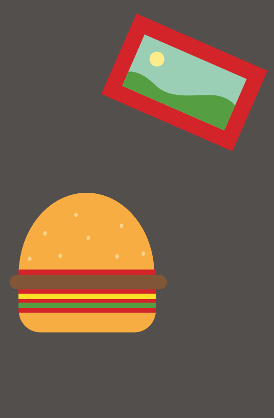
LUCIA MONICA SCORȚAR
ALEXANDRU CHIȘ

MERCHANDISE QUALITY ANALYSIS

PRACTICAL WORKS AND CASE STUDIES



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Practical works and case studies

PRESA UNIVERSITARĂ CLUJEANĂ

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Argument

This material serves as a useful tool for the preparation and implementation of practical works in the discipline *Study of Merchandise and Quality Assurance* intended for students of the Faculty of Economic in Cluj-Napoca. The content is designed to meet the requirements of the course syllabus. For the practical works, the most relevant quality characteristics for product evaluation have been selected, considering their importance in defining the utility of goods and the significant interest consumers have in them.

Every product possesses quality characteristics that can be measured through organoleptic and physic-chemical laboratory methods. Knowledge of these characteristics, as well as the methods for their evaluation, is essential for assessing the quality of goods.

Consequently, assessing the quality of goods requires future specialists in the economic field to have thorough knowledge of the characteristics of the products they commercialize and to use the most efficient methods for determining these characteristics.

Through the practical works presented below, students will learn how to evaluate the quality of goods in compliance with legislative regulations and product standards.

The content of this workbook for practical works complements and reinforces the theoretical knowledge provided in the *Study of Merchandise and Quality Assurance* course, contributing to the practical training of students.

Authors

CONTENT

Practical work 1

METHODS FOR ASSESSING QUALITY OF SOLID PRODUCTS

The assessment of product quality is a complex operation that involves both understanding the properties of the products and the methods and methodologies for determining these properties. The properties of products are attributes that confer a specific utility value, and the factors that determine these properties are the raw materials and the technological manufacturing processes. These properties are defined in standard as quality characteristics of the products. Understanding these properties is important for:

- Establishing a common language between the supplier and the customer
- Setting the price of products
- Maintaining quality throughout the supplier-customer chain.

For solid products, the most important quality characteristics that are part of contracts and analysis bulletins, which must accompany the products at the time of sale, and which will be addressed in this practical work, are: mass, water content (hygroscopic moisture), mineral substances (ash content), product hardness.

1. PRODUCT MASS

Mass is an exceptionally important physical properties and represents the quantity of substances in a particular body (goods or products).

Depending on the diversity of products and the type of goods, we distinguish:

- **Mass per unit of length (m/l):** Relevant for textile products.
- **Mass per unit of surface area (m/m²):** Applicable to items such as leather, paper, carpets, etc.
- **Mass per unit of volume (m/m³):** Used for construction materials.

Mass is determined by weighing, using weighing instruments called balances. Balance is the most important tool for quantitative analysis. The unit of mass measurement in the International System of Units (SI) is kilogram (kg).

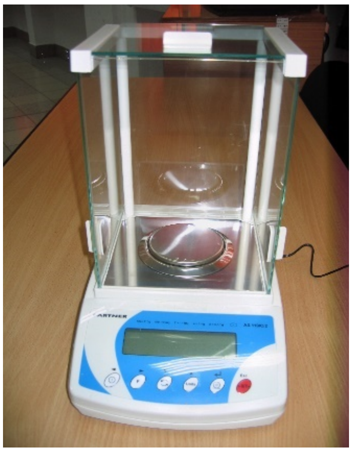


Figure 1. Analytical balance

The analytical balance is a precise weighing instrument used to measure small masses with high accuracy, often down to fractions of a milligram. It is commonly used in laboratories for quantitative analysis, quality control, and other applications requiring exact measurement of product mass.

Its design usually includes a draft shield to prevent air currents from affecting the measurement, ensuring reliable and repeatable results. Analytical balances are essential tools in assessing the mass of solid products, especially when precise data are required for quality evaluation.

2. HYGROSCOPIC MOISTURE

Hygroscopic moisture refers to the amount of water absorbed by a product from the surrounding environment. This type of moisture is held on the surface or within the pores of solid products and can vary depending on humidity and temperature conditions.

In quality assessment, measuring hygroscopic moisture is important because it affects the physical properties, shelf life, and usability of products. For example, excessive moisture can lead to spoilage, changes in texture, or reduced strength. Hygroscopic moisture is determined using a drying oven.

Figure 2. Drying oven

3. ASH

Ash is the solid inorganic residue remaining after the combustion of a product in an electric furnace. It represents the mineral content of the product, including elements such as calcium, potassium, magnesium, and other mineral salts.

The ash content is an important quality characteristic because it reflects the amount of non-combustible material present in the product. High ash content may indicate impurities or additives, which can affect the product's purity, performance, or nutritional value (in the case of food products).

Figure 3. Electric furnace

4. **PRODUCT HARDNESS**

Hardness is a critical physical property that reflects a material's ability to resist deformation or penetration by another object of superior hardness. This property is important for assessing the durability and usability of materials and products, particularly solid goods.

The hardness of a material can be determined using various methods, depending on the material type and the intended application.

Assessing the quality of solid fuels

Solid fuels are combustible materials in solid form used as a source of energy. Solid fuels are widely used across industries and domestic sectors due to their high energy density and availability:

- *power generation*: coal-fired power plants
- *industrial processes*: metallurgy, cement production, and chemical industries
- *domestic use*: heating and cooking in specific regions
- *raw materials*: feedstock for chemical synthesis (fertilizers, synthetic fuels).

Solid fuels are broadly categorized based on their origin and the processes involved in their formation or production. The two main categories are natural solid fuels and artificial solid fuels.

1. *Natural fuels*: are derived directly from natural sources without significant processing or modification. They are primarily formed through geological processes over millions of years (fossil coals, wood, agricultural and forest residues)
2. *Artificial fuels*: are manufactured by chemically or thermally altering natural fuels or organic matter. These processes improve their properties, such as energy density, burning efficiency, and emissions (semi-coke, metallurgical coke, petroleum coke, etc.)

Coal constitutes an important source of thermal energy and a valuable raw material for the chemical industry. The structure and chemical composition of coal are the basic elements for developing technological processes for its processing.

The chemical composition of coal includes three main components:

- *Organic matter* composed of carbon (C), hydrogen (H), oxygen (O), nitrogen (N), and sulfur (S)
- *Inorganic matter* is composed of alkaline and alkaline-earth silicates, sulfates, carbonates, iron, etc.
- *Water*

The main component of coal, from an energy perspective, is carbon, whose content determines the classification of coal into the following varieties:

Table 1: Types of coal: carbon content

TYPE OF COAL	CARBON CONTENT [%]
Lignite	30 - 65%
Brown Coal	67 - 79%
Bituminous Coal	76 - 90%
Anthracite	89.5 - 96.5%

During the combustion process, the substances that make up the inorganic matter almost entirely convert into ash, a non-combustible component that reduces the calorific value of coal.

Water is another component that, on one hand, decreases the percentage of combustible mass and, on the other hand, consumes a certain amount of heat to transform into vapor.

For some types of coal, their chemical composition and higher calorific value are presented in the following table:

Table 2: Types of coal: chemical composition and higher calorific value

COAL VARIETY	LOCATION	Wh %	A %	K %	V %	Sulfur %	Higher calorific value (kcal/kg)
ANTHRACITE	Schela	3.8	3.4	89.3	3.5	0.3	7400
ANTHRACITIC BITUMINOUS	Lupeni, Baia Mare, Doman	3.0	16	75.0	6.0	1.0	6100
		2.0	20	65.0	10.0	1.0	5800
LOW-VOLATILE BITUMINOUS		3.5	9.5	68.0	19.0	0.5	7200
COKING COAL	Anina	5.0	11	56.0	28.0	0.5	7000
FAT COAL	Secu	2.0	19	54.0	25.0	0.8	6400
	Cozla	4.5	20	48.0	27.0	0.5	5800
GAS COAL	Lupeni	5.0	12	46.0	37.0	2.5	6700
BROWN COAL (BITUMINOUS)	Aninoasa, Petrila, Lonea	5.5	13	43.0	38.5	3.0	6300
BROWN COAL AND LIGNITE	Comăneşti	12.0	18	34.0	36.0	2.5	4600
	Codlea	8.0	20	37.0	30.0	0.6	4800
PEAT	Carei	30.0	19	21.0	29.0	1.0	3000

Assessment of the standard quality of coal is done by determining the following characteristics: moisture, volatile matter, coke carbon (fixed carbon), and ash.

Determination of hygroscopic moisture of coals

Principle of the method
The hygroscopic moisture of a coal sample is determined by drying it in a weighing vial at 105ºC in an oven until the weight of the analyzed sample remains constant.

Procedure: Approximately 1–3 g of finely ground coal is weighed in a weighing vial on an analytical balance. The vial with coal, without its lid, is placed in a thermostat-controlled oven at 105ºC and maintained for about 60–90 minutes. This determination is not performed at a higher temperature because the coal may decompose or oxidize. The vial is then covered with its lid, placed in a desiccator to cool to room temperature, and then weighed again on the analytical balance. The calculation of the hygroscopic moisture, expressed as a percentage, is done using the following formula:

$$W_h = \frac{G_1 - G_2}{G}, [\%]$$

Where:
G_0 - mass of the empty vial, in g.
G_1 - mass of the vial with fuel before drying, in grams
G_2 - mass of the vial with fuel after drying, in grams
G - mass of the fuel taken for the determination
The experimental results obtained are recorded in a table as follows:

No.	Type of coal	G_0,[g]	G_1,[g]	G_2,[g]	G,[g]	W_h,[%]
1.						
2.						
3.						
4.						
5.						

For other products, the determination of hygroscopic moisture, besides the oven drying method, can also be performed by other methods such as infrared radiation drying and extraction with organic solvents. The importance of determining hygroscopic moisture lies in:

- assessing the nutritional value and preservation capacity for some products
- verifying the extent to which the manufacturer has complied with the official manufacturing recipe
- detecting unauthorized additives.

Determination of ash content

Ash refers to the solid inorganic residue left behind after the complete combustion of a fuel in the presence of excess air. It is primarily composed of non-combustible mineral matter inherent in the fuel, such as silica, alumina, oxides of metals, and other inorganic impurities. Ash may contain toxic elements like mercury, cadmium, and arsenic, posing risks during disposal or if dispersed into the air. Ash is no longer treated solely as a waste product and has found applications in various industries:

a) *Construction:* fly ash is used in cement and concrete production to enhance strength and durability.
b) *Agriculture:* ash can be used as a soil conditioner or liming agent in certain conditions.
c) *Waste management*: ash serves as a filler in land reclamation and road construction.

By understanding and managing ash properties, industries can minimize its adverse effects while leveraging its potential benefits.

Principle of the method

The ash content of a coal sample is determined by burning a sample of coal in a porcelain crucible in a furnace with adjustable temperature.

Procedure: 1–2 g of finely ground coal are weighed on an analytical balance into a porcelain crucible. The crucible is placed in an electric furnace heated to a temperature of 800–850°C and maintained for approximately 2 hours.
The crucible is then removed and allowed to cool for about 5 minutes on an asbestos plate, after which it is placed in a desiccator to cool down to room temperature. It is weighed again on the analytical balance. The calcination operation is repeated until a constant ash mass value is obtained.

The percentage ash content (%A) is calculated using the following formula:

$$\%A = \frac{G_3 - G_1}{G_2 - G_1} \cdot 100 ,$$

where:

G_1 - mass of the empty crucible, in grams (g)
G_2 - mass of the crucible with coal, in grams (g)
G_3 - mass of the crucible with ash, in grams (g)

The experimental results obtained are recorded in a data table as follows:

No.	Type of coal	G_1,[g]	G_2,[g]	G_3,[g]	A, [%]
1.					
2.					
3.					
4.					
5.					

Determination of volatile matter and coke

By heating coals in the absence of air, carbonization takes place, releasing gaseous products and vapor-phase products resulting from the combination of the constituent elements. The remaining residue constitutes the solid part, called coke or semicoke depending on the heating temperature. The process of heating a fuel in the absence of air is called dry distillation or pyrolysis. The gaseous and vapor-phase substances released during distillation constitute the volatile matter of the coals. Their composition is complex and depends on the temperature at which the coal was heated, as well as the type of coal analyzed.

Total volatile matter also includes hygroscopic moisture. Simultaneously with the determination of volatile matter, the determination of coke (fixed carbon) is also performed. This includes ash, the mineral part that does not burn.

Volatile matter (V) of a coal means the total amount of products released by heating under well-established conditions, minus moisture.

Coke or fixed carbon (K) means the solid residue remaining in the crucible after the determination of volatile matter, minus ash.

Principle of the method

Volatile matter and coke are determined by heating powdered coal in a metal or porcelain crucible with a lid, in the absence of air, at a temperature of 950°C for 7 minutes.

Procedure: Approximately 1 g of finely ground coal weighed on an analytical balance into a metal crucible. The crucible is covered with a lid and placed into a furnace heated to 950°C. It is kept in the furnace for 7 minutes. The crucible is removed onto an asbestos plate and allowed to cool slightly in air. To cool to room temperature, it is placed in a desiccator. It is weighed again on the analytical balance.

From the obtained weighing results and the determinations of moisture and ash, the amounts of volatile matter and coke (fixed carbon), expressed in percentages, are calculated using the following formulas:

$$\%V = \frac{G_2 - G_3}{G_2 - G_1} \cdot 100 - W_h ,$$

where:

V – volatile matter

G_1 – mass of the empty crucible, in grams (g)

G_2 – mass of the crucible with the coal sample, in grams (g)

G_3 – mass of the crucible with the residue after heating, in grams (g)

W_h – hygroscopic moisture of the sample, in %

$$\%K = \frac{G_3 - G_1}{G_2 - G_1} \cdot 100 - \%A ,$$

Where:

K – coke (fixed carbon)

G_1 – mass of the empty crucible, in grams (g)

G_2 – mass of the crucible with coal, in grams (g)

G_3 – mass of the crucible with coke, in grams (g)

A – ash content, in %.

The experimental results are recorded in a table containing the following quantities:

No.	Type of coal	G_1 [g]	G_2 [g]	G_3 [g]	W_h [%]	A [%]	**V [%]**	**K [%]**
1. 2. 3. 4. 5.								

DETERMINATION OF THE CALORIFIC VALUE OF SOLID FUELS

The main characteristic by which a fuel is thermally assessed is its calorific value. The calorific value represents the amount of heat, expressed in kJ or kcal, released during the complete combustion of one kilogram of solid fuel. A fuel with a calorific value equal to 7000 kcal/kg is called conventional fuel. In technical and economic calculations, this term is commonly used.

Since most fuels contain moisture and hydrogen, which during combustion lead to the formation of water, two types of calorific values are distinguished: a higher calorific value, denoted as **Ps**, and a lower calorific value, denoted as **Pi**.

- The **higher calorific value (Ps)** is the amount of heat released during the combustion of one kilogram of fuel when the water resulting from hydrogen combustion and the moisture are in a liquid state after combustion, at 0°C or room temperature.
- The **lower calorific value (Pi)** is the amount of heat released when the water in the combustion products is in the form of vapor, leaving the installation at 100°C.

The difference between the higher and lower calorific values represents the amount of heat required to convert the entire quantity of water resulting from the combustion of a unit mass of fuel from liquid to vapor state.

The calorific value of a fuel can be determined:

- By using empirically established formulas based on the results of technical analysis (coke, volatile substances, ash, and moisture) – via the **GOUTAL method**
- Experimentally – using **calorimeters**.

The GOUTAL method allows the calculation of the lower calorific value and requires knowledge of the fixed carbon (%K) and volatile matter (%V).

The calculation formula is as follows:

$$P_i = 81{,}5 \cdot K + a \cdot V \,, \quad \text{[kcal/kg]}$$

Where:
Pi – lower calorific value, in kcal/kg
K – fixed carbon, in %
V – volatile matter, in %
a – coefficient representing the calorific value of the volatile matter
It should be noted that "a" refers to the volatile matter of pure coal (excluding water and ash), denoted as **V'**, and is calculated using the following formula:

$$V' = \frac{100 \cdot V}{100 - (moisture + ash)},$$

Moisture and ash will be considered as mass percentages.

Table 2: Values of **V'** in relation to those of **"a"**

V'	a	V'	A	V'	a	V'	a
5	150	14	120	24	104	34	95
6	142	16	115	26	102	36	91
7	139	17	113	27	101	37	88
8	136	18	112	28	100	38	85
9	133	19	110	29	99	39	82

10	130	20	109	30	98	40	80
11	127	21	108	31	97	41	78
12	124	22	107	32	97	42	75
13	122	23	105	33	96	43	72,5

The higher calorific value can be determined using the following formula:

$$P_s = P_i + 6(9H + W_h), \quad \text{[kcal/kg]},$$

Where:
H – hydrogen content of the coal, in %
W_h – hygroscopic moisture of the coal, in %
P_i– lower calorific value, in kcal/kg
The hydrogen content is determined by using the diagram in *Figure 1*.
The results obtained are recorded in a table with the following structure:

No.	Coal Type	Lower Calorific Value [kcal/kg]	Higher Calorific Value [kcal/kg]
1. 2. 3. 4. 5.			

CALCULATION AREA:

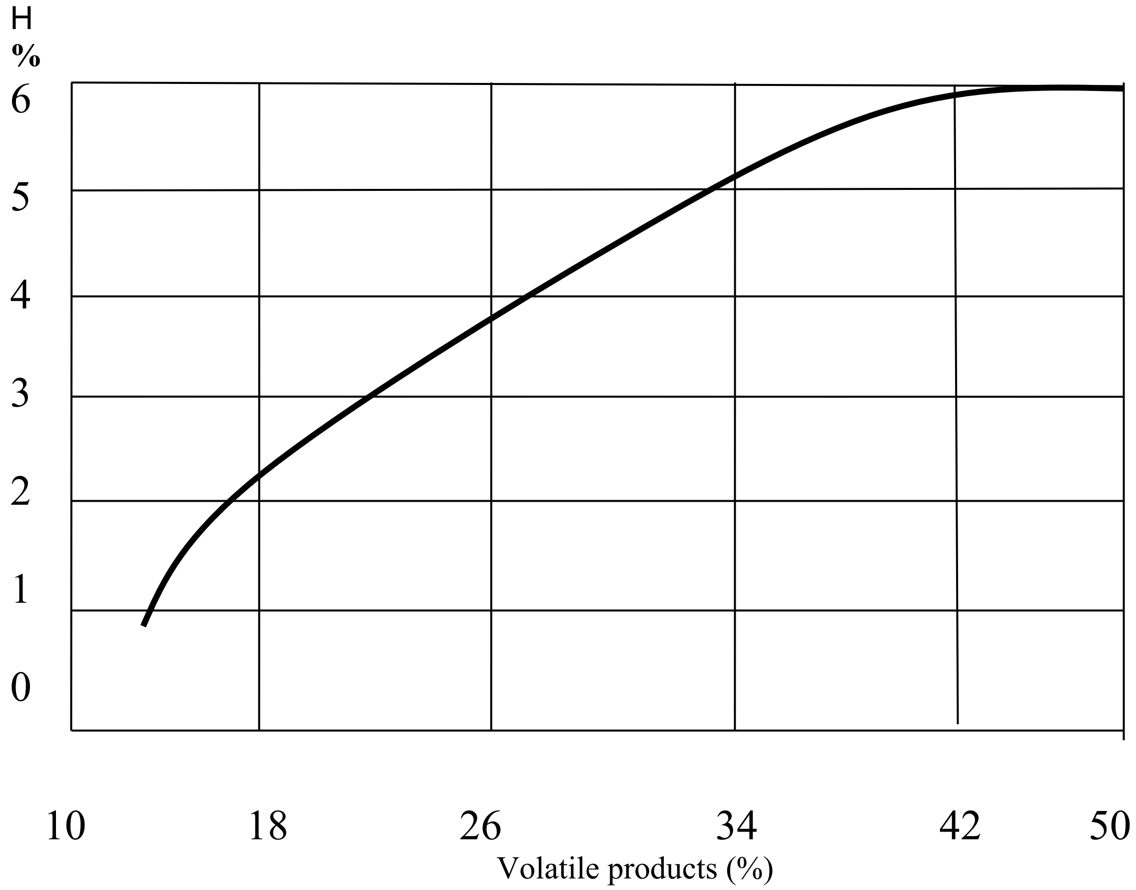


Figure 4**:** Diagram for determining hydrogen content, in percentages.

CALCULATION AREA:

DETERMINATION OF METAL HARDNESS USING THE BRINELL METHOD

General considerations

This method is one of the most important mechanical tests and allows for the relatively rapid determination of certain mechanical properties without destroying the tested piece. There are various methods for determining hardness, which naturally led to a large variety of required apparatus. Common methods for testing metal hardness are:

- **Brinell method**
- **Vickers method**
- **Rockwell method**

The Brinell hardness test is a widely used method to measure the hardness of metals and alloys. It is considered a primary method due to its simplicity, reliability, and applicability to a wide range of materials. The test determines the resistance of a material to indentation under a specific load.

Description of the method (standardized method): A heat-treated (hardened) steel ball, with a known diameter **D**, is pressed perpendicularly onto a flat surface of a test specimen with a static force **F** of a precisely determined magnitude. In this way, the tested piece undergoes permanent deformation, and a spherical cap with a diameter **d** is imprinted on its surface.

The Brinell hardness, **HB**, is defined as the ratio of the applied load **F** to area **A** of the spherical impression left by the ball on the test piece.

$$HB = \frac{2F}{\pi D(D - \sqrt{(D^2 - d^2)}},$$

where:
F – the load pressing on the ball, in kgf
D – the diameter of the ball, in mm
d – the diameter of the indentation, in mm.

The diameters of the balls used are standardized, being 2.5; 5; and 10 mm. The diameter of the indentation is measured with a magnifying glass with a graduated scale that has divisions of 0.1 mm. The speed and duration of the applied load influence the size of the indentation and thus the value obtained for hardness. For this reason, the load must be maintained for 15 seconds.

The Brinell hardness test is recommended for metals and alloys that have hardness up to 450 HB. For higher hardness values, the Vickers and Rockwell hardness tests are recommended. The construction of a Brinell apparatus consists of the following components:

1. a maneuvering screw, which allows lifting the test material
2. a steel ball
3. a hydraulic cylinder (with oil)
4. weights, which allow adjustment of the force with which the test is performed
5. the force coupling and decoupling system
6. the electric illumination installation
7. a pressure gauge (manometer).

Working procedure

- Take a metal specimen, with a cubic shape

- Place it on the plate of the maneuvering screw of the Brinell apparatus.
- Raise the specimen until it meets the steel ball (closed electric contact)
- Engage the driving force
- Disengage the locking system to apply the load
- Remove the specimen from the apparatus table and measure the diameter of the indentation using the graduated magnifying glass
- Calculate the Brinell hardness value.

No.	Material	F	D	d	HB

KNOWLEDGE CHECK

Choose the correct answers:

1. Volatile products represent:
   a) coal burned for 7 minutes at 850ºC;
   b) coal burned for 7 minutes at 100ºC;
   c) gaseous substances and vapors released.

2. Ash determination involves:
   a) complete combustion of a fuel in the presence of excess air;
   b) complete combustion in the absence of air;
   c) combustion in a chemically controlled atmosphere.

3. For the qualitative characterization of fossil coals, the following are used:
   a) moisture and volatile matter;
   b) fixed carbon;
   c) ash.

4. Hardness represents:
   a) the material's resistance to breaking;
   b) the resistance a material opposes to the penetration of a harder foreign body;
   c) resistance to impact by a body whose hardness is previously determined.

5. Brinell hardness depends on:
   a) characteristics of the tested metal;
   b) the temperature at which hardness is measured;
   c) the shape of the specimen being tested.

6. What is the main reason why the Brinell test is not recommended for metals with hardness greater than 450 HB?
   a) because the indentation marks are too small to be measured accurately
   b) because the Vickers and Rockwell methods provide more precise results for high hardness values
   c) because the steel balls may deform at high hardness

CALCULATIONS AREA:

Practical work 2

ASSESSMENT OF THE QUALITY OF LIQUID PRODUCTS

The quality of liquid products is a critical parameter in industries such as food and beverages, pharmaceuticals, cosmetics, and chemicals. Ensuring the desired quality involves assessing various physical, chemical, and functional characteristics. Among these, the determination of density, pH, refractive index, and foaming index plays a fundamental role.

These parameters provide essential insights into the product's composition, purity, stability, and performance. By measuring these properties, manufacturers can ensure compliance with industry standards, optimize formulations, and maintain consumer trust.

1. DETERMINATION OF DENSITY

The density of a product is understood as the ratio between the mass of the product (m) and its volume (V):

$$\rho = \frac{m}{V}, \quad (\text{kg/m}^3 \text{ or g/cm}^3) \qquad (1)$$

Density, a characteristic of all substances in solid, liquid, or gaseous states, is influenced by temperature and pressure. Since the influence of pressure is small, in practice, only the influence of temperature is considered. Therefore, it is always necessary to specify the temperature at which the density measurement was performed.

To compare the density of different products, it is necessary to express it at the same temperature and in relation to the density of a reference product. This density is called relative density.

The density of liquid products is reported at a temperature of 20°C and relative to the density of water at 4°C, which is considered equal to one. In this case, the relative density is denoted as d_4^{20}.

Relative density is a dimensionless number. Since the density of the liquid product is not determined at 20°C but at a temperature t, the conversion is performed using the following relationship:

$$d_4^{20} = d_4^t + c(t-20) \qquad (2)$$

d_4^t - density determined at temperature t

c - average temperature correction, for each degree Celsius, as given in Table 1

t - temperature of determination, ^{0}C.

Table 1: Average temperature correction for determining relative density d_4^{20}

d_4^t	Correction for one degree Celsius	d_4^t	Correction for one degree Celsius
0,810 - 0,820	0,000752	0,980 - 0,990	0,000534

0,820 - 0,830	0,000738	0,990 - 1,000	0,000523
0,830 - 0,840	0,000725	1,000 - 1,100	0,000503
0,840 - 0,850	0,000712	1,100 - 1,200	0,000498
0,850 - 0,860	0,000699	1,200 - 1,300	0,000478
0,860 - 0,870	0,000686	1,300 - 1,400	0,000458
0,870 - 0,880	0,000673		
0,880 - 0,890	0,000660		
0,890 - 0,900	0,000647		
0,900 - 0,910	0,000633		
0,910 - 0,920	0,000620		
0,920 - 0,930	0,000607		
0,930 - 0,940	0,000594		
0,940 - 0,950	0,000581		
0,950 - 0,960	0,000578		
0,960 - 0,970	0,000554		
0,970 - 0,980	0,000543		

Experimentally, density can be determined using the following methods:

» The hydrometer method (densimeter)

» The hydrostatic balance method (Mohr - Westphal)

» The pycnometer method

Objective of the experiment: Determine the density of liquid products using the hydrometer (densimeter) method. The relative density will be calculated for different types of solutions.

Determining density with a hydrometer

The hydrometer is a floating device made of thin glass, cylindrical in shape, with the lower end weighted with shot. The device extends into a thin glass stem inside which a density scale is fixed.

The hydrometer operates based on Archimedes' principle, which states that a body immersed in a fluid experience an upward buoyant force equal to the weight of the displaced fluid. The hydrometer floats at different levels depending on the liquid's density.

Principle of the method: The liquid product is poured into a cylinder with a temperature approximately equal to that of the sample. Based on the estimated density of the sample, a hydrometer with a suitable graduated scale is selected and immersed in the sample cylinder, allowing it to float freely. When thermal equilibrium is achieved, the density value is read from the graduated scale on the stem. At the same time, the temperature of the sample is recorded.

Procedure: The product to be analyzed is kept in the room to reach ambient temperature and then homogenized by stirring. It is then poured into a clean, perfectly dry cylinder. The hydrometer, held by its upper end, is inserted into the product so as not to touch the cylinder walls.

After the oscillations stop and the temperature remains constant, the reading is taken with the eye level aligned to the upper or lower edge of the meniscus (the reading method is indicated on the scale; if not specified, the reading is made at the lower edge of the meniscus).

The relative density is calculated according to equation (2).

2. DETERMINATION OF THE REFRACTIVE INDEX

The refractive index is a characteristic property of substances, providing information about their identification and degree of purity. By measuring the refractive index, the variation in concentration over time of solutions of gaseous, liquid, or solid substances can be monitored.

The device used to determine the refractive index of substances is called a refractometer. The most used refractometer is the ABBE ZEISS refractometer.

Figure 1. ABBE ZEISS Refractometer

Measuring the refractive index of a liquid using the ABBE refractometer:

- Rotate the ABBE refractometer in the stand until it reaches a position where the plane between the two prisms is horizontal
- Open the prisms by turning the hook and drop a few drops of the liquid to be analyzed onto the surface of the lower prism using a pipette
- Keep the lower prism in a horizontal position
- Place the upper prism over it and close it with the hook. Then rotate the refractometer using the lever until it stops
- Adjust the mirror so that the field of view in the eyepiece is as bright as possible
- Then adjust the eyepiece so that the crosshairs are as sharp as possible, and slowly rotate the prism system using the lever until the boundary line between the bright and dark fields aligns with the intersection point of the crosshairs
- Read the refractive index value from the scale.

During the measurement, the temperature must remain constant (at the initially set value). After the measurement, open the prisms, dry them with filter paper, and clean their surfaces with alcohol. Periodically, the scale calibration should be checked using standard liquids with known refractive indices.

3. DETERMINATION OF pH

The pH value is generally used to indicate whether liquid media are acidic, neutral, or basic. Measuring pH plays an important role in many practical and scientific fields such as medicine, agriculture, the food and non-food industry, and others.

Determination of the pH of water

Water is an indispensable factor for the human body. Since ancient times, human settlements have been located along rivers or by the sea. The daily water requirement for a person is approximately 1.5–2 liters consumed directly, but for personal hygiene, a person uses about 40 liters of water daily. The World Health Organization considers an optimal amount to cover these needs to be 100 liters in 24 hours.

The water used by humans must meet certain organoleptic, physical, and chemical properties. These properties can be determined through physic-chemical analysis of water. In this regard, some determinations are made at the collection site: organoleptic determinations (taste, smell), temperature measurement, and pH determination.

Methods of measuring pH

pH measurement can be done by:

- Colorimetric methods (comparison scale, Hellige comparator, pH indicator)
- Electrometric or potentiometric methods

The principle of colorimetric methods consists of comparing the color of the analyzed sample, to which an indicator has been added, with a reference scale.

Electrometric methods are based on measuring the potential difference between two electrodes introduced into the analyzed samples.

Objective of the experiment: Determination of the pH of drinking water and other liquid products using the Consort C532 pH meter and interpreting the results using Table 2.

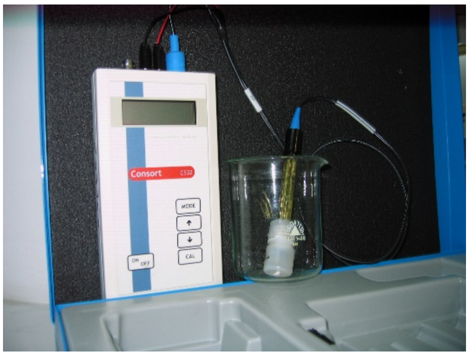


Figure 2. pH-metru CONSORT C532

The table shows the pH values for various substances, indicating their acidity (pH < 7), neutrality (pH = 7), or alkalinity (pH > 7). Highly acidic substances include strong acids and gastric juice, neutral ones include water and saliva, while alkaline ones include soap, ammonia, and lye solutions. These values are useful for understanding the chemical properties and applications of substances in everyday life, industry, and health.

Table 2: pH values of common substances

Type of substance	pH
Hydrochloric acid, 1M	0.1
Battery acid	0.5
Gastric acid	1.5 – 2.0
Lemon juice	2.4
Cola	2.5
Vinegar	2.9

Orange or apple juice	3.5
Beer	4.5
Acid rain	<5.0
Coffee	5.0
Tea	5.5
Milk	6.5
Water pure	7.0
Healthy human saliva	6.5 – 7.4
Blood	7.34 – 7.45
Sea water	8.0
Toilet soap	9.0 – 10.0
Ammonia	11.5
Bleach	12.5
Lye	13.5

In practice, knowing the pH values helps us to:

- *control product quality*: in the food and cosmetic industries, pH influences product preservation and safe
- *protect health*: maintaining the correct pH in blood and other body fluids is essential for optimal body function
- *treat water and soil*: monitoring pH helps prevent pollution and maintain a healthy environment.
- *optimize industrial processes*: in the manufacture of chemicals, detergents, or medicines, pH affects chemical reactions and process efficiency.
- *ensure workplace safety*: knowing the pH of chemical substances helps in their safe handling and storage.

4. DETERMINATION OF THE FOAM INDEX

The foam index is an important characteristic for liquid products, especially in the chemical and food industries, because excessive foaming can affect their quality and handling.

The method for determining the foam index consists of measuring the volume of foam produced after shaking a standard volume of liquid in a standardized container.

Foam index is the ability of aqueous detergent solutions to facilitate foam formation and increase its stability. In relation to foaming, foam stability and foam density are also determined.

Principle of the method: The volume of foam obtained is measured after dropping 500 ml of detergent solution from a height of 450 mm onto a liquid surface of the same solution contained in a graduated cylinder.

The apparatus consists of a separating funnel, made up of a spherical reservoir (1) with a capacity of 1000 ml, extended by a tube (2) approximately 200 mm long, equipped at the lower end with a valve (3) and a mark (3’) located 150 mm above the valve.

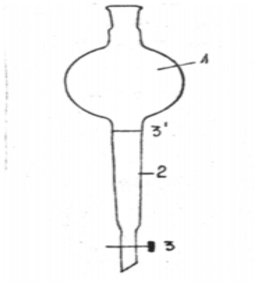


Fig. 3. Foam Testing Apparatus

Procedure: The separating funnel is fixed on a metal stand. At the lower part of the funnel there is a 1000 ml graduated cylinder used to measure the volume of the solution, and the foam formed.

Prepare 1 liter of detergent solution with a concentration of 1% in a flat-bottom flask using tap water. Pour 50 ml of the solution into the graduated cylinder carefully, avoiding foam formation by pouring the solution along a glass rod.

Introduce 150 ml of detergent solution up to the mark (3’) on the cylindrical tube of the funnel. Then pour an additional 500 ml into the funnel and let it flow freely into the graduated cylinder until the volume of solution reaches the mark (3’). Measure precisely the volume of foam after 30 seconds, 3 minutes, and 5 minutes from the moment the flow stops. Perform 3-4 determinations using the same solution and take the arithmetic mean of the results as the final value.

Calculation method:

a. The foaming power (Psp) is expressed in ml and represents the foam volume after 30 seconds (V_o), 3 minutes, and 5 minutes after stopping the solution flow (Vt), where the total volume of solution is 500 ml.

b. The foam stability (Ssp) is calculated using the formula:

$$Ssp=Vt/Vo$$

c. The foam density (Dsp) is calculated using the formula:

$$Dsp=550-Vt/Vo$$

The results are recorded in the following table:

Determination	**V_0**	**V_{t3}**	**V_{t5}**	**Psp**			**Ssp**		**Dsp**	
				30’’	**3’**	**5’**	**3’**	**5’**	**3’**	**5’**
1										
2										
3										
Mean value										

METROLOGICAL APPLICATIONS.
CALIBRATION OF THE PYROMETER

General considerations

Temperature is an important parameter in various technological processes and a key characteristic for the quality level of certain products. It is expressed in degrees, on the absolute Kelvin scale (K), and on the Celsius scale (°C).

Thermometry measures temperatures based on the variation of a body's properties depending on temperature. The measurement is done with thermometers, and for high temperatures, with pyrometers. Temperature measurement is based on one of the following methods:

- Expansion of a solid or liquid
- Variation of the pressure of a gas
- Variation of the maximum vapor pressure of a liquid
- Variation of the electrical resistance of a conductor
- Variation of the electromotive force of a thermocouple.

Frequently, temperature is measured using liquid thermometers. These are convenient, simple, and easy to carry; they allow reading the temperature only at the measurement site; they have thermal inertia; the thermal equilibrium time is usually less than one minute.

The most used are mercury thermometers, which can measure temperatures in the range –39°C to 600°C. Because mercury solidifies below –39°C, for these lower temperatures, thermometers filled with pentane or toluene are used. These thermometers have the disadvantage that the mentioned liquids wet the walls of the thermometer well, so after a rapid drop of the liquid in the thermometer capillary, due to a sudden temperature change, one must wait relatively long before a correct temperature reading can be made.

Temperature measurement with liquid thermometers is based on the volume change of the thermometric liquid caused by the heat of the environment in which the thermometer is located. Under thermal expansion, the liquid rises in the capillary tube. The height to which it rises indicates the temperature. After stabilizing the liquid column in the capillary tube, the temperature is red at the meniscus level from the graduated scale.

Along with individual liquid thermometers, sets of thermometers composed of three to seven thermometers calibrated for different temperature ranges are used. Each allows temperature measurement within intervals of 60–70°C. Thus, such a set can enable measurements over a wide range of values, for example between 0 and 450°C. These thermometers have graduated scales with divisions from 0.1 to 0.10°C or from 1 to 10°C, depending on the required measurement precision.

Liquid thermometers can be total immersion or partial immersion, with the former being more common. When using total immersion thermometers, immersion must reach the meniscus level of the liquid in the capillary tube. Since reading the temperature value under these conditions can sometimes be difficult, it is common to work with part of the liquid column protruding above the warm medium.

Thus, a temperature difference appears between the thermometric liquid in the reservoir and the end of the liquid column in the capillary tube, which leads to temperature measurement errors. Therefore, the liquid column must be corrected using the following relation:

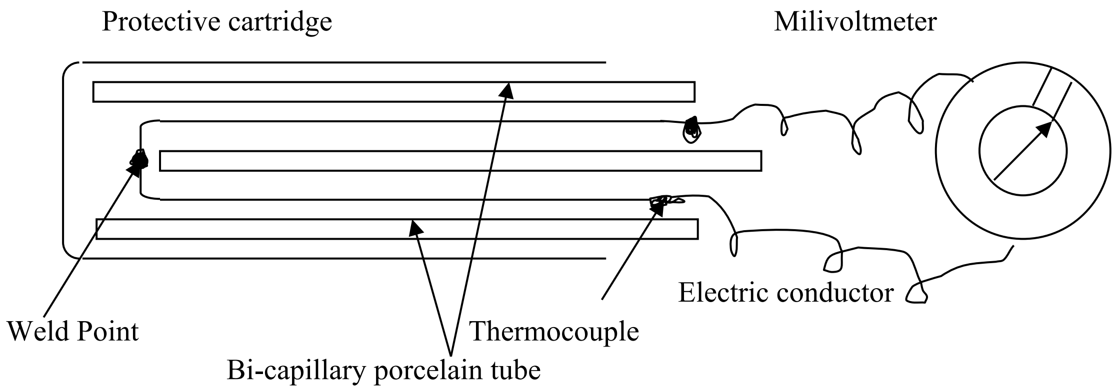
$$k = a \cdot h(t_1 - t_2),$$

where:
h – the height of the liquid column rising above the warm medium, in °C
t_1 – the temperature indicated by the thermometer, in °C
t_2 – the ambient temperature measured with another thermometer, in °C
a – a constant depending on the quality of the glass and the type of thermometer (for mercury thermometers, a = 0.00016, and for alcohol thermometers, a = 0.001)
The actual temperature is determined by the formula:

$$t = t_1 + k.$$

ELECTRIC PYROMETER

For measuring temperatures above 450°C, pyrometers are commonly used. A pyrometer typically consists of two main components: a thermocouple, which is a temperature sensor that generates a voltage proportional to temperature, and a millivoltmeter, which measures the small voltage produced by the thermocouple. This setup allows accurate and reliable temperature measurement at very high temperatures where conventional thermometers are unsuitable.



The thermocouple consists of two wires made of different metals or alloys, welded at one end. Typically, one wire is a pure metal (iron, copper, platinum), while the other is made of an alloy (copper-nickel, platinum-rhodium).

Principle of operation

The functioning of a thermocouple is based on measuring the electromotive force (EMF) generated when the weld point (hot junction) is heated. This EMF is measured using a millivoltmeter calibrated to directly indicate the temperature value. A thermocouple combined with a millivoltmeter forms an electric pyrometer.

Setup and protection

To avoid direct contact between the thermocouple wires, they are inserted into the capillary channels of a refractory porcelain rod. The weld point and wires are further protected by placing them inside a refractory porcelain cartridge. During measurements, the cartridge is immersed in the hot environment, while the thermocouple wires are extended with copper or special alloy conductors and connected to the millivoltmeter.

Experiment objectives

a) To practically learn the method of measuring temperature with various types of thermometers and apply temperature correction techniques.
b) To calibrate the millivoltmeter of an electric pyrometer using an electronic thermometer.

Procedure

1. Prepare baths at different temperatures and immerse the electronic thermometer along with the thermocouple's weld point, protected by a porcelain cartridge.
2. Wait until the bath temperature stabilizes.
3. Record the temperature from the electronic thermometer and the millivolt reading from the millivoltmeter.
4. Repeat the measurements at different temperatures to obtain multiple temperature-millivolt value pairs.
5. Plot a calibration diagram for the millivoltmeter by graphing temperature values against millivolts in a coordinating system.

DATA PROCESSING

T, ^{0}C	20	30	40	50	60	65	70	75	80	85	90	95	100
U_1, mV													
U_2, mV													
U_M, mV													

KNOWLEDGE CHECK

1. Hygroscopic moisture is determined by heating the coal sample at a temperature of:
   a) 25°C
   b) 105°C
   c) 850°C.

2. The choice of hydrometer for determining the density of a liquid depends on:
   a) the amount of liquid available
   b) the temperature at which the determination is made
   c) the existence of a convenient graduated scale.

3. The refractive index allows:
   a) identification of the substance
   b) optical-physical characterization of the substance
   c) determination of the degree of purity.

4. The standard temperature for expressing the density of a liquid is:
   a) 20°C
   b) 100°C
   c) 273 K

5. Density can be experimentally determined with:
   a) a hydrometer
   b) a densimeter
   c) a pycnometer

CALCULATION AREA:

Practical work 3

QUALITY OF SOLID GRANULAR GOODS AND THEIR CLASSIFICATION BASED ON SEPARATION EFFICIENCY BY SIEVING

Sieving is the classification operation that consists of volumetric separation using sieves, screens, or gratings, of granules of different sizes from a granular material. Sieving of solid granular goods is influenced by several specific factors that can affect the process efficiency, the quality of separation, and the lifespan of the equipment:

» *Particle size:* Materials larger than the sieve openings are retained, while smaller ones pass through the sieve.
» *Particle shape:* Irregular particles may require special equipment for efficient separation.
» *Moisture content:* Wet materials can form clumps, reducing sieving efficiency.
» *Sieve capacity:* The sieve surface area and processing speed influence the amount of material sieved per unit time.
» *Tendency to clog:* Certain materials, such as sticky ones, can block the sieve openings.

Sieving helps to comply with quality standards imposed by national or international regulations. Removing impurities or unwanted particles reduces the risk of quality problems or customer complaints.

According to the standard, sieves are marked by a number that expresses the length of the sieve opening's side in millimeters, followed by the standard indication. For example, No. 5 STAS 1077 indicates a sieve with a 5 mm side length. If the side length is less than 1 mm, the decimal point is omitted in the marking symbol.

Sieving is most applied to materials in dry form. Solid granular bodies are separated by passing the material through multiple sieves, usually stacked. This way, granulometric classes of material are obtained. To obtain "n" granulometric classes, "n-1" different sieves are required.

The efficiency of granulometric separation is determined by the moisture content of the material being sieved, the granulometric composition, particle shape, as well as the characteristics of the sieves used (total surface area, number of openings per cm²). It is calculated using the following relationships:

$$\eta_1 = \frac{100(a-r)}{a(100-r)} \cdot 100,$$

$$\eta_2 = 10000\frac{a}{M_i \cdot A},$$

where:

a – sieved material (determined as the difference between the total final amount and the retained material on each sieve), in %

r – refusal (the amount of material with granules larger than the openings of the respective sieve), in %

cg – granulometric class (amount of material with granules between two specified limits)

Mi – initial mixture mass, in grams (g)

A – percentage of granules in the initial mixture smaller than the sieve opening, calculated as the difference between Mi and the retained material on the respective sieve.

The result of sieving a sample through a series of sieves, which highlights the granulometric composition of the analyzed material, is expressed as a percentage and graphically represented, yielding the granulometric analysis diagram.

The most common graphical representation methods are cumulative graphs, where cumulative sieved values are plotted against the granule sizes. On the ordinate (Y-axis), cumulative sieved quantities are expressed in percentages, while on the abscissa (X-axis), the diameters of the sieve openings through which the material passed are plotted.

Procedure

a) Weigh a quantity of material to be subjected to the sieving operation for granulometric characterization
b) Sieve the previously weighed material using a system of sieves with openings of different sizes
c) Weigh the retained material on each sieve, express it as a percentage, determine the corresponding sieve quantities, and complete the centralization table for the measurements
d) Plot the granulometric diagram specific to the analyzed material based on the data on the table
e) Interpret the results obtained.

Table 1. Centralized results of REFUSAL determinations

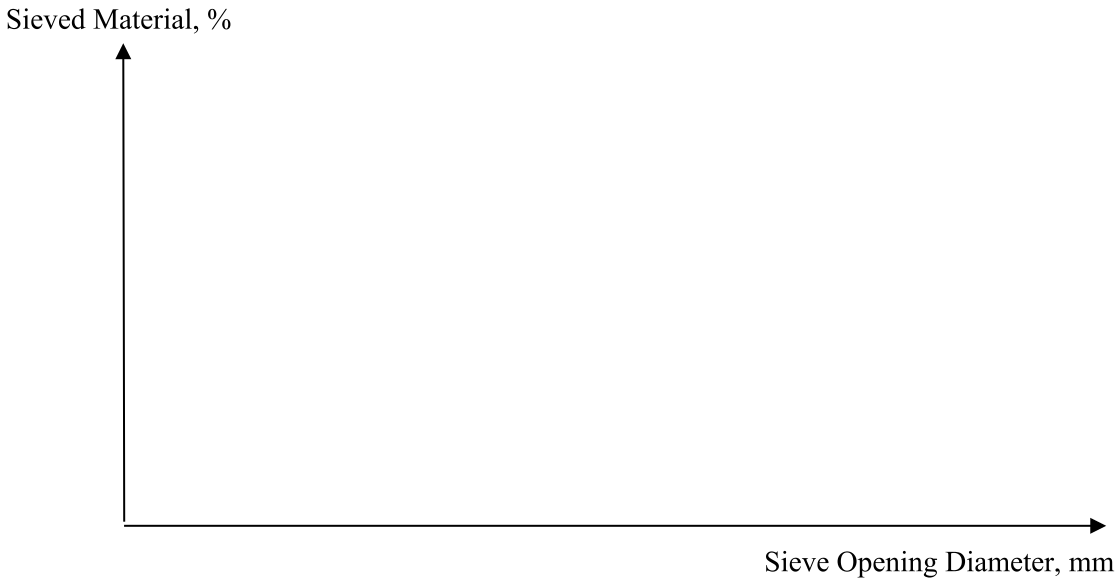
Sieve Opening Size, mm	**2,5**	**2,0**	**0,80**	**0,30**	**0,125**	**0,045**
Granulometric Class, g						
Sieving (Sieved Material), g						
Refusal, g						
Sieving (Sieved Material), %						
Refusal, %						
Efficiency						

Table 2. Centralized results of SIEVING determinations

Sieve Opening Size, mm	**0.045**	**0.125**	**0,3**	**0,8**	**2**	**2,5**
Granulometric Class, g						
Sieving (Sieved Material), g						
Refusal, g						
Sieving (Sieved Material), %						
Refusal, %						
Efficiency						

Requirement: Using the provided data on sieve opening diameters (mm) and sieved percentages (%), construct a granulometric analysis diagram. Plot cumulative sieving percentages on the Y-axis and sieve opening diameters (mm) on the X-axis.

Figure 1**. Diagram of a granulometric analysis**



CALCULATION AREA:

KNOWLEDGE CHECK

1. The sieves used for sieving are marked by:
    a. A number representing the total surface area of the sieve
    b. A number representing the side length of the sieve opening
    c. The number of openings per cm^2.

2. Sieving is a separation operation:
    a. Volumetric
    b. By weighing
    c. By the difference in resulting masses.

3. The efficiency of granulometric separation depends on:
    a. The moisture content of the material
    b. The characteristics of the sieves used
    c. The separation speed adjusted on the sieving device.

4. To obtain N granulometric classes, the following are required:
    a. N different sieves
    b. N+1 different sieves
    c. N-1 different sieves.

5. The calculation of sieved and retained material during sieving is done:
    a. In absolute values, expressed in units of mass
    b. In absolute values, expressed in units of volume
    c. In relative values.

6. What is the purpose of using multiple stacked sieves in the sieving process?
    a. To speed up the process
    b. To obtain different granulometric classes
    c. To reduce the moisture content of the material

7. What factor most significantly affects the efficiency of the sieving process?
    a. Particle size
    b. Ambient temperature
    c. Material color

8. How does the moisture content of the material affect the efficiency of sifting?

9. What are the main causes that can lead to screen blockage in the sifting process?

10. Why is sifting important in meeting quality standards for goods?

Practical work 4

WORK NORM

The work norm represents the amount of work necessary to complete products, operations, tasks, services, or to perform functions, by an executor (individual or team) who has the appropriate qualifications and works at a normal intensity under specified technical and organizational conditions.

The work norm is expressed, depending on the characteristics of the production process or other activities being standardized, in the form of time norms, production norms, personnel norms, scopes of responsibility, or other forms corresponding to the specifics of each type of work. Work norms are used to determine production cycle durations, establish production capacities, and plan the required workforce. Work norms are set for all categories of employees.

The production norm represents the quantity of products or tasks established to be completed within a unit of time by an executor who has the appropriate qualifications and works at normal intensity under specified technical and organizational conditions.

The time norm is a way of expressing the work norm, representing the time necessary to complete one unit of product or one operation. The time norm is expressed in units of time-standard seconds, standard minutes, standard hours per unit of production-while the production norm is expressed in production units (pieces, kilograms, meters per unit of time, work shift hours). The most used method to determine the technical time norm is the analytical-experimental method described below.

The technical time norm consists of several categories of time and is given, for one piece, by the following formula:

$$T = T_{op} + T_{on} + T_{dl} + T_{pi}/n \quad \text{(min)}$$

Where:

T– time required to produce a part, in minutes;

T_{op}– operational time, consumed by the human operator to perform a phase or operation

$$T_{op} = t_b + t_a \quad \text{(min)}$$

t_b – basic time during which the actual processing takes place

t_a – auxiliary time standardizes the activities performed by the worker between phases and within each phase: time required for securing the parts, stopping and starting the processing machines, approaching and retracting the cutting tool, etc.

T_{on} – time for rest and natural needs

T_{dl} – time for workplace servicing

$$T_{dl} = t_{dt} + t_{do} \quad \text{(min)}$$

t_{dt} – time for technical servicing: tool sharpening, dimension adjustment etc.

t_{do} – time for organizational servicing: removal of machining allowance, arranging semi-finished products, finished parts, etc.

T_{pi} – preparation and completion time: standardizes the activities performed by the operator during the preparation and conclusion of an operation, such as reading and analyzing technological documentation, supplying semi-finished products, producing a test piece, handing over the finished parts, and cleaning the workplace. This time is standardized for the entire production batch
n – the number of pieces in the batch being produced.

Work execution

A simple part is manufactured based on a technological process, noting the parameters of the cutting regime (e.g., for a nut). The semi-finished product is chosen with material consumption as the selection criterion. There are two options in the analyzed case: cylindrical semi-finished product and hexagonal profile semi-finished product. Material consumption is calculated for both variants (cylindrical and hexagonal semi-finished products) to compare efficiency and optimize resource usage.

- ✓ cylindrical semi-finished product:

$$m = A_b \cdot h \cdot \gamma$$

$$A_b = \pi \cdot R^2;$$

- ✓ hexagonal semi-finished product:

$$m = A_b \cdot h \cdot \gamma$$

$$A_b = \frac{n}{2} \cdot R^2 \cdot \sin\frac{360^0}{n}$$

where:
A_b – base area, in mm²
h – height of the semi-finished product, in mm
γ – specific weight (density) of the material, in g/mm³
n – number of sides of the regular polygon
R – radius of the circumscribed circle of the regular polygon

$$t_b = \frac{L}{n \cdot s} \cdot i \qquad \text{(min)}$$

where:
L – length to be machined in the feed direction, in mm
n – rotational speed of the piece, in revolutions per minute (rpm)
s – feed (the distance the cutting tool moves during one complete revolution of the piece), in mm/rotation
i – number of passes (a pass is the part of the operation repeated identically in terms of working regime and technological length)

No. op.	Operation name	L mm	n rot/min	s mm/rot	i	t_b min
1.						
2						
3.						
4.						
5.						

6.						
7.						

KNOWLEDGE CHECK

1. The time standard is used for:
   a) calculating labor costs per product unit
   b) calculating raw material costs
   c) calculating overhead costs of sections and overall enterprise overhead

2. The basic time in mechanical processing is calculated in:
   a) monetary units
   b) minutes
   c) hours.

3. The time standard is a way of expressing:
   a) the work norm
   b) the working regime
   c) the norm over a shift

4. The work norm is determined under an operator's work regime:
   a) at the maximum possible level
   b) at the level of existing possibilities
   c) at a normal intensity level

5. The auxiliary time is determined:
   a) based on calculations
   b) based on experimental data obtained in accredited laboratories
   c) from standards (normatives)

6. What does the work norm represent?
   a) The amount of raw materials needed for production
   b) The amount of work needed to complete products, tasks, or services under normal conditions
   c) The total cost of production

7. What is the time norm?
   a) The cost of producing one unit of product
   b) The time necessary to complete one unit of product or one operation
   c) The total working hours in a week

CALCULATION AREA:

Practical work 5

THERMAL ANALYSIS OF MERCHANDISE

Thermal analysis is an essential method in the evaluation of the physic-chemical properties of goods, with diverse applications in multiple industrial and commercial fields.

This technique contributes to quality assurance, to the identification of substances and materials, and to the determination of critical parameters that influence the safety, stability and usefulness of products. For example, in the food industry, thermal analysis helps preserve temperature-sensitive flavors and nutrients. Plastics used in the automotive industry are tested to withstand high temperatures around the engine.

MELTING POINT

Melting point of a substance is the temperature at which it changes from a solid state to a liquid state (at a given pressure). It is one of the most important physical constants used to verify the purity of solid substances and to generally characterize solids. The allowable deviation from the tabulated value can be between 0.5 and 1°C.

Thus, the melting point can be used for substance identification based on tabulated melting points. However, this is only possible for pure substances because impurities tend to lower the melting point to varying degrees, depending on the level and nature of the impurities.

Therefore, determining the melting point can be used to assess the purity of products. For some chemical reagents, a melting point range is specified in which the product's melting point must fall. If the melting point is below the range indicated by the product standard, purification is necessary. After achieving the required purity, the melting point will fall within the permissible limits set by the product standard.

Impurities may also cause the appearance of a melting range. Pure inorganic or organic substances melt at a specific temperature. In the case of polymers, there is usually a melting range because polymers consist of molecules with a certain molecular weight distribution. Generally, the higher the molecular weight, the higher the melting temperature.

The purpose of this work is to identify substances using a digital apparatus for measuring melting points.

Figure 1: Apparatus for measuring melting points

Thermal analysis is an essential method in the evaluation of the physico-chemical properties of goods, with diverse applications in multiple industrial and commercial fields.

This technique contributes to quality assurance, to the identification of substances and materials, and to the determination of critical parameters that influence the safety, stability and usefulness of products. For example, in the food industry, thermal analysis helps preserve temperature-sensitive flavors and nutrients. Plastics used in the automotive industry are tested to withstand high temperatures around the engine.

The unit is turned on with the O/I switch located in the rear, upper left corner of the power supply. The presence of the power supply is confirmed with an audible signal, then the appliance runs with a short self-test, during which time the keys will illuminate successively. The display will show the current oven temperature. For the most accurate measurements, the appliance should be left to stabilize for about 30 minutes. If moisture condensation is observed on the parts in the oven area, it is recommended that before any measurements are taken, the observation lens should be removed and a heating cycle should be carried out until the temperature reaches 30^0 C. Then disconnect the furnace and allow the apparatus to cool, and then re-assemble the lens.

Sample preparation

For best results, samples must be perfectly dry, especially hygroscopic samples. The drier the sample, the easier it is to insert it into the capillary tube. A good method for drying samples is to leave them overnight in a vacuum desiccator in the presence of a suitable drying agent.

Procedure: The capillary tubes are notched in the middle and broken, resulting in two usable tubes. The amount of sample introduced should not be too large, only 1-2 mm from the bottom of the tube. For compacting the dust, the tube can be gently tapped on the table. Air voids can cause problems in determinations. The oven has three slots for capillary tubes. The non-sample positions must be occupied with empty capillary tubes. Rotate the eyepiece to get the best view and locate the sample in the oven. Set the final temperature for the heating ramp (this must be 2-3^o C below the expected melting point).

As the sample is heated, the following phases can be observed:

- the first signs of phase change (color darkening, compaction, synthesization, etc.). These changes may be due to solvent evaporation or crystallization. Occasionally, condensation of the solvent may be observed on the cooler portion of the tube;
- first signs of fluid formation;
- meniscus formation;
- complete transition to the liquid state.

Note that not all samples behave similarly. In particular, very pure substances do not show any signs before complete conversion to liquid.

The table below is based on the results:

Sample number	Measured melting temperature	Melting temperature or melting range according to tables or standards	Name of the substance
1.			
2.			
3.			

Once the first two columns have been drawn up, i.e. with the sample designator and the corresponding experimentally measured melting temperature, the substances under study can be identified from the tables.

FLASH POINT

The flash-point of a combustible liquid is the temperature at which its vapour, produced by heating a sample of the liquid under certain conditions, mixed with the air in the vaporization space ignites (and burns) in contact with an open flame. After combustion of the mentioned mixture the flame goes out. So the liquid does not burn in its mass.

The purpose of this determination is to characterize the product from the point of view of safety in terms of the danger of ignition during storage, transport and the uses to which it will be put.

The flash point is determined using the following three apparatuses which also give their names and methods:

1. *Abel-Pensky apparatus*: used for gasoline, white spirit, and kerosene, i.e., products with flash points between +20°C and +50°C.
2. *Pensky-Martens apparatus:* used for diesel fuels, light oils, and heating fuel, with flash points between 20°C and 275°C.
3. *Marcusson apparatus*: used for fuel oil, lubricants, and semi-solid products with flash points exceeding 80°C.

Determination of flash point using PENSKY-MARTENS apparatus

The determination of the flash point using the Pensky-Martens apparatus is conducted for products with flash points between 20°C and 275°C. The Pensky-Martens apparatus, shown in Figure 2, consists of an air bath made of a cast iron vessel with a steel jacket, which is heated directly by the flame of a burner. The cast iron vessel contains a reservoir in which the product to be analyzed is placed. Inside the reservoir, there is a marker indicating the level to which the liquid being tested must be added.

The cylindrical vessel is equipped with a lid that includes an ignition device and a stirrer.

Fig. 2. Pensky-Martens apparatus

Both the sample to be analysed and the reservoir must be perfectly dry. Place the sample in the reservoir up to the level indicated by the reference mark, put the lid on and place the apparatus in a place protected from draughts and diffused light. Heat the apparatus so that the temperature rises by 5 to 8°C per minute for petroleum products with a flash-point below 150°C and by 10 to 12°C per minute for those with a flash-point above 150°C. At a temperature 10 ^{0}C below the probable flash-point, the ignition test shall be repeated every two degrees.

During the determination the product is stirred continuously with the stirrer, except for the ignition test. The uncorrected flash-point of the product to be analysed is the temperature read on the thermometer when a blue flame suddenly appears over the entire surface of the product. The difference between the results of two determinations may not exceed 2 ^{0}C.

The flash-point depends in addition to the nature of the product also on the atmospheric pressure at which the determination is made. The flash point determined at any pressure is called the uncorrected flash point. The uncorrected flash point is given at a pressure of 760 torr or 1013 mbar with the formulas:

$$t_{760} = t_p - \frac{p-760}{30};$$

$$t_{1013} = t_p - \frac{p-1013}{40}$$

Depending on the scale of the barometer used, so if the pressure p is measured in torr the first formula is used and in mbar the second formula is used. With the experimental results obtained the table below and the analysis bulletin are prepared.

Product identification data	t_{p1}	t_{p2}	t_p	P torr or mbar	t flash at 760 torr	Observations

Analysis report (to be completed after determination of flash point):

Data for product identification:
Flash point at 760 torr:
Date of analysis:
Standard:
Remarks:
Full name:
Position:
Signature and stamp

Determining the FREEZING POINT

The freezing point indicates the highest temperature at which a liquid petroleum product, when cooled under specified conditions, practically ceases to flow. The freezing point is used to assess the mobility of lubricants and liquid fuels when transferred, pumped and used at low temperature.

Petroleum products have a complex chemical composition solidifying within a temperature range if cooled. These products do not undergo mass solidification, only the paraffin they contain crystallises causing them to lose their fluidity. The presence of asphaltic and resinous substances hinders the crystallisation of the paraffin and lowers the freezing temperature. The removal of asphaltic substances from oils by refining leads to an increase in the freezing temperature due to the presence of paraffin.

It is necessary to know the freezing point in order to know under what temperature conditions mineral oils, and in particular lubricating oils, can be used. If such an oil is used at temperatures at which freezing occurs, its lubricating capacity disappears.

Procedure: In the situation where we do not have the apparatus required by the standards, we proceed as follows for the approximate determination of the freezing point:
A test tube is placed in a test tube and a thermometer is inserted in the product under study. Then place the test tube in a freezer. Every 10 minutes we take the test tube out of the freezer, tilt it by 45 degrees and observe the menisci of the liquid. When the meniscus stops moving, take the test tube out of the freezer and hold it at an angle of 45 degrees. We can roughly determine the freezing temperature by actually measuring the flow temperature, the lowest temperature at which the product starts to flow, by reading that temperature at which the meniscus starts to move.

We repeat the determination a couple of times and draw up the next table, the analysis report. The extreme results are discarded from the series of results and the others are used to calculate the pour point, which can be considered as the freezing point.

Data for product identification	t_{c1}	t_{c2}	t_{c3}	t_{c4}	t_{c5}	$t_{c\ med.}$	Observations

Please note that these data are only approximate and indicative, to determine the freezing point in case of disputes we have to use the services of authorised laboratories.

BENEFITS

Thermal analysis plays an important role in various industries, significantly contributing to product quality assurance, consumer protection, safety in use, and the efficiency of manufacturing and distribution processes.

a. Food industry:

1. Perishable food products must be stored at specific temperatures to prevent spoilage. Thermal analysis allows the determination of freezing points, which is crucial for establishing proper storage and transport conditions, preserving product quality and safety.
2. For products requiring production lines with controlled temperatures (e.g., ice cream), thermal analysis helps optimize the process.
3. Melting points of fats and oils are essential for determining their purity.
4. Thermal analysis is vital for identifying and monitoring safe temperature ranges for food products that might be affected by bacterial growth at uncontrolled temperatures.

b. Automotive industry:

1. Materials used in vehicle components must withstand extreme temperatures and varying environmental conditions. Thermal analysis helps evaluate their stability, ensuring parts perform under fluctuating temperature conditions.
2. Plastics, rubber, metals, and alloys must endure temperature variations without deforming, cracking, or degrading.

c. Logistics sector:

1. Thermal analysis aids in establishing optimal transport and storage conditions for temperature-sensitive goods (e.g., food products, medicines, or chemicals).
2. It helps evaluate the performance of transport equipment (refrigerated trucks, containers) and refrigeration systems, preventing product deterioration.

CALCULATIONS AREA:

Practical work 6

QUALITY ASSESSMENT OF FLUID MERCHANDISE BY DETERMINING VISCOSITY

Viscosity is an essential parameter in many industries, significantly impacting product quality. It influences the handling, transport, processing, and use of goods across various fields. Viscosity affects a wide range of products, from food and pharmaceuticals to chemicals and fuels.

Viscosity represents the property of fluids to resist flow due to internal friction. The measurement of viscosity, known as viscometry, is of great importance in production control and the quality assessment of widely used goods, such as lubricants, fuels, bitumen, rubber, plastics, paints, inks, food products, and cosmetics.

Viscosity is as crucial for characterizing pure substances as melting point, density, boiling point, or refractive index. Increasingly, tables of constants for pure organic substances include viscosity values at various temperatures. For goods like lubricants, viscosity and its temperature dependency are the most important properties specified in standards. In the petroleum and automotive industries, knowledge of product viscosity is required for calculating flow rates, pipeline sizing, and determining pump efficiency and power.

Viscosity is a key aspect of rheology. Rheology (from Greek "rheos" = flow and "logos" = science) is the study of the flow of substances under the action of friction forces or, more broadly, the continuous deformation of materials. All materials experience continuous deformation and thus flow under specific conditions.

In practice, viscosity measurement is often used for lubricants to ensure quality control. Standards require lubricants to meet narrow viscosity ranges at various temperatures. If a product falls outside these ranges, it is considered non-compliant with the standard. Non-compliance may result from product degradation or adulteration.

Viscosity, like other physical constants such as melting point, density, and boiling point, is a fundamental property used to characterize pure substances. Its measurement is essential in understanding the behavior of fluids under various conditions, particularly in industrial applications.

A critical parameter in viscosity assessment is its dependence on temperature. This relationship is especially significant for lubricants, where viscosity determines performance under varying thermal conditions. Accurate viscosity measurements ensure that products meet operational standards, maintain efficiency, and avoid failures due to improper flow or resistance.

Viscosity is quantified using specific units in different measurement systems.

1. *In the International System (SI)*: the standard unit is $N \cdot s/m^2$. This unit represents the dynamic resistance of fluid to flow under an applied force, aligning with the broader framework of SI standards.
2. *In the CGS System*: the unit is Poise (P), with its more commonly used subunit, centipoise (cP); 1 cP = 0.001 $N \cdot s/m^2$, making it a practical choice for many applications, particularly in industries requiring precise measurements at smaller scales.

$$1\ cP = 10^{-2}\ P$$

The ratio between the viscosity and density of a fluid is called **kinematic viscosity** υ.

$$\upsilon = \frac{\eta}{\rho}$$

In the SI system, the unit of measurement is the square metre per second (m2/s). In the CGS system, the unit of measurement is called stokes (St). The usual submultiple is centistokes (cSt). In addition to the kinematic and dynamic viscosities, the conventional Engler, Saybolt and Redwood viscosities are also used in practice.

For the determination of dynamic and kinematic viscosity, the following apparatus have been standardised:

- Vogel-Ossag viscometer for the determination of kinematic viscosity
- Höppler viscometer for the determination of dynamic and kinematic viscosity

The viscosity of various petroleum products will be determined with the Höppler and Engler viscometers at several temperatures.

Determination of viscosity with HÖPPLER viscometer

The Höppler viscometer (Fig. 1) is a ball viscometer which makes it possible to determine the dynamic viscosity by measuring the time of fall of a ball of a given diameter and weight falling eccentrically in an inclined cylindrical tube under conditions in which the proportionality between viscosity and falling velocity is maintained.

Description of the apparatus:

The Höppler viscometer consists of a glass tube fitted with a glass mantle, which is mounted on a stand. The tube is fitted at both ends with stoppers and caps with gaskets. The plug of one of the caps is fitted with a capillary. Two marks (a and b) are engraved on the tube, about 100 mm apart.

The tube is mounted in a metal frame, which can be rotated together with the bath surrounding the tube, in a bearing located in the stand and secured with a screw. The liquid whose viscosity is to be determined and one of the six glass or stainless metal balls belonging to the apparatus are introduced into the tube.

The glass mantle allows heating and cooling of the drop tube between temperatures of 1 ^{0}C and 150 ^{0}C. It is fitted with shims through which it is connected to a recirculating liquid thermostat, which ensures that the temperature of the bath and the liquid in the tube is kept constant. The bath is fitted with a thermometer with divisions of 0,1 ^{0}C, on which the temperature of the determination is read.

Fig. 1. HÖPPLER viscometer

The viscometer is equipped with a set of 6 balls which are chosen according to the viscosity of the product to be analysed. In order to distinguish the balls, the Höppler is fitted with a perforated plate. Ball No. 1 is made of glass and does not pass through the hole in the plate, ball No. 2 is also made of glass and does not pass through the hole in the plate, but is smaller than the glass ball No. 1.

Ball No. 3 passes exactly through the hole in the plate, ball No. 4 passes through easily, ball No. 5 very easily and ball No. 6 is the smallest.

Making the determination. Before inserting the product to be analysed, the tube, beads, stoppers and stopper gaskets must be clean and dry. Place the apparatus in the light and adjust the position of the apparatus by means of the loop level, which must indicate the horizontal position, using the levelling screws at the base of the stand.

Heat the product to be analysed to approx. 10 ^{0}C above the determination temperature. The tube, sealed at the bottom with a stopper and cap, is loaded until about 2 cm to its upper edge, any air bubbles collected on the surface of the product in the tube are removed by bringing a heated glass rod close to the tube. Insert the selected bead, then carefully place the upper stopper together with the sealing gasket. The product must also pass through the capillaries of the stopper. Apply the gasket and screw cap.

Recirculate the water from the thermostat connected to the appliance through two rubber tubes and when the bath temperature remains constant for 15 minutes, the determination can be made. Loosen the fastening screw and turn the apparatus 180^{0}C, the ball drops to the bottom, turn the apparatus round again and return it to its original position for determination. When the descending ball becomes tangent to the plane determined by the upper mark on the tube, start a stop-watch, and when the ball becomes tangent to the plane determined by the lower mark, stop the stop-watch. Several measurements (3-5) are made and the arithmetic mean of the times found is taken for calculation.

In the case of dark-coloured liquids in which the tangent of the ball to the reference line cannot be observed, the stopwatch is started when the centre circle of the ball passes the upper reference mark and stopped when the centre circle of the ball passes the lower reference mark.

Calculations:

- Calculating dynamic viscosities

$$\mu_t = T\ (\rho_b - \rho_t)\ K$$

where:
μ_t - dynamic viscosity at temperature t^0 C in cP;
T - drop time of the bead between the two reference points, in s;
ρ_t - relative density of the product analysed at the temperature at which the determination was carried out;
ρ_b - relative density of the bead, as shown in the following table;
K - constant of the bead used, as in the following table.

Bead no.	**Relative density of the bead (20^{0}C)**	K
1	2,408	0,009447
2	2,410	0,07575
3	8,125	0,1141
4	8,124	0,148
5	8,12	10,2
6	8,17	41,6

The kinematic viscosity is calculated with the formula:

$$\upsilon_t = \frac{\mu_t}{\rho_t}$$

υ_t - kinematic viscosity at t^0C, in cSt
μ_t - dinamic viscosity, at t^0C, in cP
ρ_t - relative density of the product to be analysed at the temperature at which the viscosity determination was carried out (g /cm^3).

Density of the product, g/cm^3 (20^{0}C)	Correction factor (c) for 1 ^{0}C
0,70	0,00075
0,80	0,00070
0,84	0,00065
0,86	0,00064
0,88	0,00063
0,92	0,00060
0,96	0,00057

Calculation example:
A mineral oil has a density of 0.860 g/cm^3 at 20 ^{0}C. What will be the density of the oil at 45 ^{0}C?

The correction factor is 0.00064 g/cm^3. The temperature difference is: 45 - 20 = 25 ^{0}C.
Therefore 0.00064 X 25 = 0.016 g/cm^3.
The (liquid) density of the oil at 45 ^{0}C will be 0.860 - 0.016 = 0.844g/cm^3.
The density of the bead at the determination temperature is calculated by the formula:

$$\rho_b^t = \rho_b^{20}\,[1 - \beta\,(t - 20)]$$

β – cubic expansion coefficient of glass beads is 0.000018
t – determination temperature

Determinations will be carried out at the following temperatures ~20^0C, ~30^0C şi ~40^0C. Table 1 and 2 are completed using the experimental results.

Table no.1: Results

Sample No.	Temp. ^{0}C	T_1 sec	T_2 Sec	T_3 sec	T_4 sec	T_5 Sec	$T_{med.}$ sec	μ_t cP	υ_t cSt
1.									
2.									
3.									

Table no.2: Analysis bulletin

Supplier:		
Product:		
Invoice:		
Operator:		
Apparatus:		
Temperature ^{0}C	**Dynamic viscosity** CP	**Kinematic viscosity** cSt

Date_______________ Signature_____________

Using the data obtained in the dynamic viscosity calculation, plot the dependence of dynamic viscosity on temperature.

USES OF PARAFFIN WAX

Paraffin wax is a by-product of petroleum, used in various industries and with multiple uses:

a) it is used for candle making
b) It is used in the cosmetics industry
c) it is used for packaging to treat certain ailments
d) it is used in the food industry (cheese coating)
e) used for impregnating wrapping paper
f) liquid paraffin is used in the furniture industry
g) paraffin oil is used as an ingredient in fatty creams used to treat dermatological conditions.

Determination of conventional relative viscosity by the ENGLER METHOD

The Engler viscometer is an apparatus for practically technical use. It consists of an inner vessel 1 with a gold-plated inner surface, which is closed by a lid 2, into the openings of which are inserted the rod 3 for closing the drain hole 4 and the thermometer 5 for measuring the temperature of the liquid sample whose viscosity is being measured. Around the vessel 1 there is a jacket 6 containing the thermostating liquid, the temperature of which is measured with thermometer 7.

The viscosity determined with this apparatus is called Engler viscosity and is expressed in degrees Engler (0E) at a given temperature: 20, 50 and 100 ^{0}C. The more viscous the sample analysed, the higher the temperature at which it is determined.

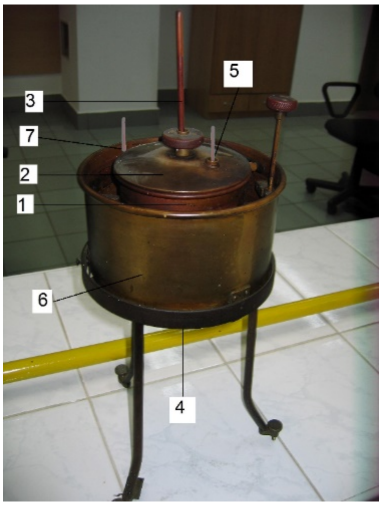


Fig.2. Engler viscometer

Carrying out the determination:

For determination of Engler viscosity, 200 ml of distilled water (for calibration of the apparatus) and 200 ml of the liquid to be analysed must be drained from the apparatus (at a certain temperature), measuring the draining times. The flow times are measured in seconds. The numerical value of the Engler viscosity is found by the ratio of the flow time of the analysed liquid sample to the flow time of the water:

$$°\mathrm{E} = \frac{\text{flow time of 200 ml analysed liquid}}{\text{flow time of 200 ml distilled water}}$$

The time taken for water to drain at 20 ^{0}C should be 50 - 52 seconds and is called the viscometer constant. The drained liquids are captured in Engler flask. The drain time is measured with a stopwatch. In the case of very viscous liquids (which, at the end of the determination, drip in drops), measure the draining time of 100 ml and multiply it by 2,35 to obtain the draining time of 200 ml of liquid. If Engler viscosity is greater than 10^{0}E, then the kinematic viscosity is calculated as follows:

$$\upsilon = °E \cdot 7{,}58$$

If the Engler viscosity is between 1 and 10 ^{0}E, the kinematic viscosity is taken from the table below:

Engler viscosity	Kinematic viscosity	Engler viscosity	Kinematic viscosity	Engler viscosity	Kinematic viscosity
1,00	1,00	2,00	11,80	5,00	37,30
1,10	1,80	2,10	12,80	5,50	41,20
1,20	2,80	2,20	13,80	6,00	45,10
1,30	3,90	2,30	14,80	6,60	49,00
1,40	5,00	2,40	15,70	7,00	52,90
1,50	6,25	2,50	16,60	7,50	56,80
1,60	7,45	3,00	21,10	8,00	60,60
1,70	8,30	3,50	25,40	8,50	64,40
1,80	9,60	4,00	29,30	9,00	68,20
1,90	10,70	4,50	33,30	9,50	72,00
				10,00	74,80

The leakage time is measured 4 - 5 times and their arithmetic mean is used. The obtained results will be listed in Table 3 and 4.

Table 3: Results

Sample no.	Temp ^{0}C	T_1 sec	T_2 sec	T_3 sec	T_4 sec	T_5 sec	T_{med} sec	$°E$	υ_t cSt
1.									
2.									
3.									

Table 4. Analysis Bulletin

Supplier:		
Product:		
Invoice:		
Operator:		
Apparatus:		
Temperature ^0C	**Dynamic viscosity** CP	**Kinematic viscosity** cSt

Date_______________ Signature______________

Identifying the most suitable engine oil for your car is becoming more and more complicated. The secret of a good oil lies in the quality requirements to be met in the engine lubrication process, which are:

- maintaining optimum viscosity
- good lubricity
- anti-friction qualities (reduced friction)
- anti-stripping qualities
- antioxidant and anti-acidity qualities
- detergent and dispersant qualities
- anti-foaming qualities

Maintaining optimum viscosity refers to the fact that we would like to have a thin oil in the engine when starting the engine cold (especially in winter) and still have sufficient viscosity at full load to provide normal engine pressure and lubrication. Viscosity variation is a function of temperature. Therefore all oils have a viscosity index.

Onctuosity is the property of a liquid to adhere to the surfaces with which it comes into contact. For internal combustion engines, it is very important that even after long periods of standstill, a film of oil remains on all parts so that a minimum of lubrication is ensured when the engine is started for the first time until the lubrication system is primed.

Anti-friction qualities of automotive oils ultimately lead to lower fuel consumption and savings of 10-15%. The anti-friction qualities refer to the resistance of the oil film to the high pressures occurring between the different parts in contact and friction (e.g. gears).

Anti-oxidising and *anti-acidity* qualities are necessary for the chemical stability of the oil during the recommended period of storage and especially use. The detergent and dispersant qualities help to avoid the build-up of various particles on engine parts as a result of operation.

Anti-foaming qualities are necessary because the lubrication process is very violent in some phases and it would be a big problem to have oil foam (i.e. about 99% air) instead of oil in the engine.

All these qualities of engine oils are mainly obtained by adding substances to a base oil (mineral, semi-synthetic or synthetic), an operation called additivisation. The number, quality/quantity of additives and the quality of the base oil ultimately determine the quality of the motor oil.

Role of viscosity in various fields

A. In the *food industry*, viscosity plays an important role in determining the consistency of products. For example, juices, sauces, sauces, ice-creams, jams or beverages need to have a specific viscosity to ensure the correct texture and a pleasant drinking experience.
B. In *food manufacturing and packaging*, knowledge of viscosity is essential to adjust equipment and production lines. For example, for products such as creams or oils, viscosity influences how the product is transported through pipelines and filled into packaging.
C. In the *automotive industry*, engine oil viscosity is a critical factor in engine performance and longevity. Oils must have optimum viscosity to ensure effective lubrication, protecting engine parts from wear.
D. In the *textile industry*, the viscosity of dyeing and finishing liquids is crucial to ensure uniform coating of materials.
E. In *the cosmetics industry*, the viscosity of products such as creams, lotions and gels is essential to achieve the desired texture. Viscosity also influences the product's applicability to the skin as well as its long-term stability.
F. In the *pharmaceutical industry*, viscosity is important in the formulation and administration of liquid medicines such as syrups or suspensions.

KNOWLEDGE CHECK

1. Quality control of lubricants involves determining:
   a) their boiling point
   b) their viscosity
   c) their distillation range

2. The unit of measurement for dynamic viscosity in the CGS system is:
   a) Poise with centipoise submultiple (P, cP)
   b) Stokes with centistokes submultiple (St, cSt)
   c) Engler degrees.

3. The Hoppler method of viscosity determination is preferred because:
   a) the time required to perform is short
   b) it allows determination of both viscosities (dynamic and kinematic)
   c) gives information about the ball used

4. Can viscosity be used as a quality parameter for liquid products?
   a) yes, always without further specification
   b) yes, with specification of the determining temperature
   c) no.

5. Viscosity is:
   a) a physical quantity characterising the Hoppler apparatus balls

b) a frictional force that arises within a liquid due to the relative sliding motion of the layers against each other

c) a characteristic of solids which are subject to friction

CALCULATION AREA:

Practical work 7

CHARACTERIZATION OF FUELS AS MIXTURES OF SUBSTANCES BY DETERMINING THE ANILINE POINT, DIESEL INDEX, AND CETANE NUMBER

The analysis of fuels used in compression ignition engines (also called diesel engines) is of particular importance in practice. Fuels must meet national and international quality standards in order to be legally marketed.

In order to determine the quality and composition of fuels, the aniline point is practically determined. Using the aniline point value and the distillation temperature we can characterise the quality of diesel fuel.

The determination of these fuel characteristics plays an important role in ensuring the efficient, safe and environmentally friendly operation of vehicles and industrial equipment using diesel or similar fuels.

ANILINE POINT

The aniline point is the lowest temperature at which, under specified working conditions, aniline and the petroleum product to be analysed, mixed in equal volumes, form a homogeneous (cloud-free) phase.

The determination of the aniline point gives an indication of the relative content of paraffinic, naphthenic and aromatic hydrocarbons in the sample under test and also makes it possible to calculate the Diesel Index of diesel oils used as fuels in diesel engines.

Aim of the work. To determine the aniline point of samples of petrol, petrol and diesel; to determine the Diesel index of samples of diesel oil and petrol.

Description of the apparatus. The apparatus used to determine the aniline point is shown in Fig. 1. It consists of a glass test tube 1, 25 mm in diameter, 150 mm in length, fitted with a cork stopper 3 with two channels. A thermometer is fixed in the middle channel and a glass or aluminium stirrer 5 is fixed in the side channel, the inner part of the stirrer being in the form of a ring, which encloses an angle of 90° with the stirrer rod. The test tube 1 is provided with a sleeve 2 (in the form of a test tube) which is applied by means of a rubber ring (stopper) to the test tube 1.

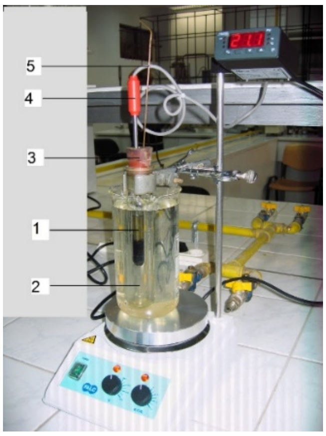


Fig.1. Apparatus for aniline point determination

1,2-spheres; 3-dop; 4-thermometer; 5- stirring device

Making the determination.

Insert test tube 1 into the test tube 2 in such a way that there is a distance of about 2 cm between the bottoms of the two tubes. 20 mm.

Pipette 5 ml each of freshly distilled aniline and the petroleum product to be analysed into the cleaned and dried test tube 1, then place the rubber stopper with thermometer and stirrer. The thermometer is fixed at a distance of 5 mm from the bottom of the test tube. The assembled apparatus is placed in a Berzelius beaker containing water, which is used as a heating bath.

The mixture of aniline and petroleum product is stirred and the phenomenon is observed. If the components remain immiscible at room temperature, forming a slurry by fine dispersion of the phases, then the bath is heated at a rate of about 1 ^{0}C per minute and stirring is continued. When the turbidity disappears, the components (phases) become miscible, the temperature is read off and the apparatus is removed from the bath. The stirring is stopped and the mixture cools in air. Note the exact temperature at which the thermometer reservoir is no longer distinguishable in the reflected light due to the renewed appearance of the slurry. The temperature read on this occasion will be taken as the aniline point.

If the mixture of aniline and petroleum product becomes homogeneous by stirring at room temperature, then the sample is cooled at 10 °C per minute until the sample becomes turbid. The apparatus is then removed from the cooling bath and allowed to warm in air until the sample becomes homogeneous (by continuous stirring), the thermometer reservoir being visible in the reflected light. Note the temperature which is taken as the aniline point. The operation is repeated until constant values are obtained. Paraffins have an aniline point between 60 – 80 ^{0}C, naphthenes between 20 – 40 ^{0}C and aromatics below 0 ^{0}C.

DIESEL INDEX AND CETANE NUMBER

The cetane number and the Diesel Index are the most important characteristics marking the quality of fuels used in diesel engines. They express the auto-ignition behaviour of these products. The higher the cetane number and Diesel Index of a diesel oil used as a fuel in engines of the same designation, the better the diesel oil will be. Diesel fuels have a cetane number between 45 and 65.

A standardised C.F.R. (Coordinated Fuel Research) engine is used to determine the cetane number, in which the ignition lag of the fuel analysed is measured. Mixtures of n-ketane and alpha-methylnaphthalene were chosen as a basis for comparison. n-ketane conventionally is assigned a cetane number of 100 and alpha-methylnaphthalene 0.

The ignition lag in the CFR engine of mixtures of different compositions (consisting of the two components) is determined. The same test is carried out on the given diesel oil. In the light of the above, the cetane number of the given diesel oil shall be considered to be equal to, for example, 55 if it has the same autoignition gap as a mixture of 55 per cent n-ketane and 45 per cent alpha-methylnaphthalene.

The ease of determination has led to the widespread introduction of the Diesel Index (D.I.) as a means of assessing the ignition quality of diesel fuels. It is numerically equal to the product of the aniline point of the fuel expressed in degrees Fahrenheit (^{O}F) and its density, expressed in American Petroleum Institute (A.P.I.) degrees, divided by 100.

Transformation ^{0}C In ^{0}F is done with the relation:

(A): $^0F = {^0C} \cdot 1{,}8 + 32$,

and of the relative density (D) in A.P.I. degrees with the equation:

$$D = \frac{141{,}5}{d_4^{15,7}} - 131{,}5$$

Where:

$d_{15,7}$ is the relative density of the product to be determined at 15,7^{0}C, in relation to the density of distilled water at the same temperature.

The density at 15,7^{0}C is calculated with the relation:

$$d_4^{15,7} = d_4^{20} - c(15{,}7 - 20),$$

Where:

C - is the correction factor specific to each product with the following values:

Product name	Correction factor (c)
Heavy petrol	0,000725
White spirit	0,00071
Petrol	0,00069
Diesel	0,00064

Calculating the Diesel Index (DI)

The Diesel Index value is calculated by the following relationship:

$$I.D. = \frac{D \cdot A}{100} \quad \text{(grade A.P.I.)} \qquad (1)$$

where:

D – relative density of diesel oil in degrees A.P.I.

A – aniline point of diesel oil, in ^{0}F.

Diesel Index can also be calculated by the formula:

$$I.D. = 2{,}367(t + 17{,}8)\left(\frac{1{,}076}{d + 0{,}004} - 1\right), \qquad (2)$$

where:

d - is the density of the sample at 20 ^{0}C, in g/cm3.

t - aniline point, in ^{0}C.

To calculate the cetane number (C.C.), the following mathematical relation is applied, in which the I.D. also appears:

$$C.C. = 0{,}8 \times I.D. + 10 \qquad (3)$$

In the case of Romanian petroleum products, the C.C. can also be calculated using an empirical formula based on the kinematic viscosity of the product analysed, determined at 20 ^{0}C, and its density, also assumed at 20 ^{0}C:

$$C.C. = (V_{20} + 17{,}8) \cdot \frac{1{,}5879}{d_{20}} \qquad (4)$$

V_{20} - is the kinematic viscosity of the product determined at 20 ^{0}C and expressed in cSt;
D_{20} - is the density of the sample at 20 ^{0}C.

or: C.C. = - 0,24 A + 0,1N + 0,85 P

A, N and P - are the percentage content of aromatic, naphthenic and paraffinic hydrocarbons in the sample.

The results are given in the tables below.

Product:..................

t ^{0}C	I.D. (1)	I.D. (2)	C.C. (1)	C.C. (2)	Observation

(1), (2) - is the number of calculation formulae

Product:..................

t ^{0}C	I.D. (1)	I.D. (2)	C.C. (1)	C.C. (2)	Observation

Product:..................

t ^{0}C	I.D. (1)	I.D. (2)	C.C. (1)	C.C. (2)	Observation

Product:..................

t ^{0}C	I.D. (1)	I.D. (2)	C.C. (1)	C.C. (2)	Observation

KNOWLEDGE CHECK

1. The cetane number is a quality index for:
    a) Otto type engine fuels
    b) standardized CFR type engine fuels
    c) engine oils

2. Aniline point indicates information on:
    a) the content of aromatic, naphthenic and paraffinic hydrocarbons and may be used in the calculation of the Diesel Index and the cetane number
    b) the quality of oils
    c) the degree of wear of diesel oils.

3. The higher the Diesel Index, the better the quality of Diesel fuels:
    a) lower
    b) between 45 and 65
    c) higher

4. Several .... methods are used to determine the cetane number.
    a) two
    b) three
    c) four

5. Which statement about the cetane number and Diesel Index is correct?
    a. They measure the viscosity of diesel fuel
    b. They represent the auto-ignition behavior of diesel fuels
    c. Higher cetane numbers indicate poorer quality diesel fuel.

CALCULATION AREA:

CALCULATION AREA:

Practical work 8

QUALITATIVE CHARACTERIZATION OF PETROLEUM PRODUCTS BY ENGLER FRACTIONAL DISTILLATION

Engler fractional distillation is a method used to separate a mixture of substances on the basis of their boiling points, with the aim of identifying and separating fractions of a fuel or other liquid.

Engler fractional distillation allows the behaviour of a fuel to be evaluated at different temperatures. This is important for understanding how well a fuel will withstand extreme temperature conditions, impacting on its stability and safety in use.

In petroleum refining, Engler fractional distillation helps to separate crude oil into distinct fractions, which are used to produce different types of fuel such as petrol, diesel and kerosene. Kerosene is mainly used as a fuel for aircraft engines, especially in commercial aeroplanes, having an optimal mix of light and heavy fractions that allow complete, efficient and safe combustion at high altitudes. Kerosene is designed to remain stable at extremely low temperatures, essential for high-altitude flights where outside temperatures can drop below -50°C. Kerosene has a higher flash point than other types of fuel, which reduces the risk of spontaneous ignition in flight conditions.

Fractional distillation involves heating the product sample and collecting the condensed fractions at different temperature ranges. The principle of the Engler distillation method is to successively vaporise, condense and collect the different fractions which make up a liquid product based on a mixture of liquid substances.

The purpose of this operation is to determine the boiling limits of the liquid products and the temperatures at which the various fractions distil by forming the Engler diagram. This operation also makes it possible to determine the yields of the fractions obtained. For this purpose, the volumes of the fractions distilling in temperature intervals of 10 ^{0}C are noted. At the same time, the initial distillation temperature and the final distillation temperature are noted.

Description of the distillation apparatus

- Würtz flask, made of steel (1);
- heating source, standard adapted for gas heating (2);
- copper cooler 700 mm long, with 10 mm diameter cooling pipe (3);
- thermometer (4).

Fig.1: Distillation apparatus

Performing determination

Place 50 ml of the product to be analyzed into the flask, measured using a graduated cylinder. Insert the thermometer through a stopper into the neck of the flask so that the thermometer's axis aligns with the flask's axis, and the upper part of the mercury reservoir is level with the lower edge of the outlet tube. Connect the side tube of the flask to the upper end of the condenser tube; place a graduated cylinder at the lower end of the condenser to collect the distillation fractions. Start the cooling water flow.

Once the apparatus is set up, begin heating the flask. It is recommended to adjust the heating so that the first drop of distillate falls between 5-10 minutes and no later than 10-20 minutes. Continue the distillation at a uniform rate (2-5 ml/min).

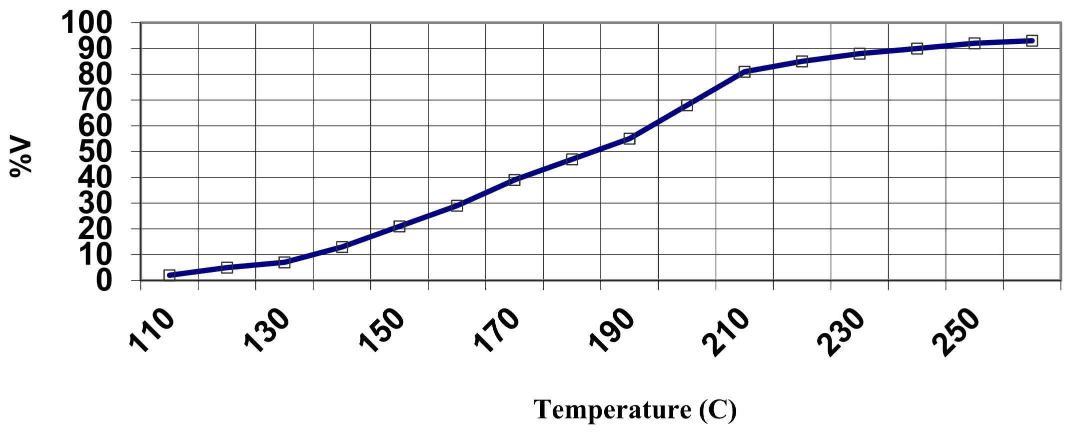
During the distillation process, record the volume of the distillate (cumulative) at every 10°C interval. The final boiling point is determined by continuing to heat the flask until the mercury column of the thermometer begins to drop.

Engler diagram and preparing material balance

Based on the distribution of distillate volumes across the temperature scale, information about the composition and homogeneity of the analyzed product is obtained. Correct interpretation of the practical results is achieved by plotting the distillation diagram (Engler diagram). This diagram involves a graphical representation of the percentage volume of the distillate as a function of the distillation temperatures.

Practically, based on the experimental data collected (distillate volumes as a function of distillation temperature), calculate the percentage volumes of the distillate for each 10°C interval. Additionally, note the temperatures at which distillation begins and ends. When plotting the diagram, plot temperature values on the x-axis (measured at 10°C intervals from the start of distillation) and the cumulative percentage volumes of distillate collected at those temperatures on the y-axis.

Fig. 2: Engler diagram (exemple)



After plotting the Engler diagram, the material balance for the distillation operation is prepared based on the distillation intervals corresponding to each fraction. For the selected product (petroleum product), the possible fractions within the temperature range of 100–260°C are:

- Up to 180°C – Gasoline
- 180–210°C – White spirit
- 210–250°C – Kerosene
- Above 250°C – Diesel fuel

The quantity of distillation residue is measured using a graduated cylinder to collect the residue remaining in the distillation flask where the analyzed sample was placed. The mass of the residue is calculated based on its density, which is 0.920 g/cm³**.**

Losses are calculated by difference to ensure the material balance is accurate and complete.

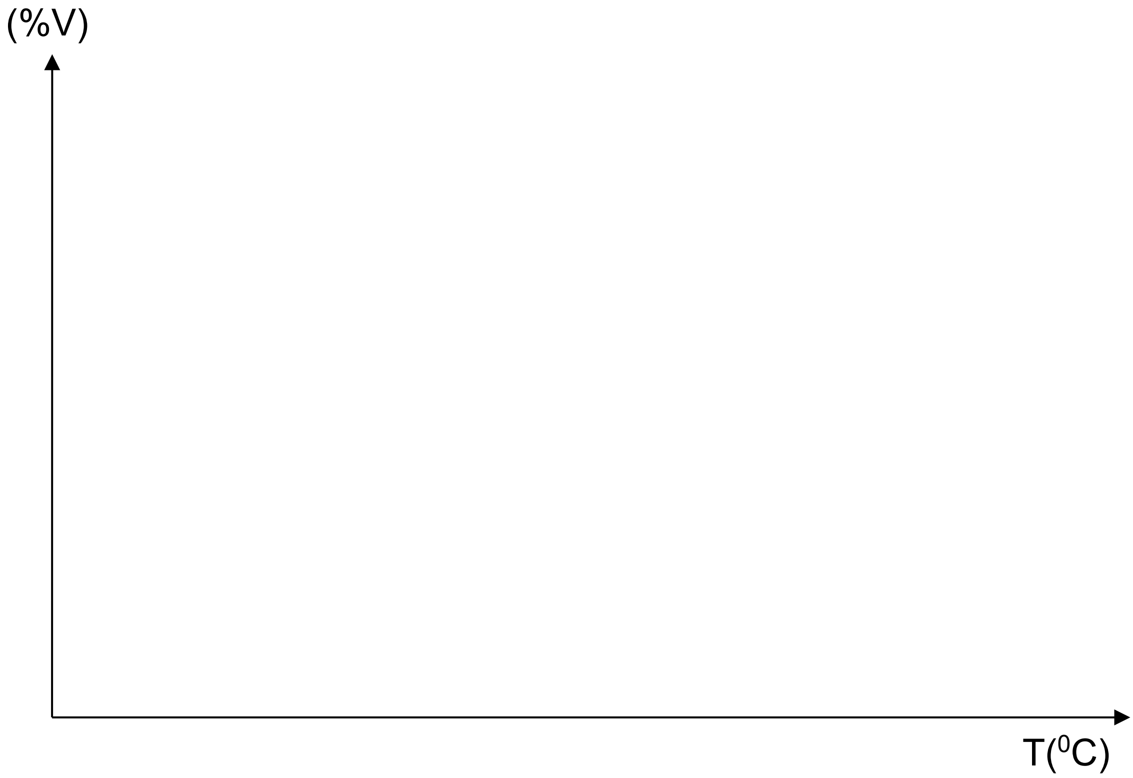
Table 1: Material balance for Engler distillation

Materials Entered				**Materials Exited**			
Substance	UM	Quantity (g)	%	Substance	UM	Quantity (g)	%
Petroleum liquid mixture	g	42	100	Gasoline White-spirit Petrol Diesel Residue Losses	g g g g g g		
TOTAL		42	100	TOTAL		42	100

Table 2: Experimental results

Temperature, ºC	**Distilled volume, ml**	**Volume percentage, %**

Plot the Engler diagram using the experimental results.



KNOWLEDGE CHECK

1. The principle of the Engler distillation method is:
   a) to vaporize, condense, and successively collect different fractions that make up a liquid product;
   b) to recover and measure the distillation residue;
   c) to monitor the volume of distillate every 10 ml.

2. The correct interpretation of practical results in Engler distillation is done:
   a) by calculating the percentage volumes of the distillates;
   b) by carefully monitoring the temperature variation;
   c) by plotting the Engler distillation diagram.

3. The order of distillation of the main petroleum fractions analyzed is:
   a) gasoline, white-spirit, petrol, diesel;
   b) diesel, petrol, white-spirit, gasoline;
   c) gasoline, petrol, white-spirit, diesel

4. Engler distillation represents:
   a) an analytical method for petroleum products;

b) a process for obtaining petroleum fractions;
c) a way to evaluate the efficiency of catalytic cracking.

5. The Engler diagram can provide information about:
a) the content of the petroleum product according to the distillation intervals;
b) the technical-economic indicators of distillation;
c) the economical operation of the distillation plant.

CALCULATION AREA:

Practical work 9

CHARACTERIZATION OF TECHNOLOGICAL PROCESSES BY PREPARING MATERIAL BALANCES AND CALCULATING TECHNICAL-ECONOMIC INDICATORS

(exemplified on a simple technological process consisting of two basic unit operations)

To clearly illustrate what it means to characterize a technological process (regardless of its type) by preparing a material balance and then calculating some technical-economic indicators, a technological process consisting of two basic operations was chosen: extraction followed by distillation. In practice, such a process is encountered in the extraction of useful substances from various raw materials (for example, in the pharmaceutical and dye industries), obtaining oils and extracts from plants (for example, in the food industry), etc. This pair of unit operations (extraction-distillation) is also found in many other technological processes, ranging from those in the coke-chemical and petrochemical industries to those in the food industry.

EXTRACTION

It is a diffusion operation through which mixtures of solids or liquids are separated into components using selective solvents. Based on this principle, extraction is also used to improve the quality of some products (refining extraction in the petrochemical industry). If the initial mixture subjected to extraction is solid, the operation is called solid-liquid extraction; if it is a homogeneous mixture of liquids, the operation is called liquid-liquid extraction. Factors influencing extraction include: the solvent, degree of dispersion, granulation, duration, temperature, etc.

The solvent must also meet several conditions: it should extract the useful substance, be pure, easily volatile, non-corrosive, and non-flammable (if possible). At an industrial scale, the following solvents are more commonly used: extraction gasoline, benzene, ethyl alcohol, acetone, etc.

Simple solid-liquid extraction with single contact using a Soxhlet-type apparatus

In this procedure, the solvent (S) is passed over the material to be extracted (A). The extracted substance together with the solvent (A+S) siphons into the base of the extraction apparatus. The solvent condensed in the condenser of the apparatus flows over the extraction cartridge located in the Soxhlet apparatus.

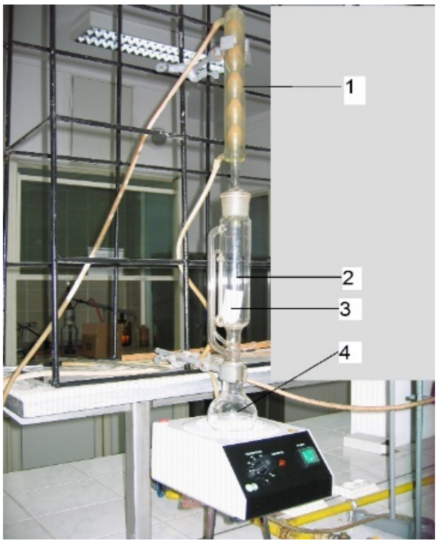


Fig. 1: Soxhlet-type apparatus

Working method

The sample intended for extraction is weighed and then placed in the extraction cartridge (3) of the apparatus. The necessary amount of solvent is placed in the flask (4) of the apparatus, after which heating is started and continued until 5–6 siphon cycles occur in the apparatus (sometimes even more). Then, the installation is disassembled, the solution from the flask moves on to the next phase, and the cartridge from the Soxhlet apparatus (2) is removed, dried, and weighed.

Knowing the masses of the raw materials introduced and the resulting components, a partial material balance (for the extraction operation) is prepared. Losses are calculated by difference so that the material balance closes correctly.

Material balance of the extraction operation

INCOMING MATERIALS				OUTGOING MATERIALS			
Substances	UM	Quantity	%	Substances	UM	Quantity	%
Solid mixture	g			Solvent product-mixture	g		
Solvent	g			Solid residue	g		
				Cartridge	g		
Cartridge	g			Losses	g		
TOTAL			100	TOTAL			100

For this stage of the technological process, among the technical-economic indicators that can be calculated, the extraction yield is of particular importance because it provides information about the efficiency with which this technological operation was performed.

DISTILLATION

The distillation operation consists of the partial vaporization of a liquid and condensation of the vapors formed. In this case, it is applied to separate the components of a homogeneous liquid mixture. The separation is based on the different boiling points of the components and becomes easier as the difference between boiling points increases.

The liquid obtained during distillation by vaporization and condensation is called the distillate, while the part that remains in the distillation flask is the distillation residue. Before the desired fraction, small amounts of volatile substances (impurities) called "heads" are often removed from the liquid mixture subjected to distillation, and after the collected fraction, "tails" appear.

The main types of distillation are the following:

a) *Simple distillation*: Used for mixtures with large boiling point differences.
b) *Fractional distillation*: Uses a fractionating column to separate components with closer boiling points.
c) *Steam distillation*: Used for heat-sensitive materials by introducing steam.
d) *Vacuum distillation*: Operates under reduced pressure to lower boiling points.

Working method

The mixture of solvent and useful product obtained in the extraction stage is placed in the distillation flask (boiling flask). The distillation setup is assembled, consisting of the flask, a descending condenser, and a collection flask. Cooling water for the condenser is started, followed by heating the boiling flask at an appropriate rate. Distillation is considered complete when the temperature read on the thermometer in the side neck of the condenser begins to decrease.

The volumes of distillate in the collection flask and residue in the boiling flask are measured. In this case, the residue obtained in the boiling flask represents the useful product of the technological process.

Knowing the densities of the useful product (0.840 g/cm³) and the recovered solvent (1.256 g/cm³), a partial material balance (for the distillation operation) is then prepared.

Material balance of the distillation operation

INCOMING MATERIALS				OUTGOING MATERIALS			
Substances	UM	Quantity	%	Substances	UM	Quantity	%
Solvent product-mixture	g			Useful product	g		
				Solvent	g		
				Losses	g		
TOTAL			100	TOTAL			100

Final analysis of the technological process

Having the partial material balances for the two operations, the next step is to prepare the overall material balance of the technological process by algebraically summing the two balances and calculating the technical-economic indicators.

Material balance of the technological process

INCOMING MATERIALS				OUTGOING MATERIALS			
Substances	UM	Quantity	%	Substances	UM	Quantity	%
Solid mixture Solvent Cartridge	g g g			Useful product Solvent Solid reziduu Cartridge Losses	g g g g g		
TOTAL			100	TOTAL			100

Knowing the general material balance of the technological process, the actual calculation of some techno-economic indicators can be performed, such as:

***Extraction yield (η)*:**

Extraction Yield is the ratio between the amount of active substance (or product) obtained by extraction and the total amount initially available in the raw material. It is a measure of the efficiency of the extraction process. Higher yields mean more efficient use of raw materials and solvent, which reduces production costs.

$$\eta = \frac{M_e}{M_c} \cdot 100 \text{ [\%]}$$

where:

M_e is the mass of the useful product obtained

M_c is the mass of the useful component in the initial mixture, determined by preliminary analyses (4.2 g).

Practical specific solvent consumption:

It measures how much solvent is consumed (used up, lost, or required) to produce a given quantity of product in a solvent-based process.

In the extraction operation, the solvent is used to separate a desired substance from a solid or liquid mixture. The practical specific solvent consumption refers to the actual amount of solvent consumed (used and lost) to extract a unit of product. The extraction yield shows how well the process is able to recover the desired useful product from the mixture. A high yield indicates efficient extraction.

$$C_{sp}^{p} = \frac{M_{si} - M_{sr}}{M_p} \text{ [t/t]}$$

Where:

M_{si} - mass of solvent entering the technological process;

M_{sr} - mass of solvent recovered in the technological process

M_p - mass of useful product

CALCULATION AREA:

KNOWLEDGE CHECK

1. If the initial mixture subjected to extraction is solid, the operation is called:
   a) solid-liquid extraction;
   b) liquid-liquid extraction;
   c) solid-solid extraction.

2. In order for a solvent to be used in extraction, it must meet the following conditions:
   a) extract the useful substance;
   b) be pure and slightly volatile;
   c) non-corrosive and non-flammable;

3. The recovery and recycling of raw materials leads to:
   a) an increase in the specific consumption of raw materials;
   b) a decrease in the specific consumption of raw materials;
   c) insignificant effects on the specific consumption of raw materials.

4. The specific consumption of raw materials can be defined as:
   a) the amount of raw material consumed in a batch;
   b) the quantity of raw material consumed to obtain a unit of product;
   c) the quantity of raw material consumed.

5. What is Extraction Yield and why is it important to measure it in an extraction process?

6. How is extraction yield calculated and what information is needed for this calculation?

7. What is the difference between extraction yield and specific practical solvent consumption in the extraction process?

8. Why is monitoring specific practical solvent consumption essential in an industrial extraction process?

9. How does a low extraction yield influence the costs and efficiency of the process?

10. What are the main causes of solvent losses in the extraction process and how can they be reduced?

CASE STUDY

PRODUCT QUALITY ANALYSIS: FROM DESIGN TO AFTER-SALES SERVICES

âIn the world economy of this beginning of the millennium, certain trends can be highlighted such as the rapid renewal and unprecedented diversification of the product offer as a result of the increasing penetration of technical progress in production, the globalization of markets, the increase in customer demands, and recently the emergence of strict rationalization of the efficient use of all resources, a necessity required by the economic and financial crisis at the end of this first decade.

Under these conditions, the quality of products through its economic effects firmly determines the competitiveness of companies, because any consumer, before purchasing a product, checks the quality of the purchased product in relation to the purchase price through a brief check.

Quality standards encourage the organization to focus on meeting customer requirements and exceeding their expectations. As a result, the quality of products and services provided has improved, leading to increased customer satisfaction.

Certification of compliance with a management system is not legally mandatory, but many organizations choose to obtain this certification to demonstrate their commitment to quality and strengthen their reputation in the market.

SR EN ISO 9001:2015 certification is voluntary and is available to any type of organization, regardless of size or field of activity. Many customers and business partners require their suppliers to be certified according to the ISO 9001 standard, as a way to ensure that they will provide high-quality products and services.

Obtaining ISO 9001:2015 certification involves implementing a quality management system in the organization, which complies with all the requirements of the standard. This involves documenting processes and procedures, monitoring and measuring performance, analyzing data and taking corrective action if non-conformities are identified.

The SR EN ISO 9001:2015 certification is granted by accredited certification bodies, which verify compliance with the requirements of the standard. These bodies have specific criteria and methodologies for granting certification and are internationally recognized. Obtaining certification requires maintaining the conformity of the quality management system over time.

DEMANDS OF THE MARKET

Market demands represent the expectations, preferences, and needs of consumers for specific products or services within a given industry. Understanding and addressing market demands are crucial for businesses to remain competitive and successful. These demands are shaped by various factors, including economic conditions, technological advancements, cultural shifts, and consumer behavior trends.

Market demands are dynamic and continuously influenced by external and internal factors. For instance, economic stability or instability can impact consumer purchasing power, while technological innovation often creates new demand for advanced products, such as smartphones or renewable energy solutions. Social and cultural trends also play a significant role; the rise of sustainability and health consciousness, for example, has driven demand for eco-friendly products and organic food.

Understanding market demands is critical for product development, pricing strategies, and marketing efforts. Businesses that align their offerings with these demands can better meet customer expectations, ensuring satisfaction and loyalty. For example, offering electric vehicles meets environmental concerns, while providing remote work solutions addresses the changing dynamics of modern workplaces.

Adapting to market demand also helps businesses gain a competitive advantage. Identifying and addressing unmet needs can position a company as a leader in innovation within its industry. Additionally, tailoring marketing strategies to resonate with specific consumer segments enhances market penetration and brand recognition.

Any organization oriented to quality must comply with the demand of the market to which it is addressed, adjusting its supply to the consumers' requirements as best as possible. Market research can provide extremely important information about market needs and size, as well as competition. In this context, the answer to the following questions will contribute to the clarification of the analyzed phase:

» *Who are the consumers of the product being analyzed?*
» *What are their consumption needs?*
» *What is the product used for?*
» *Where do consumers buy from?*
» *When do individuals consume?*
» *Who are the competitors?*
» *What differentiates this product from existing alternatives on the market?*

Understanding and targeting consumers is important for any company that seeks to succeed in a competitive environment.

DESIGNING OF THE PRODUCT

Product design is a crucial phase in the development of any good or service, as it defines the shape, functionality, and overall appeal of the final product. It involves a creative and systematic process that transforms ideas and customer needs into tangible solutions. The goal of product design is not only to meet market demands but also to ensure usability, manufacturability, and cost-effectiveness.

During the design process, several key factors must be considered. These include understanding the target audience, identifying essential features, selecting appropriate materials, and ensuring compliance with industry standards and regulations. A well-designed product balances aesthetics with practicality, making it both attractive and functional.

Effective product design also integrates feedback from various stakeholders such as engineers, marketers, and end-users. This collaborative approach helps to refine the product, anticipate potential issues, and enhance its performance. Furthermore, sustainability is becoming an increasingly important aspect of product design, with a focus on minimizing environmental impact throughout the product's lifecycle.

Ultimately, successful product design leads to improved customer satisfaction, competitive advantage, and business growth. By aligning the product with user expectations and market trends, companies can create innovative solutions that stand out in a crowded marketplace.

In this stage, you have to consider how the analyzed product is designed. Nowadays, quality-oriented companies emphasize the ecological design of products intended for customers and the need to apply an eco-design strategy that means the development of innovative products with high efficiency.

Eco-design aims to improve the product to reduce energy consumption, waste, radiation and toxins. Thus, the basic idea in eco-design is to reduce the impact on the environment throughout the whole life cycle of the products through an improved design.

Questions for debate:

» *Are simulations or prototype tests performed before product launch?*

» *What is the design review process to reduce the risk of errors?*

» *Is there a team specialized in analyzing potential design issues?*

» *How does product design influence the perception of quality?*

» *What are the aesthetic preferences of the target group?*

» *How can the design be improved based on user feedback?*

» *Does the product follow current design trends or propose something innovative?*

PREPARATION

Preparation refers to the serial production of the prototype or prototypes made in the previous stage or to the assembly of parts and subassemblies previously made by another company on an order and invoice basis. Based on the drawings of the component parts and the necessary characteristics, the company establishes the technological processing process necessary to transform all the materials, raw materials, components and subassemblies provided into a finished product that fully meets the customer's expectations and is made under the most economical conditions possible.

In order for a product to be manufactured, it is necessary in advance:

8. to define in detail all the operations of the technological manufacturing process;
9. to establish the optimal sequence of these operations (including intermediate inspections, self-inspections, waiting times for cooling, stabilization, aging, drying) so as to involve minimum costs and maximum quality;
10. to program – by months, weeks and days – the manufacturing process so that the implementation of the manufacturing plan can be monitored and controlled;
11. to specify the essential stages of the technological process with their "stationary points" (starting from which the process cannot continue until the required checks are carried out and the results obtained are compared with the corresponding information in the documents).

Situated between conception/design and manufacturing, preparation is indispensable for the production of a "quality" product, since it refers both to the execution and control technology and to the programming and planning of manufacturing, both objectives being currently achievable, advantageously, with the assistance of a computer.

SUPPLY PROCESS

The supply process refers to the series of activities involved in sourcing, procuring, and delivering raw materials, components, or finished products necessary for production and distribution. It is a vital part of the overall supply chain management that ensures the right materials are available at the right time, place, and cost to meet production schedules and customer demands.

An efficient supply process begins with identifying reliable suppliers and negotiating contracts that balance quality, price, and delivery terms. It also involves forecasting demand accurately to plan procurement and avoid shortages or excess inventory. Throughout the process, effective communication and coordination between suppliers, manufacturers, and logistics providers are essential to maintain smooth operations.

Inventory management plays a key role in the supply process by controlling stock levels and minimizing holding costs while preventing production delays. Additionally, modern supply processes often incorporate technology such as ERP systems, automated ordering, and real-time tracking to enhance visibility and responsiveness.

A well-managed supply process contributes significantly to reducing production costs, improving product quality, and increasing customer satisfaction. It enables businesses to be agile and competitive by quickly adapting to market changes and maintaining continuous flow from raw materials to finished goods.

Currently, the success of a business requires a change in the thinking and the attitude of the management both inside the organization and abroad. The reconsideration the relationships with the suppliers, the positions that they have in relation to the customers is essential to ensure stable partnerships throughout the supply chain.

Before producing products or services, an enterprise is in the position of buyer. In this context, the answer to the following questions will help clarify the stage analyzed by each of you:

» *What are the raw materials and materials that are incorporated into the analyzed product?*
» *Who are the suppliers of raw materials and auxiliary materials?*
» *What are the criteria based on which suppliers are chosen?*
» *What problems can be identified in the procurement process?*

MANUFACTURING PROCESS

The manufacturing stage plays a key role in ensuring product quality, directly impacting performance, durability and customer satisfaction. The manufacturing process determines compliance with the technical specifications established in the product design.

The quality of the materials used and the precision of the assembly process influence essential characteristics such as dimensions, finishes and functionality of the product. Quality standards and procedures are applied at this stage to prevent defects. At the same time, the use of advanced technologies such as automation and artificial intelligence can improve product consistency and accuracy.

The analysis of data collected during manufacturing allows the identification of areas for improvement. The manufacturing stage is a central pillar in quality assurance, as it directly determines the product's compliance with requirements and expectations.

During this stage, it is necessary to explain the stages of the manufacturing process for the analyzed product. For this, some of the hints provided below help you elaborate this part of the project. The manufacturing process consists of all the technological operations through which a product is made. The result of a manufacturing process could be a finished product that is ready for use or consumption, or it could be a semi-finished product that becomes an input element for another manufacturing process (for example, a manufacturing process for a more complex product).

The technological process changes both the shape and the chemical structure and the composition of the raw materials that are processed. The technological process is the assembly of the mechanical, physical, chemical and biological processes necessary to obtain a certain product.

The technological scheme is the graphical representation of the processes that make up the technological flow. Within the project, you can also present a technological scheme for the manufacturing of the product.

Questions for debate:

- » *What are the main steps in the manufacturing process for this product?*
- » *Are there methods to reduce losses or waste during manufacturing?*
- » *What role do operators and technical staff play in maintaining quality?*
- » *Is specific training required to ensure quality standards?*

PACKAGING PROCESS OF THE PRODUCT. PACKAGING TYPES

Product packaging arose from the need to protect various products during their distribution, sale and use. Choosing a quality packaging is a form of respect for both the product sold by a manufacturer in the field and the final consumer. From a technical point of view, packaging is an integrated system of preparing products for transport, storage, sale and use.

Within the project it is necessary to describe the stages of the packaging process for the analysed product, the packaging methods used, as well as the main materials used in the making of the packaging.

Product packaging is the process of designing and creating packaging for a product. This includes the physical materials used, the design, the printing, and the assembly. Packaging is an integral part of the product because it protects it, makes it easy to transport, and can be used to promote it while also supporting your recognizable brand identity.

The first step in the packaging process is the manufacturing of that packaging. The manufacturing process needs to be considered when thinking about the design of the packaging. After the manufacturing process is completed, the packaging needs to be filled and assembled. This can take many forms depending on the nature of the product.

Once the packaging has been completed, the product will be transported to wherever it is being sold. It is imperative for the product to be protected during this important step. Whether it is being moved by land, sea, or air, steps need to be taken to protect the integrity of the product. This needs to be incorporated into the design of the packaging. Consider the transportation of the product and take steps to protect it. In addition to protecting the packaging and final product, it’s important to note that packaging efficiency is also important when it comes to logistics.

Shelf life is yet another area to consider when designing a packaging design. A design that is too intricate and fragile might easily damage a store shelf or display, making it unattractive to consumers. The last step in the packaging process is the experience of the user. Industry-leading brands know this and value this part of the packaging process significantly. They understand that packaging is a vehicle for communicating with the customer.

For example, using high-quality physical materials and printing techniques can make a big difference in how a product looks and feels. In addition, choosing the right colors, fonts, and images can also help to create a more lasting customer experience.

IMPACT OF PACKAGING ON ENVIRONMENT

Packaging contributes significantly to the amount of waste produced globally. A large portion ends up in landfills or as litter, causing pollution. Packaging production requires raw materials such as paper, plastics, metals, and glass, which consume natural resources like trees, water, and fossil fuels.

The widespread use of packaging and its negative impact on environmental factors have also imposed the need for recycling, determined taxation and a growing global concern for environmental protection. Knowing a dynamic development in recent years, the packaging industry is now facing a major challenge, which imposes radical changes in the field. The strongest impact on the environment is the one generated by plastics. Therefore, the first European strategy on plastics has emerged, which aims to make all packaging used in Europe recyclable by 2030.

Environmental consciousness has become a major factor in purchasing decisions, making sustainable packaging essential for modern brand identity.

Consumers can easily distinguish between genuine environmental commitment and superficial marketing tactics, which means brands need authentic approaches to earn trust and improve brand recognition.

Companies are moving beyond surface-level changes to implement meaningful sustainability practices. This includes using biodegradable materials, eliminating unnecessary packaging layers, and partnering with environmentally responsible suppliers. These choices reflect a brand's personality and communicate brand values more effectively than traditional advertising methods.

Sustainable packaging creates stronger consumer engagement by appealing to customers who share similar environmental priorities. When a company's brand demonstrates a genuine commitment to sustainability through packaging choices, it builds lasting relationships focused on retaining customers rather than single transactions. This approach strengthens brand consistency while supporting long-term customer loyalty.

Questions for debate:

- » *What measures should be taken to reduce the environmental pressures of the packaging?*
- » *What types of packaging are used to protect the product?*
- » *What types of packaging are used to protect the product?*
- » *Specify the main actions taken by the organization to prevent and minimize packaging placed on the market?*

PRODUCT LABELING

The label represents any written, printed, lithographed, etched or illustrated material containing the identifying elements of the goods and associated with the product when it is presented to the clients or adhering with its package.

The labeling represents the operation of applying a label or writing the identifying elements on the product, the trading package on the closing device of the product to be sold.

The aim of the labeling is to give to the clients enough, easy to verify and to compare information, to enable them to choose the product according to their exigencies regarding the needs and financial possibilities and to know the possible risks.
The products labeling is different, depending on the type of products (food or non-food products).

It is important to list the mandatory information that must appear on the product label, as well as the most common irregularities in product labeling. I also recommend attaching an image with the product label to compare the information on the label with European product labeling regulations.

Questions for debate:

» *What is the mandatory information that is included on the label according to the legislation for this type of product?*
» *What size and format do the label have to fit correctly on the product?*
» *What specific graphic elements or symbols (e.g. recycling pictograms, allergens, warnings) are included on the label?*
» *Is the readability of all information on the label ensured (font, contrast, size)?*

PRODUCT STORAGE

Product storage is an essential stage in the supply chain that involves safely holding finished goods or raw materials until they are needed for production or delivery to customers. Proper storage ensures that products maintain their quality, remain accessible, and are protected from damage, spoilage, or theft.

Effective product storage requires well-organized facilities designed to accommodate the specific needs of different types of products—whether they are perishable, fragile, bulky, or hazardous. Factors such as temperature control, humidity, ventilation, and security must be carefully managed to preserve product integrity.

Inventory management systems play a vital role in product storage by tracking quantities, locations, and expiry dates, which helps optimize stock levels and minimize losses. Efficient storage also facilitates faster order fulfillment and reduces the risk of stockouts or overstocking.

The stores are structural units of a company having specific equipment, plants or devices destined to perform different operations of storage and issuing for materials or final products according to their destinations. The main operations performed in stores are:

- receiving of the goods
- keeping of the goods
- delivery of the goods.

The goods are stored in special arranged stores, considering the specific of the products. The conditions under which some products are manufactured and stored can have a major impact on their quality. Factors such as temperature, humidity, air quality, time and production process characteristics can all have a significant impact on the final quality. For many products requiring storage in cool conditions, refrigeration plants are widely used, which needs to be carefully monitored to ensure that the correct temperatures are maintained. Stock must be stored in appropriate and auditable environmental conditions.

Appropriate conditions of light, humidity, ventilation, temperature, and security should be ensured. The products must be stored in accordance with the manufacturer's directions and within the terms of product authorization.

Questions for debate:

- *What storage practices are used to prevent product damage?*
- *How are products prepared for shipping to avoid defects?*
- *Are there specific measures in place for sensitive or fragile products?*

SELLING THE PRODUCT

Selling the product is the final and crucial step in the product lifecycle, where the goods or services are offered to customers in exchange for payment. This process involves not only the transaction itself but also the activities that create awareness, generate interest, and persuade potential buyers to choose a product over competitors.

Effective selling requires a deep understanding of the target market, including customer needs, preferences, and purchasing behaviors. Sales strategies often combine pricing, promotion, distribution channels, and personal selling techniques to maximize reach and appeal. Building strong relationships with customers through excellent service and support also plays a key role in successful selling.

Marketing efforts such as advertising, digital campaigns, and product demonstrations help create demand and differentiate the product in a competitive marketplace. Additionally, feedback from customers gathered during the selling process can provide valuable insights for product improvement and future development.

Most of the manufacturers are using specialized distributors (or agents) to sell their products on the market. They try to form a distribution channel – consisting in several interdependent organizations involved in the delivery process of a product or service to a consumer. The distribution channel ensures the passing of the product, by these organizations, from the manufacturing place to the consuming place. The manufacturers are using intermediates because, this way, they give up to a part of the control related to the selling mode of their products. Moreover, the manufacturer can better focus on its main activity – manufacturing goods or providing services.

The distribution channels can be described depending on the number of intermediate stages contained. A channel without intermediate stages (also called direct channel) is represented by the manufacturer that sells its goods directly to the final consumers.

The main direct distribution method is the following:

- distribution at the client home ("door to door")
- distribution by selling meetings at the client's home.
- distribution based on mailed of phoned orders.
- distribution by manufacturers owned shops.

For the manufacturer, the advantages of a direct channel are:

- manufacturer sells the products in his name and on his account.
- it does not share the profit with other intermediates.
- it is known on the market.
- it can collect information regarding the market state and the competitors' actions.
- it has control over his trading actions.

Among the disadvantages of the direct channel, we mention:

- increased distribution expenses
- if the manufacturer is not known on the market it is difficult to use the direct channel due to the non-confidence of the clients, leading finally to use intermediates.

A channel with stages (also called) means that the manufacturer uses one or several intermediates to sell its products and it does not get in direct contact with the final consumer.

These intermediates could be retailers or wholesalers. From the manufacturers' point of view, the bigger the number of intermediate stages is, the more difficult it is to obtain information regarding the final consumer.

The products can be displayed using shop windows. The shop window represents the most efficient way to keep a continuous dialogue between the seller and his clients. It is organized in a special arranged space to realize a natural presentation of the goods. In the same time, the shop window is the most direct way to inform the buyer about the range and the quality of the goods available in the shop.

AFTER SALES SERVICE

After sales service refers to the support and assistance provided to customers following the purchase of a product. It plays a vital role in ensuring customer satisfaction, building loyalty, and enhancing the overall reputation of a company. This service includes activities such as installation, maintenance, repairs, troubleshooting, and handling customer inquiries or complaints.

Effective after sales service helps to address any issues that may arise post-purchase, ensuring that the product continues to perform as expected. It also provides an opportunity to engage with customers, gather feedback, and offers additional products or upgrades. A strong after sales support system can turn one-time buyers into repeat customers and brand advocates. Moreover, in competitive markets, excellent after-sales service can be a key differentiator that sets a company apart from its rivals. By delivering reliable and timely support, businesses reinforce trust and satisfaction, which are essential for long-term success.

A specialist in marketing knows that the act of buying is only the beginning of a relationship with the client and in no case the end of it. The after-sale service gives the possibility to create a long-term relationship with the clients, encourages repeated buying actions and in this way the supplier is advantaged compared to his competitors.

The after-sale services consist of:

- training of the personnel used by the client to operate the purchased equipment
- providing the repair and maintaining services needed to keep the equipment in a good operating state at the asked parameters
- continuation of the relationship with the client, to encourage them to transmit the "feed-back" to find out their reactions and their answers.

Examples of after sales service

- **Warranty**. A common example of after sales service is the provision of a warranty for the goods. A warranty allows the goods to be repaired or replaced if it breaks down within a certain period after purchase.
- **Free service** after six months (e.g. car/bike)
- **Advice** on how to use the product (Apple care)
- Firms following up with a **phone call** to the customer asking how the product is working out.

The key to a correct strategy regarding the repair and maintaining services is to design the products in such a way as having disturbances as seldom as possible. If a disturbance appears, the product must be easily and quickly repaired, with minimum costs. The manufacturing companies must ensure delivery of service packages for their clients. These should be a much more convincing element compared to the products themselves in attracting more and more numerous clients.

Questions for debate:

- » *What types of after-sales services does the organization offer?*
- » *(e.g. warranty, repairs, technical support, consulting, service, etc.)*
- » *What is the product warranty period?*
- » *Are there any additional costs for after-sales services?*
- » *What procedure should be followed if the product is defective or not working properly?*
- » *Can I opt for original spare parts for my product?*

PRODUCT QUALITY DEFECTS

Product quality defects are deviations from established specifications and standards that can affect the functionality, appearance, or safety of the final product. These defects can occur at various stages of the production cycle, from raw material sourcing, manufacturing, to packaging, and transportation. Effective identification and management of defects is essential to maintaining consumer trust and protecting brand image.

To prevent defects, companies implement rigorous quality control systems that include visual inspection, functional testing, and process monitoring. At the same time, effective communication between departments involved in production is important so that any problems are quickly reported and corrected before the products reach the market.

Root cause analysis of defects allows the identification of the real sources of problems, whether they are non-conforming materials, faulty equipment, or human error. Based on these analyses, preventive and corrective measures can be implemented to reduce the defect rate and optimize the production process.

Defect management also includes establishing clear criteria for accepting or rejecting products, as well as procedures for reconditioning or eliminating non-conforming ones. Ultimately, reducing quality defects leads to lower costs, increased customer satisfaction, and strengthened market position.

In SR ISO 9001-2015: Quality management systems, the "defect" concept is defined as: *"failure to meet a reasonable requirement or expectation of intended use, including safety"*.

The same standard defines a more comprehensive concept, sometimes used as a synonym for defect**:** non-compliance. The non-compliance concept is defined as "the deviation or absence of one or more quality characteristics or elements of the quality system, in relation to the specified requirements, referring to the quality characteristics of the products".

Product quality defects refer to flaws, issues, or deficiencies in a product that prevent it from meeting its intended purpose, specifications, or customer expectations. These defects can occur at any stage of the product lifecycle, from design and manufacturing to distribution and storage. Addressing and preventing these defects is crucial for maintaining customer trust, regulatory compliance, and brand reputation.

At the level of an organization, some causes of product quality defects that occur more frequently can be identified:

- Poor quality control during production.
- Inadequate testing or inspection procedures.
- Supplier issues with raw materials or components.
- Design oversights or errors.
- Mishandling or improper storage during transit.
- Equipment malfunctions in the production line.

Questions for debate:

» *What quality defects were identified in the analyzed product?*
» *What is the source of product quality defects?*
» *What are the most common defects identified in the analyzed product?*

CONCLUSION

In the conclusions of this study, please state your overall assessment of the quality of the analyzed product, answering the following questions:

» *What strengths and weaknesses have you identified in the quality of the product?*
» *How does the chosen product compare to other similar products on the market?*
» *What impact does the quality of the product have on user satisfaction?*
» *What recommendations do you have for improving the quality of the product?*

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