Astronautical Congress. IAC-05-C3.P.05., 2005. Retrieved 2012-03-18.

[2] Carbon Trust (2007). "Micro-CHP Accelerator — Interim Report — Executive summary". Retrieved March 19, 2012.

[3] COOKE-YARBOROUGH, E.H., FRANKLIN, E., GEISOW, J., HOWLETT, R., WEST, C.D.: *Harwell Thermo-Mechanical Generator*, Proceedings of the 9th IECEC. San Francisco: American Society of Mechanical Engineers. pp. 1132–1136. Bibcode:1974iece.conf.1132C, 1974.

[4] COOKE-YARBOROUGH, E.H.: *Heat Engines*, US patent 3548589. Granted to Atomic Energy Authority UK, 22 December 1970, 1970.

[5] COOKE-YARBOROUGH, E.H.: *A Proposal for a Heat-Powered Nonrotating Electrical Alternator*, Harwell Memorandum AERE-M881, 1967.

[6] CHUSE, R., CARSON, B.: *Pressure Vessels, The ASME Code Simplified*, McGraw–Hill. 1992.

[7] FINKELSTEIN, T., ORGAN, A.J.: *Air Engines*, Professional Engineering Publishing, 2010.

[8] HARGREAVES, C.M.: *The Philips Stirling Engine*, Elsevier Science, 1991.

[9] HARRISON, J.: *What is micro generation?*, Claverton Energy Research Group, 2008.

[10] PASCO Scientific: *Instruction Manual and Experiment Guide for the PASCO scientific Model SE-8575*, Retrieved 2009-01-18, 1995.

[11] Precer Group: *Solid Biofuel-Powered Vehicle Technology*, Retrieved 2009-01-19, 2009.

Review process
Single-blind peer review process.

Acta Tecnología – International Scientific Journal about Technologies
Volume: 4 2018 Issue: 2 Pages: 25-28 ISSN 2453-675X

doi:10.22306/atec.v4i2.35
Received: 16 May 2018
Accepted: 30 May 2018

BASIC PRINCIPLES OF SAMPLE PREPARATION FOR PROTEOMIC ANALYSIS

Marianna Trebuňová
Technical University of Košice, Faculty of Mechanical Engineering, Department of Biomedical Engineering and Measurement, Letná 9, 042 00 Košice, Slovakia, marianna.trebunova@tuke.sk (corresponding author)
Jozef Živčák
Technical University of Košice, Faculty of Mechanical Engineering, Department of Biomedical Engineering and Measurement, Letná 9, 042 00 Košice, Slovakia, jozef.zivcak@tuke.sk

Keywords: proteins, proteomics, sample preparation
Abstract: Proteomics studies and evaluates all proteins found in cells, tissues, organisms in terms of quantity, structure, function, and their interaction. An important step in this discipline is the preparation of the studied sample. Proteomics evaluates the samples obtained from patients from body fluids and tissues, this step is the starting point of the whole methodology.

1 Introduction, analysis of proteomics samples

Proteomics studies and evaluates all proteins found in cells, tissues, organisms in terms of quantity, structure, function, and their interaction. An important step in this discipline is the preparation of the studied sample. Proteomics evaluates the samples obtained from patients from body fluids and tissues, this step is the starting point of the whole methodology [1].

The main goal of the proteomic approach is global protein analysis. To achieve this goal, methods such as 2D electrophoresis, mass spectrometry type - electrospray ionization, matrix-assisted laser desorption ionization associated with flight time detection and fragment detection by tandem mass spectrometry are used.

In order to get the right results in the study of proteins using the techniques already mentioned, the first step is the correct preparation of a sample obtained from the patient, Figure 1.

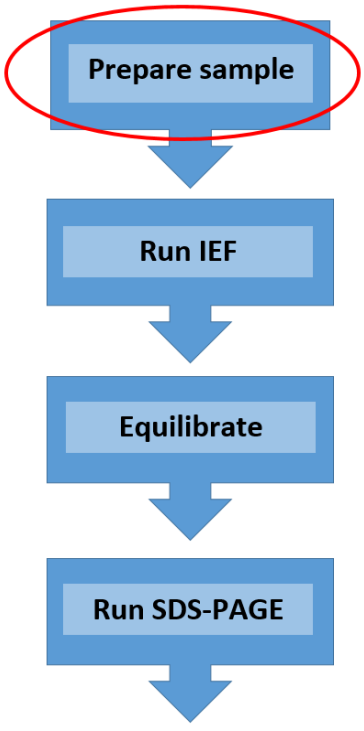

Figure 1 Schematic part of proteomics

2 Sample preparation

Sample preparation by proteomic analysis consists of the individual steps that are shown in the diagram, Figure 2.

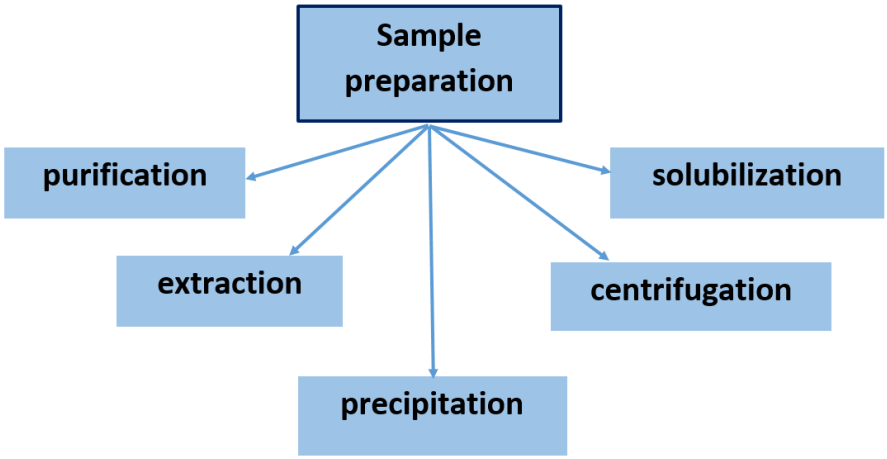

Figure 2 Sample preparation in individual steps

2.1 Purification

Protein purification is a series of processes intended to isolate one or more proteins from a complex mixture, usually cells, blood, plasma, serum or parts of tissue. Protein purification is important for characterizing their function, structure and protein interactions. In this process, protein and non-protein can be separated or the desired protein is separated from all other proteins. Separation of one protein from all others is usually very demanding. Separation steps usually use protein-protein differences, physicochemical properties, binding affinity, and biological activity.

Methods used to purify proteins can be roughly divided into analytical and preparative methods. The decisive factor is the amount of protein that can be purified by the method.

The aim of analytical methods is detect and identify the protein in the mixture, while the aim of preparative methods is produced a large amount of protein for other purposes, for example for industrial and biomechanical applications. Analytical purification produces a relatively small amount of protein for various research or analytical purposes, including identification, quantification and study of protein structure, post-translational modifications and functions.

Preparative methods use commercial products such as enzymes (e.g. lactases), nutritional proteins (e.g. soy protein isolate) and some biopharmaceuticals (e.g. insulin) [3].

2.2 Extraction

Depending on the source, the extracted proteins must be obtained in solution, so it is necessary to break the tissue or cells. There are several ways to achieve this: Repeated freezing and thawing, ultrasonication, high pressure homogenisation, filtration, or permeabilization with organic solvents. The method depends on how fragile or robust the protein is. Soluble proteins in the solvent may be separated from the cell membrane, e.g. centrifugation. Also, proteases that digest proteins in solution are also used. If the protein is sensitive to proteolysis, it is necessary to proceed quickly and the extract must be in a cold thermoregulatory environment, this slows the proteolysis process itself.

2.3 Precipitation

For mass purification of proteins, the first common step in protein isolation is precipitation with ammonium sulphate $(NH_4)_2SO_4$. This is accomplished by the gradual addition of ammonium sulfate to form a protein precipitate. Ammonium sulfate can be removed by dialysis. The precipitated protein will be large enough to be visible to the eye. One of the advantages of this method is that it is inexpensive and suitable for large volumes.

The purification of integral membrane proteins requires the disruption of the cell membrane to isolate one particular protein from the others in the same membrane space. Sometimes the membrane fraction can be isolated first, for example, it is necessary to isolate the mitochondria from the cells before purifying the protein found in the mitochondrial membrane. A detergent such as sodium dodecyl sulfate (SDS) may be used to dissolve cell membranes. However, because SDS causes denaturation, it is better to use milder means, such as Triton X-100, to preserve native conformation of proteins.

2.4 Centrifugation

Centrifugation is a biomechanical process that uses centrifugal forces to separate particles of different masses or densities dispersed in the liquid.When the tube, with a mixture of proteins or other particles, rotates at high speed, the particle suspension is rotated in a centrifuge. On the bottom of the tube, pellets are formed where heaviest particles are. The incompatible particles remain mostly in the liquid, in the supernatant, and can be removed from the pellet by pipetting. The spin speed is determined by the angular acceleration applied to the sample. This is usually measured as compared to gravitational acceleration [2].

2.5 Solubilization

The solubility (influence of ionic strength) of proteins at low ionic strengths increases with the salt concentration - salting in. This is because, at low ionic strengths, attractive interactions exist between protein molecules. Through back-charged portions of these molecules, their solubility is reduced. By increasing the salt concentration, the magnitude of these interactions decreases, thereby increasing the solubility. By increasing the salt concentration, the magnitude of these interactions decreases, thereby increasing the solubility. At very high ionic strengths, the charges on the protein molecules are shielded ⇒ there are only very weak electrostatic interactions between the protein molecules leading to low solubility. This phenomenon is called salting out. Salting out is one of the most important processes for the isolation and purification of proteins.

3 Izoelectric focusing

The first step of 2D electrophoresis (SDS-PAGE) is isoelectric focusing (IEF), Figure 3.

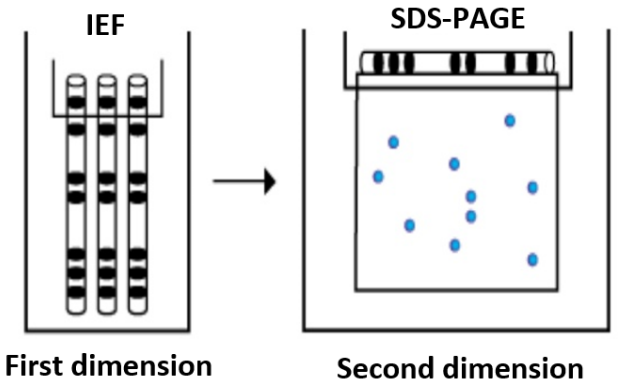

Figure 3 Separation of proteins ***Chyba! Nenašiel sa žiaden zdroj odkazov.***

Division by this method is after application of voltage, by migration of proteins in a variable pH environment. In a basic environment, the proteins have a negative charge and are therefore traveling to the anode. In the acid environment, on the contrary, the total charge is positive and they are traveling to the cathode. At a pH equal to the isoelectric point, pI, the molecule is neutral and focuses at this point because at this point the total charge of the protein is zeroed. The isoelectric point (pI) is the pH value of the solution at which the molecule, resp. the set of all molecules originating from the starting molecule in the solution is electroneutral, i.e. it has no electrical charge.

The protein breaks out of the isoelectric point immediately as soon as it gets the charge, and it returns back to the isoelectric point due to the tension. By means of isoelectric focusing, we can achieve protein separations. They differ in isoelectric points by only 0.01. Isoelectric focusing takes place on IPG strips, Figure 4.

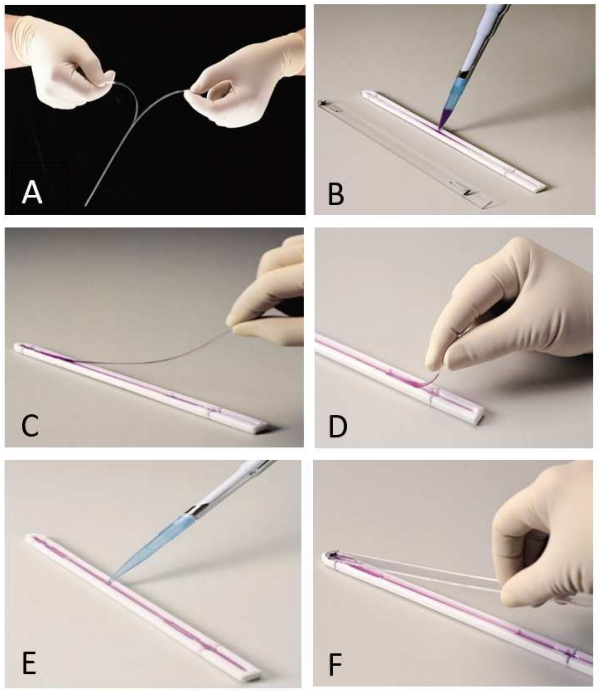

Figure 4 IPG strip: A: remove protective film, B: Apply rehydration solution to the strip, C: wet entire length of IPG strip in rehydration solution by placing IPG strip in strip holder (gel facing down), D: gently lay entire IPG strip in the strip holder, placing the end of IPG strip over cathode electrode. E: protein sample can be applied at sample application well following the rehydration step if the protein sample was not included in the rehydration solution, F: place cover on strip holder [3]

The strips are inserted into the IEF. High voltages (up to several tens of kilovolts) are used [4,5].

4 Conclusions

Different types of cells contain different proteins, so proteome of a cell will be different from another cell proteome. In addition, cells that are the result of diseases such as cancer, have a different proteome than normal cells. For this reason, understanding the "normal" proteome of a cell is critical to understanding the changes that occur as a result of the disease. This knowledge can

lead to an understanding of the molecular basis for diseases that can then be used to develop treatment strategies.

Acknowledgement
This article was supported by the state grants KEGA 069TUKE-4/2017(50%) of the Ministry of Education of the Slovak Republic and APVV-15-0356 (50%) MEDPEEK.

References

[1] www.fnspba.sk/aktuality-subory/postery/C19.ppt, 2018. (Original in Slovak)
[2] http://en.wikipedia.org/wiki/Protein_purification, 2018.
[3] https://www.slideshare.net/sindoori/iso-electro-foucing-nitu, 2018.
[4] ŽIVČÁK, J., TREBUŇOVÁ , M.: Basic principles of isoelectric focusing in biomedical engineering, Transfer inovácií, Vol. 2013, No. 28, pp. 222-224, 2013.
[5] TREBUŇOVÁ, M., LAPUTKOVÁ, G., Živčák, J.: Izoelektrická fokusácia v biomedicínskom inžinierstve, Transfer inovácií, Vol. 2013, No. 28, pp. 225-228, 2013. (Original in Slovak)

Review process
Single-blind peer review process.

Acta Tecnología – International Scientific Journal about Technologies
Volume: 4 2018 Issue: 2 Pages: 29-32 ISSN 2453-675X

doi:10.22306/atec.v4i2.36
Received: 20 May 2018
Accepted: 04 June 2018

SURFACE TOPOGRAPHY OF COMPOSITE REINFORCED WITH FIBRES FROM USED TYRES

Lucia Knapčíková
Technical University of Košice, Faculty of Manufacturing Technologies with a seat in Prešov, Department of Industrial Engineering and Informatics, Bayerova 1, 080 01 Prešov, Slovak Republic, lucia.knapcikova@tuke.sk

Keywords: atomic force microscopy, used tyres, matrix, polyvinyl butyral, PVB
Abstract: This paper aims to study the surface topography of composite reinforced by fabric from used tyres. By the research was used an atomic force microscopy (AFM). AFM can drive the force between the sense probe and the surface and the in Z axis can move piezo and sensor. The composites were reinforced with fibres from used tyres. After homogenization the thermoplastics matrix and fibres from used tyres we pressed test specimens and after this technology was material tested by atomic force microscopy. Generally we can say, therefore, it provides important information about the surface of the display material and its properties that are necessary to know for the further examination, in particular for of utilization the material and displayed by using atomic force we can get a clearer idea of the investigated materials and other behavior in a various mechanical tests.

1 Introduction

Atomic force microscopy, mainly AFM operates in a constant amount or under constant force (load) and according to the required feedback between the carrier and piezo. If the feedback is week while surface capturing, amount of the piezo and sample remains unchanged and the rate of change on the surface (of relief) is bending carrier with tip. In this case, the force between the tip and the surface varies. If the feedback is strong, piezo amount varies according to the surface relief in order to bending of the carrier with the tip and thus the transmitted power were constant. [1,2,4] AFM can drive the force between the sense probe and the surface and the in Z axis can move piezo and sensor. Mostly is used just constant load mode, for example in a situation when there are not display surfaces of samples with solid periodic structures, but fragile organic samples as DNA, protein, blood cells, Langmuir-Blodgett films, and polymers adsorbed on a particular substrate. In constant height mode would be possible to result in a large radius of the carrier, formation of a major forces between the tip and the surface and thereby to infringe the organic adsorbates. Constant height mode can also cause damage to the surface with fairly rugged topography. [3,4] The rugged relief is also present in the composite materials reinforced with textiles from worn tires. Characteristics of composite material depend on various factors. Among the most important belong, characteristics of the fibers and the polymer matrix, fiber content in the composite, fiber length and orientation, the nature of interfacial interface and method for composite manufacturing. By unidirectional oriented fibers in the composite materials is obtained by far the largest improvement of properties. In terms of choice of fibers is important that the the mechanical properties of the fibers (σ f , E f) were significantly higher than the properties of the matrix (σm, Em). In the selection of the polymer matrix is important that the extension of the matrix (σm) was greater than the extension of the fibers (σf). Overall, it must therefore apply:

$$\sigma_f >> \sigma_m \quad (1)$$

$$E_f >> E_m \quad (2)$$

$$\sigma_f < \sigma_m \quad (3)$$

Impact of fibre content is as important as choosing the fibres themselves. [2-5] For the specific type of the composite is therefore essential to set the lowest content of the fibres, referred to as ($n_{f\ krit}$), that will achieve improvement of mechanical properties. It is therefore very important that $n_f > n_{krit}$. The actual orientation of the fibres in the composite is critical not only for the final application properties, but in terms of the choice of appropriate processing technology. The relevant product ion technology is the technologically intensive; the higher criteria are placed on the orientation of the fibres. Therefore, it is necessary to specify in which direction in relation to the orientation of the fibres will be products stressed when designing the resulting application properties of the composites. Longitudinal strength direction is termed an index X_1 and S_1, and depends in particular on the fibre content in the composite. Typically, S_1 is directly proportional to the fibre content in the composite. About the transverse strength (S_2, S_Y), determines the strength of the polymer matrix and the interfacial strength of the interface, while the strength of the fibre does not have effect on this quantity virtually. Shear strength depends primarily on the angle of force. [8,9] At unidirectional and face oriented fibers is a hallmark anisotropy of properties (anisotropy, i.e. the dependence of the physical properties of the substances from the direction of force). It is known that the strength of the composite in the direction of fiber orientation, i.e., longitudinal is substantially higher than in the direction

perpendicular to the axis of the fiber in composites with face orientated fibers longitudinal strength is the same as transverse. In the case of the face oriented fibers (laminates) are properties of the composites isotropic in each individual level, but in the direction perpendicular to the axis of the fibers are substantially lower. Isotropic properties are achieved in composites with spatially orientated fibers. In the selection of matrix for the application, it is necessary to consider application and production properties of the polymer. In the case of a thermosetting matrix in terms of application properties of composites has important role: strength, elongation in tension, toughness, heat resistance, UV resistance, chemical resistance, moisture absorption, flammability and dielectric properties. In terms of the selection of manufacturing technology is mainly viscosity, the wettability of fibers, shelf life, rate of curing, the volatile products, by-products of the curing. A deeper study of the issue polymers is dedicated to scientific literature, for example G.H. Michler in publication "Electron Microscopy of Polymers" [13] Nielsen in "Composite materials, properties as influenced by phase geometry" [16] Thomas G. Mezger in "The Reologhy Handbook" [11].

2 Experimental Procedure

2.1 Atomic force microscope using by scanning of surface topography

AFM is used sharp point to measure surface of the sample, several tens of microns long, which is formed at the free end of the spring bar. The spikes are mainly made of silicon or Si3N4, the radius of the tip of such a spike is 2 ÷ 20 nm. The bar captures interaction force between the tip and surface of the sample [1,3,7]. Piezoelectric crystal with a bar that is fastened thereon, moves (rasterized) in the x and y plane (parallel to the surface of the sample). A sharp point follows the irregularities at the surface of the sample and according to the relief and bends in the z direction (perpendicular to the surface of the sample). Bar bending detection is based on optical principles. The beam of a laser diode is incident on the tip and it is reflected on the photodetector. It is divided in two or four sensitive parts. Before the actual scanning system is mechanically adjusted so that the beam power turned out same to all parts of the photodetector. [6,8] When measuring the deflection of the beam reflected by moving traces of the reflected beam, so energy falling on each of the detector is no longer the same and from their ratio it is possible to determine the deflection of the beam. Quadrant detector allows detecting the movement of the light spot in the horizontal direction, thus deflection of the beam (Lateral Force Microscopy - LFM). [5,9,10] The detector is able to register a change of position of the beam from one nanometer. The ratio of the beam between the bar and detector to the length of the bar causes mechanical amplification. This results in that the system can detect the vertical movement of the bar below 0.1 nm. [12,13,14] Bar deflection is recording during measurement and with the help of other program processing is generated resulting surface topography. The tip that is very close to the surface particular act short-range repulsive forces of electrostatic origin (presented as overlap of electron orbitals of the atoms or molecules of the surface of the tip and the sample) and the long-range, the attractive van der Waals forces (that is, dipole-dipole force interaction). The exact quantum-mechanical calculations of these forces for the system of atoms of the tip and the surface is quite complex. The influence of both forces can be modeled, for example as empirical Lennard-Jones potential. The interaction of tip - sample for the potential we can use relationship:

$$V(r) = 4\varepsilon\left[\left(\frac{\sigma}{r}\right)^{12} - \left(\frac{\sigma}{r}\right)^{6}\right] \quad (4)$$

Where r is the distance of the tip from the the sample, σ, ε are specific Lennard-Jones parameters. Proportional member (1 / r) 12 describes the field of repulsive force, the member proportional to (1 / r) 6 area attractive force [3].

2.2 Material characterization

Mixing of polymers produces a mixture of two or more polymers, with non-polymeric additives (e.g. fillers, plasticizers etc.). For preparation of composite was used continuous mixing of various mixtures. For continuous mixing of polymers in the modern production lines is used twin-screw mixing equipment. Thermoplastics are almost exclusively prepared on twin-screw devices less demanding mixing on single-screw devices with the inclusion of kneading and mixing elements. [3,4,8] Twin-screw extruders have two screws in the housing that can be positioned to their threads overlap one another or they are positioned without mutual overlap. For preparation of the compositions are used only twin-screw devices with mutual overlaps of threads. The direction of rotation of the screw can be affirmative or controversial. Modern twin-screw devices are constructed segmental, i.e. the elements (threads) can be exchanged on the core or rearrange [2,4,6]. In our case we used for the homogenizing the mixture twin-screw auger and the specific device for kneading polymers Plastic-Corder W 350 E, Brabender (Germany). Kneading itself was preceded by determining the weight of the sample required for the first kneading and later for pressing. In our case was total weight of the mixture 200 g. The first step was to heat the machine to the required operating temperature. The heating took 10 minutes, after the temperature reached 100 ° C was added into the feeding tube polyvinyl butyral (PVB), homogenization time was 20 minutes, after the completion of the homogenization of the first component are subsequently added to mixture the amount of fabrics, we need to used weight in order to out the whole required amount the into the kneading machine. Homogenization, already with fabric, it lasted 30 minutes. The whole kneading process was set to a time of 60 min.

For further homogenizing of the ingredients with a higher proportion of the fabrics, , the period was shortened by approximately 10 minutes, since the machine has already been heated up to working temperature. Homogenization of pure thermoplastic PVB (without addition of the fabric) was set for time of 30 minutes [4,7].

2.3 Specimen Preparation

Feed material is a composite material made from used tires, in particular from the textile component as the filler and the matrix - polyvinyl butyral (PVB), which was obtained by after the recycling of car windshields. The test sample was a material containing 10% fabrics and 90% PVB.

Table 1 Measurement characteristics [4]

Equipment	Solver Scanning Probe Microscope (Russia)
Scanning bar	NSG01 Golden Silicon Probe (NT-MDT)
Length of the bar	130 µm
Width of the bar	35 µm
Thickness of the bar	1,7-2,3 µm
Scanning frequency	115-190 kHz
Scanning strength	2,5-10 N/m
Scanning mode	semi contact, phase contact

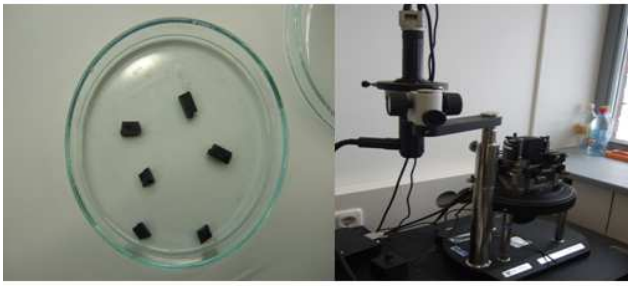

Figure 1 Specimen preparation for AFM testing (left side) and AFM equipment (right side) [4]

3 Results and discussion

Utilization of Atomic force microscopy has just an irreplaceable position for studying the surface topography of various materials and also thermoplastics. Therefore, it provides important information about the surface of the display material and its properties that is necessary to know for the further examination as to the utilization of the material [3,4]. The following figure shows the color scheme that displays the values mean in how "deep" the sample was situated at the time of measurement. More specifically, the movement of the bar across the surface of the sample, in view of the fact that for measuring is required a minimum amount of sample about 20 mg. The sample was adjusted for the preparation with a knife, for comparison was prepared also a sample by fracture after treatment with liquid nitrogen [15]. From images is visible inequality of area, textile fibers course, the presence of rubber particles and also cavities incurred after dropping the rubber particles after the breaking of the sample. The 3D view also helps to imagine how is in materials arranged fiber of fabric. Figure shows the display 50x50 microns of the height. The analyses were performed with the sample frozen with liquid nitrogen. [2,3] The figure shown cavity (black), according color scheme, we can see that the darker the color is, the deeper penetrated the scanning bar in the sample. [4,5] Figure shows a 3D view of the sample under consideration. It is seen that fracture by liquid nitrogen was broken rubber compound, giving us interesting view of the sample - cavity (crater) in view examined material. Third in the series is displayed using the form of a phase, where there is surface tracking in the direction of fibers.

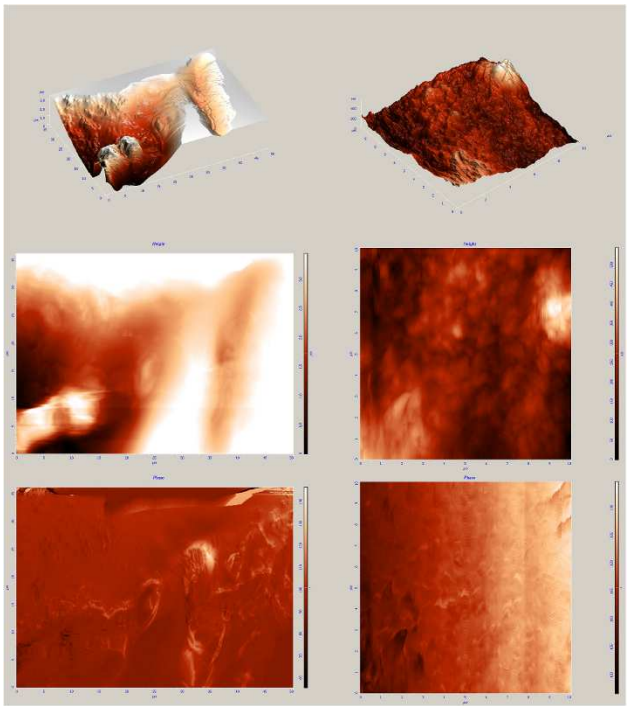

Figure 2 Results from AFM analysis (left side: 90%PVB and 10% Fabric, 50x35, 3d height, height and phase contrast. Right side: 90% PVB and 10% Fabric, 10x10, 3d height, height and phase contrast)

4 Conclusion and future direction of research

Atomic force microscopy application is primarily used for research probing of samples. Currently, has an irreplaceable position in the study of surface topography of various materials such as composite materials. We can say, therefore, it provides important information about the surface of the display material and its properties that is necessary to know for the further examination, in particular for of utilization the material. Displayed by using atomic force we can get a clearer idea of the investigated materials and other behavior in a various mechanical tests.

- For these types of composites by AFM was seen that the structure is distorted in places rubber compound, which was located in the fabrics.
- This disruption could cause defects for example in tensile test, when the material does not meet predetermined load.

References

[1] AVERY, J.: *Injection Moulding Alternatives*, Carl Hanser Verlag., 1998.
[2] ŠOLTÝS J, MARTAUS, J.: *Výskum povrchov metódou atómovej silovej mikroskopie*, Elektrotechnický ústav, SAV, Bratislava, 2009. (Original in Slovak)
[3] KNAPČÍKOVÁ, L: *Štúdium povrchu termoplastov pomocou mikroskopie atomárnych síl*, Plastics Production, 2011. (Original in Slovak)
[4] KNAPČÍKOVÁ,L: *Optimalizácia technologických procesov pri zhodnocovaní plastov*, Dissertation, Technical University of Kosice, 2011. (Original in Slovak)
[5] KLUVÁNEK P.: *Dlhá cesta k atómovému rozlíšeniu*, http://www.sav.sk/. Accessed 25 November. 2015. (Original in Slovak)
[6] HUYNH H, RAGHAVAN D, FERRARIS CF.: *Rubber particles from recycled tires in cementitious composite materials*, In: National institute of standards and technology, Washington, 1994.
[7] LIPTAKOVA, T., ALEXY, P. et al. *Polymérne technické materiály*, Vysokoškolská učebnica, Bratislava, 2009. (Original in Slovak)
[8] MADEJOVA, J.: *Infračervená spektroskopia*, SAV, Ústav anorganicke.j chémie, Bratislava, 2009. (Original in Slovak)
[9] MENGES G.: *Werkstoffkunde der Kunststoffe*, 4. Auflage, Carl Hanser Verlag, München,1998. (Original in German)
[10] MEZGER G.T.: *The Rheology Handbook*, 2nd ed.,Vincentz Network, Hannover, 2009. (Original in German)
[11] MEZGER, G.: *Das Rheologie Handbuch*, Vincentz Verlag, Hannover, 2000. (Original in German)
[12] MICHAELI, K.: *Training in Injection Moulding*, Carl Hanser Verlag, Berlin, 2001.
[13] MICHLER, G.H: *Electron Microscopy of Polymers*, Springer Verlag Berlin Heidelberg, 2008.
[14] MORTENSEN, A.: *Concise encyclopedia of composite materials*, Elsevier, London, 2007.
[15] MUELLER, M.: Hybrid composite materials on basis of reactoplastic matrix reinforced with textile fibres from process of tyres recyclation, *Agronomy Research*, Vol.13, No.3, pp. 700-708, 2015.
[16] NIELSEN L. F.: *Composite materials, properties as influenced by phase geometry*, Springer-Verlag, Berlin, 2002.

Review process
Single-blind peer review process.

.