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Preface

We would like to present, with great pleasure, the inaugural volume-11, Issue-8, August 2025, of a scholarly journal, *International Journal of Engineering Research & Science*. This journal is part of the AD Publications series *in the field of Engineering, Mathematics, Physics, Chemistry and science Research Development*, and is devoted to the gamut of Engineering and Science issues, from theoretical aspects to application-dependent studies and the validation of emerging technologies.

This journal was envisioned and founded to represent the growing needs of Engineering and Science as an emerging and increasingly vital field, now widely recognized as an integral part of scientific and technical investigations. Its mission is to become a voice of the Engineering and Science community, addressing researchers and practitioners in below areas:

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Each article in this issue provides an example of a concrete industrial application or a case study of the presented methodology to amplify the impact of the contribution. We are very thankful to everybody within that community who supported the idea of creating a new Research with IJOER. We are certain that this issue will be followed by many others, reporting new developments in the Engineering and Science field. This issue would not have been possible without the great support of the Reviewer, Editorial Board members and also with our Advisory Board Members, and we would like to express our sincere thanks to all of them. We would also like to express our gratitude to the editorial staff of AD Publications, who supported us at every stage of the project. It is our hope that this fine collection of articles will be a valuable resource for *IJOER* readers and will stimulate further research into the vibrant area of Engineering and Science Research.

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Development of a 24/7 Odor Gas Analyzer System for Spoiled Products in Cryogenic Warehouses and Its Market Potential in Europe and Asia

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Abstract— *The quality of freezing is primarily checked by the operating parameters of the cryogenic equipment itself: power losses during operation, freon leaks, etc. However, the end user is interested in whether the product will spoil in the freezer or in the warehouse or not. This work is devoted to the creation of thermodynamic gas analyzers for the smell of spoiled frozen products and their 24/7 monitoring on the company's website and an assessment of their implementation in the European and Asian markets.*

Keywords— Thermodynamic Gas Analyzers, Smell Detection, Spoiled Frozen Products, 24/7 Monitoring, Food Safety Sensors, Cryogenic Equipment.

I. INTRODUCTION

In the European Union, special attention is paid to the transition of cryogenic equipment to less aggressive coolants and a complete ban on their use by 2050 by manufacturers of cryogenic equipment. In this regard, it is interesting to know how these methods affect the final result and whether frozen products spoil in supermarkets and food cryogenic warehouses, in automobile, rail, river and sea cryogenic transport. [1,2]

II. PROBLEM FORMULATION

Thermodynamic food smell gas analyzers are designed to determine the spoilage of frozen products in cryogenic chambers installed outside the cryogenic equipment. Usually, the quality of the product is measured by the presence of gases of decay of various food products. Rotting and spoilage of meat products is ammonia, carbon dioxide, methane, hydrogen sulfide. Dairy products are carbon dioxide, methane and hydrogen sulfide, etc. In other words, if you have the appropriate gas analyzers for these gases or have all 4 or 3 gases in this gas analyzer (calibration curves, for example, a gas analyzer for hydrogen sulfide, but also contains curves, for example, carbon dioxide, ammonia and methane), then depending on the different degrees of decay, and this is the corresponding number, the value of this gas in ppm, then you can program this data into the memory of the microcontroller. Upon reaching certain parameters, the sensor: gas analyzer with a microcontroller will give and show not only the values of rotting gases but also the degree of rotting.

However, many gases have odors: methane, hydrogen sulfide, ammonia, organic rotting has a smell. The smell is a more subtle substance than the presence of some gas in the air. This increases the accuracy of rotting detection, even behind the wall of cryogenic equipment. As experiments have shown, an insignificant content of the smell of rotting, seeping through the freezer is enough to identify rotting by the smell of the product inside the chamber. In order to determine the smell of rotting frozen products inside the cryogenic chamber, a second calibration was made by the smell of rotting.[3,4]

The first calibration is factory by gas type. Calibration was carried out for a given gas analyzer and for a given gas depending on the strength of the unpleasant smell of rotting. Conventionally weak, weak average, strong weak, strong, unbearable. The

obtained data for each gas were stored in the microcontroller memory and depending on the type of product. For example, frozen fish, pizza with meat.

The odor measurement system is a nonequilibrium thermodynamic system [5,6] and at any moment it depends on various factors, the strength of decay, the impact of other gases involved in the decay process, temperature, humidity both in the room and in the chamber, etc., that is, the functionality of the decay process of various parameters.Their changes show the odor's intensity for each concentration, each incoming gas and for 2 functional or their sub functional have the form:

$$P_1 = f_1 (E_1 , E_2)$$

$$P_2 = f_2 (E_1 , E_2)$$

Differentiating among the equation, absolutely the outcome will be:

$$dP_1 = A_{11} dE_1 + A_{11} d E_2$$

$$dP_2 = A_{12} dE_1 + A_{12} d E_2$$

There are simple and cross-sectional coefficients of connections between singles structures of state and interactions of structures under distribution of arrays of odor's rotting concentration data under depending on the change and increase in freezing temperature, the time periods of these changes, humidity and other reasons. Basic and cross coefficients A in the form of corresponding functions of various functionals E:

$$A_{11} = f_{11} (E_1, E_2)$$

$$A_{12} = f_{12} (E_1, E_2)$$

$$A_{21} = f_{21} (E_1, E_2)$$

$$A_{22} = f_{22} (E_1, E_2)$$

That is, the refined data array is calculated using the equations of a nonequilibrium thermodynamic system and stored in the microcontroller's memory.

Thermodynamic food odor analyzers are combined into a system for measuring odors of volumes or measured points of a refrigerated warehouse with registration of concentrations of odors of rotting frozen products on the website of the company that owns the cryogenic equipment in 24/7 mode constantly.

The prospects for the implementation of a system for monitoring thermodynamic gas analyzers based on the smell of food for cryogenic equipment for frozen products in supermarkets are as follows.

2.1 Analysis of the efficiency of using thermodynamic food odor gas analyzers in the European and Asian markets:

2.1.1 European Market:

Competitors and Analogues:

Gas analyzers for Modified Atmosphere Packaging (MAP) control:

- Cambridge Sensotec (Rapidox 1100Z, Oxybaby) – analysis of O_2, CO_2, humidity.
- DynaSNACK – leak detection in packaging.

Odor sensors:

- Aryballe Technologies (universal sensors for the food industry).
- Figaro Engineering (gas sensors for quality control).

Prices and Sales Volume:

- The European gas analyzer market was valued at approximately $766.7 million in 2023, with a CAGR of 5.9%.
- Odor sensor segment is growing faster, with a CAGR of 29.4%, forecasted to reach $19.4 billion by 2031.

- Price examples: portable MAP analyzers range from $2,000 to $5,000; stationary systems can cost up to $20,000.

Buyers:

- Food manufacturers (freshness control, compliance with EU standards).
- Logistics companies (monitoring storage conditions).
- Quality control and certification laboratories.

2.1.2 Asian Market:

Competitors:

- **Chinese manufacturers:** Beijing Zetron (smoke gas analyzers), Beijing HiYi Technology (portable detectors).
- **Japanese brands:** Figaro Engineering, Panasonic (sensors for smart homes and food industry).

Trends:

- The gas analyzer market is growing due to stricter environmental regulations and demand for "smart" agriculture.
- In China and India, there is a strong focus on combating food fraud and ensuring safety.

Prices:

- Budget Chinese analyzers start from around $500; industrial-grade solutions range from $3,000 to $10,000.

Buyers:

- Large agricultural holdings.
- Seafood and meat processing factories.
- Premium retail supermarkets.

2.2 Product Uniqueness and Recommendations

Advantages:

- Miniature size (matchbox-sized modification) – an advantage for field inspections.
- Linking odors with basic tastes – potential for standardization in R&D and quality control.

Risks:

- Strong competition from MAP analyzers and multi-gas systems.
- Need for certification according to ISO, CE, FDA standards to enter European and Asian markets.

Go-to-Market Strategy:

Focus on niche segments: premium products (coffee, chocolate, cheeses) where flavor and aroma profiles are critical.

Partnerships with quality laboratories and universities (e.g., for research on taste compatibility).

Pricing strategy: $1,500–$3,000 for the portable version; $8,000–$12,000 for the stationary unit (positioned below premium competitors).

2.3 Review of Competitors and Analogues in the European and Asian Gas Analyzer Markets

2.3.1 European Market:

Key Players and Products:

ABB Ltd, Honeywell International Inc., Emerson Electric Co., Siemens AG, Thermo Fisher Scientific are leading manufacturers of gas analyzers, offering a wide range of stationary and portable devices.

Products include gas chromatographs, electrochemical, paramagnetic, and infrared analyzers used in the food industry, oil and gas sector, pharmaceuticals, and environmental monitoring.

Examples:

- **Emerson Rosemount** - stationary analyzers for emission and product quality control.

- **Cambridge Sensotec Rapidox** - portable O_2 and CO_2 analyzers popular in the food industry.

Prices and Trends:

Average Price Range:

- Portable devices - $2,000–$5,000
- Stationary systems - $10,000–$20,000 and higher

The gas analyzer market in Europe is growing at a CAGR of around 5.9% (2024–2029), driven by tightening environmental and food safety standards.

Trend towards integration with digital platforms and IoT for remote monitoring and analytics.

Prices for basic models remain stable, but premium systems with extended functionality and automation are gradually becoming more expensive.

Market Segments and Changes

- **Food Industry** - a growing segment due to requirements for quality control and food safety.
- **Environmental Monitoring and Emission Control** - a key driver of demand, especially in the EU with new sustainable development regulations.
- **Oil and Gas Sector** - steady demand for analyzers to control processes and ensure safety.

Implementation of new EU regulations (e.g., PPWR) is stimulating demand for innovative solutions for packaging and product quality control.

2.3.2 Asian Market:

Key Players and Products

- Chinese companies, such as **Beijing Zetron** and **Beijing HiYi Technology**, offer budget-friendly and industrial gas analyzers, including portable models for quality control.
- Japanese brands **Figaro Engineering** and **Panasonic** are known for their sensors for the food industry and household applications.
- Growing interest in "smart" sensor solutions integrated into smart agriculture and product safety control systems.

Prices and Trends

Price Range:

- Budget Chinese analyzers - from $500 to $2,000
- Industrial solutions - $3,000–$10,000

The gas analyzer market in the Asia-Pacific region demonstrates the highest CAGR globally (above 6% in 2024–2029), driven by manufacturing growth and stricter safety standards.

Prices for basic models are declining due to local production and scaling, while complex systems with high precision and automation are becoming more expensive.

Increased quality control and combating product counterfeiting are stimulating demand for innovative gas analyzers.

Market Segments and Changes:

- **Agro-Industrial Complex and Food Processing** - the main driver of growth, especially in China and India.
- **Premium Retail** - a growing segment requiring monitoring of freshness and taste qualities.
- **Environmental and Industrial Monitoring** - developing in parallel with industrial production growth and environmental requirements.

TABLE 1
MARKET SEGMENTS AND CHANGES

Parameter	Europe	Asia
Key Players	ABB, Honeywell, Emerson, Siemens	Beijing Zetron, Figaro, Panasonic
Price Range	$2,000–$20,000	$500–$10,000
Market Growth Rate	CAGR ~5.9%	CAGR >6%
Price Trends	Stable basic, premium growth	Decline in budget, premium growth
Key Segments	Food industry, environmental monitoring	Agro-industry, retail, environmental monitoring
Technological Trends	IoT, digitalization, automation	Localization, smart sensors

If your product – a compact, digital gas analyzer with a unique feature for measuring odors and linking them to taste profiles – it can carve out a niche in the premium segment of the food industry and laboratory control, especially in Europe and the Asia-Pacific region.

For successful market entry, it is important to consider certification requirements, integration with digital systems, and partnerships with laboratories and food manufacturers.

III. COMPARATIVE ANALYSIS

Here is the detailed comparative analysis of prices, brands, and models of gas analyzers for the food and related industries in European and Asian markets in table format:

TABLE 2
COMPARATIVE ANALYSIS OF PRICES, BRANDS, AND MODELS OF GAS ANALYZERS

Region	Brand / Model	Device Type	Key Features	Price Range (USD)	Price & Market Trends	Key Market Segments
Europe	Cambridge Sensotec Rapidox 1100Z	Portable Gas Analyzer	O_2, CO_2, humidity analysis, accuracy ±0.1 ppm	$2,000 – $5,000	Prices stable; growing demand for IoT and digitalization	Food industry, labs, logistics
	Emerson Rosemount 700XA	Stationary Analyzer	High-precision emissions and air quality analysis	$10,000 – $20,000+	Premium systems prices rising with automation	Environment, oil & gas, industry
	Figaro Engineering (Sensors)	Odor Sensors	Universal gas sensors for odor control	$1,500 – $4,000	Stable prices; increasing adoption in food sector	Food industry, consumer devices
	Aryballe Technologies	Sensor Devices	Optical odor sensors with digital processing	$3,000 – $8,000	Prices rising with tech development; sensor market growth	Food industry, R&D
Asia	Beijing Zetron Portable Analyzer	Portable Gas Analyzer	Budget models for quality control	$500 – $2,000	Prices decreasing due to local manufacturing	Agro-industry, food processing
	Beijing HiYi Technology	Industrial Analyzers	Compact and stationary models	$3,000 – $10,000	Complex systems prices rising; basic models decreasing	Agro-industry, industry, retail
	Figaro Engineering (Japan)	Gas Sensors	High-precision sensors for food and consumer use	$1,500 – $4,500	Stable prices; gradual growth	Food industry, consumer devices
	Panasonic Gas Sensors	Sensors and Modules	Integration into smart systems, consumer & industrial	$1,000 – $5,000	Growing demand for smart solutions; moderate price growth	Smart homes, food industry

3.1 Comparative Analysis. Detailed comparative analysis of prices, brands, and models of gas analyzers:

For the food industry and related sectors in European and Asian markets. **Price and Market Trends**

Europe:

- Prices for basic portable analyzers remain stable, around $2,000–$5,000.
- Premium stationary systems are becoming more expensive due to IoT integration and automation (up to $20,000+).
- Increasing demand for digital and networked solutions for remote monitoring.
- The food industry and environmental monitoring are the main growth drivers.

Asia:

- Budget Chinese portable models are reducing prices in the $500–$2,000 segment.
- Complex industrial systems have become more expensive due to the implementation of new standards and technologies ($3,000–$10,000).
- The smart sensor system segment is growing, especially in Japan and South Korea.
- Main demand is from agro-industrial complexes, food processing, and premium retail.

3.2 Market Segments and Their Dynamics

Food Industry

- Europe: Growth due to quality control and safety requirements
- Asia: Rapid growth, especially in processing and agro-industrial sectors

Environmental Monitoring

- Europe: Key segment supported by the EU
- Asia: Growing segment, driven by industry and urban development

Oil & Gas and General Industry

- Europe: Stable demand
- Asia: Growth in industrial sectors, especially in China and India

Premium-Class Retail

- Europe: Moderate growth, focus on quality
- Asia: Rapidly growing, especially in large cities

The new gas analyzer model with integrated odor detection offers strong profitability potential due to its niche positioning in the premium segment. Unlike standard analyzers, it combines precise leak detection with AI-powered spoilage monitoring — a unique feature highly valued in food safety, logistics, and retail. With growing regulatory pressure in the EU and Asia to improve refrigeration efficiency and environmental standards, demand is expected to rise.

The model's compact format, IoT compatibility, and modular design make it suitable for both high-end supermarkets and industrial applications. These factors ensure long-term market relevance and justify premium pricing.

TABLE 3
COMPARATIVE TABLE OF GAS ANALYZERS BY REGION

Region	Brand / Model	Device Type	Key Features	Price Range (USD)	Price & Market Trends	Key Market Segments
Europe	**Cambridge Sensotec Rapidox 1100Z**	Portable gas analyzer	O_2, CO_2, humidity analysis, accuracy ±0.1 ppm	$2,000 – $5,000	Stable prices, growing demand for IoT and digitalization	Food industry, laboratories, logistics
	Emerson Rosemount 700XA	Stationary analyzer	High-precision emissions and air quality analysis	$10,000 – $20,000+	Rising prices for premium systems with automation	Environmental monitoring, oil & gas, industry
	Figaro Engineering (sensors)	Odor sensors	Universal gas sensors for odor control	$1,500 – $4,000	Stable prices, increased use in food sector	Food industry, household appliances
	Aryballe Technologies	Sensory devices	Optical odor sensors, digital processing	$3,000 – $8,000	Prices rising with tech advances, sensor market growth	Food industry, R&D
Asia	**Beijing Zetron Portable Analyzer**	Portable gas analyzer	Budget models for quality control	$500 – $2,000	Decreasing prices due to local production	Agro-industry, food processing
	Beijing HiYi Technology	Industrial analyzers	Compact and stationary models	$3,000 – $10,000	Price increase for complex systems, basic models decreasing	Agro-industry, industry, retail
	Figaro Engineering (Japan)	Gas sensors	High-precision sensors for food and home sectors	$1,500 – $4,500	Stable prices, gradual increase	Food industry, household appliances
	Panasonic Gas Sensors	Sensors and modules	Integration into smart systems, home and industrial use	$1,000 – $5,000	Demand for smart solutions rising, moderate price growth	Smart home, food industry

IV. CONCLUSION

1. Fundamentally new thermodynamic gas analyzers for the smell of food with a second calibration for the smell of decay have been developed based on the equations of a nonequilibrium thermodynamic measurement system for cryogenic equipment with the installation of gas analyzers outside the chamber in 24/7 monitoring mode on the website of the company that owns the cryogenic equipment.
2. The European market is characterized by stable prices for basic models and rising costs for premium systems with IoT integration.
3. The Asian market offers more budget-friendly solutions, but rising demand for high-precision and smart systems is increasing prices for complex models.
4. This product, with a miniature digital gas analyzer and a unique odor detection feature, can occupy a niche in the premium food industry and laboratory monitoring segment — especially in Europe and Asia.
5. The comparative table highlights key differences in gas analyzer offerings across European and Asian markets. European brands focus on high-precision, IoT-integrated systems with stable prices for portable models and rising costs for premium stationary solutions. In contrast, Asian manufacturers provide more affordable options, especially for entry-level and mid-range analyzers, while also expanding smart sensor technologies.

6. Market demand in both regions is driven by food safety, environmental monitoring, and industrial applications. Europe emphasizes quality and regulation, while Asia shows rapid growth in cost-sensitive and smart device segments. These trends present strategic opportunities for niche, innovative solutions.

REFERENCES

[1] https://freonleaksblock.netlify.app/

[2] https://harvardmarine.netlify.app/

[3] Vlastopulo, V. I. (2025). *Evaluation of the prospects for using the system of monitoring and blocking freon leaks of low-temperature volumes in supermarkets in 24/7 mode on the European market*. Doctor of Mechanical Engineering, SEO, Director. https://doi.org/10.62731/mcnd-30.05.2025

[4] UkrPatent of Ukraine. (2025, June 2). *Application for utility model 3581: Method and device for measuring the odors of rotting frozen products with the installation of a gas analyzer outside the cryogenic equipment*.

[5] Vlastopulo, V. I., & Polichronidi, A. G. (2021). *Equations of thermodynamics for expansion and filling by human civilization*. *International Journal of Engineering Research (IJOER)*, Article ID: IJOER-NOV-1.

[6] Vlastopulo, V. I., Chaadaev, I. E., & Gazin, A. V. (2022). *Gas analysis Codivirus method for detecting the threshold of contagiousness and therapy adjustment*. *International Journal of Engineering Research (IJOER)*, Article ID: IJOER-APR-2022-6.

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