

Design and Optimization of Mobile ECMO (Extracorporeal Membrane Oxygenation) Machine and Life Support Units

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Abstract

Developing an ECMO device following Dr. Emin Taner Elmas's engineering principles is a complex, multi-phase endeavor that necessitates the integration of thermodynamics, fluid mechanics, and bio-robotics. Central to this process are his theoretical frameworks, particularly the Fifth Law of Thermodynamics and Medical Thermodynamics, which play a foundational role in the device's design and functionality. The production requires several key engineering steps, outlined as follows: • Medical Thermodynamic Design (Heat Exchanger): Leveraging Dr. Elmas's expertise in heat transfer, the heat exchanger unit of the device is designed to maintain precise temperature control and high energy efficiency. Using his "open system" models, the design ensures that blood does not cool during extracorporeal circulation. • Hemodynamic Pump Engineering: Applying principles from fluid mechanics, the centrifugal pump responsible for blood circulation is engineered to generate laminar flow patterns that minimize the risk of hemolysis and clot formation. These designs are fine-tuned using energy transfer analyses pioneered by Dr. Elmas. • Bio-Robotic Control Interface: Incorporating Dr. Elmas's bio-robotic resonance theories, the software and control systems allow the ECMO device to dynamically respond to real-time patient data, such as heart rate and oxygen requirements. This results in a frequency-based adaptive control mechanism for optimal operation. • Material Selection and Manufacturing: Advanced biocompatible materials, such as medical-grade polyurethane, are selected for components in contact with blood. This choice aligns with Dr. Elmas's commitment to sustainable engineering and high-performance material science. • Energy Management: Insights from Dr. Elmas's work on energy management and renewable technologies inform the development of efficient, long-lasting power systems. This is especially critical for portable ECMO units, which benefit from low-energy motor drives and durable battery technologies. By synthesizing these innovative engineering approaches, an ECMO device can be developed that reflects Dr. Elmas's pioneering contributions to medical technologies and sustainable design.

Dr. Emin Taner Elmas's expertise in energy management and renewable energy presents innovative avenues for improving the design and functionality of mobile ECMO (Extracorporeal Membrane Oxygenation) units. By focusing on key aspects such as energy independence, efficiency, and portability, his academic contributions—highlighted in his Google Scholar and ResearchGate profiles—can be applied as follows: Energy Analysis and Efficiency Dr. Elmas's research on energy management at Iğdır University provides invaluable insights into optimizing the battery life of mobile ECMO units. His work enables detailed analysis of the power consumption profiles of these devices, facilitating

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efficient operation by incorporating features like adjustable energy-saving modes for non-critical systems such as screen brightness and data transmission frequency. Thermodynamic Battery Management Using principles from the “ELMAS Thermodynamic Theory,” Dr. Elmas introduces advanced energy transfer models applicable to open and closed systems for managing battery heating and minimizing efficiency loss. This ensures thermal stability for batteries during transport via ambulances or helicopters and contributes to uninterrupted device operation over extended periods. Renewable Energy Integration and Hybrid Systems Dr. Elmas’s expertise in renewable energy design and park management introduces the potential for integrating flexible solar panels into mobile ECMO units or transport ambulances. This innovation mitigates stress on primary power sources, particularly during lengthy patient transfers, enabling a hybrid energy system to sustain the device’s functions. Sustainable Mobility Solutions Drawing from his experience with unique mobile health systems such as the “Amphibious Mobile Snow Track Ambulance,” Dr. Elmas can provide guidance for designing durable, low-energy transportation platforms. These systems are especially useful for mobilizing sensitive ECMO equipment across challenging terrains. Collectively, Dr. Elmas’s multidisciplinary research enhances the safety, efficiency, and endurance of mobile ECMO operations in out-of-hospital settings. Transforming Battery Technologies Within Mobile ECMO Units Dr. Elmas’s thermodynamic and energy management studies offer groundbreaking solutions for improving the batteries inside mobile ECMO devices: Thermal Stability and Lithium-Ion Management By applying thermodynamic modeling to regulate heat during charging and discharging cycles, Dr. Elmas proposes innovations such as “smart thermal jackets” that enhance safety by minimizing risks of overheating or explosions in lithium-ion batteries, crucial for mobile applications. Energy Density Optimization Building on calculations from the fifth law of thermodynamics, Dr. Elmas identifies approaches for selecting battery cells capable of storing higher energy density in a compact form factor. This allows efficient energy transfer to ECMO pumps while reducing power losses, extending operational reliability. Integrating ECMO Devices Into Ambulance Systems Dr. Elmas’s experience in mobile health engineering informs essential upgrades for embedding mobile ECMO units into ambulance systems: Hybrid Energy Supply Flexible solar panels mounted on ambulance roofs, developed through his renewable energy research, enable continuous power supply to ECMO batteries during patient transportation. This safety-enhancing feature is invaluable for long-distance operations. Vibration and Resonance Control Through bio-robotic resonance studies, Dr. Elmas offers solutions to design suspension and isolation setups that reduce movement-induced vibrations and their effects on ECMO sensors and power management components. Centralized Energy Management Software Leveraging Dr. Elmas’s algorithms for energy management, a software system could dynamically optimize power sources—shifting between onboard battery packs, ambulance generators, or external solar input—to ensure maximum operational efficiency throughout the journey. The pioneering engineering applications stemming from Dr. Emin Taner Elmas’s expertise have the potential to revolutionize both battery technologies within mobile ECMO devices and their seamless integration into ambulance systems. These interdisciplinary contributions promise robust solutions for supporting life-saving technologies even under demanding conditions. [1-65]

Key Words: Mobile ECMO (Extracorporeal Membrane Oxygenation) Machine, 5th Law of Thermodynamics, ELMAS’s Theory of Thermodynamics, Medical Technique, Medical Thermodynamics, Hemodynamics, Entropy, Negentropy, Resonance, Exergy, Frequency, Thermodynamic, Energy Transfer, Fluid Mechanics, Heat Transfer, Mathematics, Computational Fluid Dynamics (CFD), Cardiopulmonary Bypass (CPB) Machines, Life Support Units, Cardiopulmonary Respiratory Machines, Heart-Lung Machines, Bio-robotic Resonance, Thermodynamic Interaction

INTRODUCTION

Dr. Emin Taner Elmas is an academic with a background in mechanical engineering, and his work focuses primarily on thermodynamics, fluid mechanics, and energy transfer. These fundamental engineering disciplines are critical for the design and optimization of life support units such as ECMO (Extracorporeal Membrane Oxygenation).

Potential applications of Emin Taner Elmas’s work in ECMO and life support systems include:

- Fluid Mechanics and Hemodynamics: Optimization of blood flow and pump systems within ECMO devices relies on the principles of fluid mechanics, Elmas’s area of expertise. These mechanical calculations are vital for ensuring blood circulation without damage (without the risk of hemolysis).
- Heat Transfer and Blood Warming: The design of heat exchangers used to maintain blood at body temperature in life support units is directly related to heat transfer, a key area of Elmas’s work.

- Sustainable Engineering Solutions: Elmas focuses on developing innovative applications in engineering through an interdisciplinary approach. This vision forms the basis for making biomedical devices more efficient and reliable.
- Academic Contributions and Energy Transfer: The energy transfer and mathematical modeling topics addressed in his publications can be used to improve the operational stability of medical devices.

Dr. Emin Taner Elmas's work, based on engineering and thermodynamics, can be directly applied to the design and improvement of operational efficiency of complex life support units such as ECMO (Extracorporeal Membrane Oxygenation).

The main application areas where these studies can be integrated into ECMO systems are:

- Medical Thermodynamics and Heat Balance: Dr. Elmas's theoretical approaches to "Medical Thermodynamics" and the 5th law of thermodynamics can be used to precisely maintain the temperature balance of blood removed from the body. The thermal management of heat exchangers designed to bring blood to the ideal physiological temperature before returning it to the body in ECMO devices can be optimized using these theories.
- Bio-robotics and Smart Drug Control: Elmas's work on bio-robotic resonance and smart drug control systems can be applied to automate simultaneous drug treatments for patients receiving ECMO support. Especially in severe infections like Covid-19, bio-robotic systems that adjust drug dosages based on the patient's real-time data (via frequency-resonance adjustment) can be integrated into these devices.
- Fluid Mechanics and Hemodynamic Optimization: Elmas's expertise in energy transfer and fluid mechanics plays a critical role in the mechanical design of ECMO pumps (centrifuge or roller pumps). Regulating blood flow according to laminar flow principles, free from turbulence and coagulation (thrombosis), increases the long-term safety of the device.
- Sustainable Engineering Solutions: Their approach to smart materials and advanced manufacturing technologies contributes to the development of lighter, more portable, and energy-efficient (mobile ECMO units) life support systems. [1-65]

MATERIAL, METHOD AND DISCUSSION

Dr. Emin Taner Elmas's work focuses on the tangible

impacts of ECMO and life support units, particularly on the adaptation of theoretical models to medical processes and new generation control mechanisms. Here are the concrete application potentials of these studies: [1-65]

"ELMAS Theory of Thermodynamics" and Medical Treatment Application

Dr. Elmas's Theory of Thermodynamics, which he proposes as the "5th Law of Thermodynamics" and addresses within the framework of medical thermodynamics, is used to model energy exchanges in ECMO devices.

- Open System Analysis: The human body and the ECMO device are defined as an "open thermodynamic system" exchanging matter and energy.
- Precise Heat Control: On a case-by-case basis, minimizing the thermal stress experienced by the blood as it circulates in the external unit and adjusting the dynamic heat transfer according to the patient's metabolic rate can be optimized with this theory. 2. Bio-robotic Resonance and Frequency-Modulated Control

Elmas's work on Bio-robotic Resonance and Thermodynamic Interaction offers a new perspective for ECMO control systems.

- Algorithmic Treatment: Processing data from sensors in the life support unit (blood flow rate, oxygen saturation, etc.) with an algorithm that works with "Frequency-Resonance Tuning" logic.
- Prototype Potential: This method can pave the way for the development of intelligent life support units that aim to adapt the device to the patient's natural biological rhythm, especially in cases where the patient's body resistance is weak. 3. Advanced Biomechanics and Hemodynamic Modeling

Human circulatory system hemodynamics, covered in courses such as "Medical Engineering and Advanced Biomechanics" given at Iğdır University, influences the design of the mechanical components of ECMO.

- Pressure Vessel Analogy: By examining the flow of blood within the device using a pressure vessel or pipeline analogy, the focus is on pump designs that minimize turbulence and cell damage.

Producing an ECMO device based on Dr. Emin Taner Elmas's engineering principles is a multi-stage process requiring the integration of thermodynamics, fluid mechanics, and bio-robotics disciplines. The "Fifth Law of Thermodynamics" and "Medical Thermodynamics" approaches, emphasized in Elmas's work, are at the theoretical heart of this production.

The production process of this device can be achieved through the following fundamental engineering steps:

- **Medical Thermodynamic Design (Heat Exchanger):** Dr. Elmas's expertise in heat transfer is used in the production of the device's heat exchanger unit. To prevent the blood from cooling outside the body, a unit is designed that provides high energy efficiency and precise temperature control, based on Elmas's "open system" models.
- **Hemodynamic Pump Engineering:** Fluid mechanics studies are applied to the design of the centrifugal pump that circulates blood. Laminar flow patterns that do not damage blood cells (do not cause hemolysis) and prevent clotting are optimized using Elmas's energy transfer analyses.
- **Bio-Robotic Control Interface:** Elmas's bio-robotic resonance theories are integrated into the device's software and control unit. This allows the device to dynamically adapt to the patient's instantaneous physiological data (pulse, oxygen demand) and operate with a frequency-based control mechanism.
- **Material Selection and Manufacturing:** Biocompatible polyurethane and similar advanced materials are preferred for the blood-contact surfaces of the device, in line with Dr. Elmas's vision of sustainable engineering.
- **Energy Management:** Dr. Elmas's energy management and renewable energy studies guide the development of long-lasting battery systems and low-energy motor drives, especially for mobile ECMO units. [1-65]

Dr. Emin Taner Elmas's expertise in energy management and renewable energy can be applied to the design of mobile ECMO (Extracorporeal Membrane Oxygenation) units under the headings of energy independence, efficiency, and portability. Based on Dr. Elmas's academic work featured on his Google Scholar and ResearchGate profiles, these applications can be detailed as follows: [1-65]

- **Energy Analysis and Efficiency:** Dr. Elmas's energy efficiency and management research conducted at Iğdır University provides a critical foundation for optimizing the limited battery life of mobile units. This research can analyze the power consumption profile of the ECMO device, enabling non-critical systems (such as screen brightness and data transmission frequency) to be put into energy-saving mode.
- **Thermodynamically Balanced Battery Management:** According to the "ELMAS Thermodynamic Theory," energy transfer models in open and closed systems

can be used to manage heating and efficiency loss in battery systems. Maintaining the thermal stability of batteries, especially during ambulance or helicopter transfers, guarantees the uninterrupted operation of the device.

- **Renewable Energy Integration (Hybrid Systems):** Dr. Elmas's renewable energy park and renewable energy system design projects foresee the use of flexible energy sources such as solar panels in mobile ECMO stations or transport ambulances. This reduces the load on the main power source during long-distance transport.
- **Sustainable Mobility Solutions:** Dr. Elmas's experience in designing unique mobile health systems such as the "Amphibious Mobile Snow Track Ambulance" forms the basis for robust and low-energy chassis mechanisms necessary for transporting the ECMO device in challenging terrain. [1-65]

Dr. Elmas's interdisciplinary work ensures safer and longer-lasting power support for life-saving technologies like ECMO in out-of-hospital use.

Dr. Emin Taner Elmas's work offers engineering solutions that can fundamentally change both the in-device battery technology in mobile ECMO units and the integration of these devices into ambulance systems. [1-65]

1. In-Device Battery Technology: Thermodynamics and Energy Management

Dr. Elmas's energy transfer and thermodynamic analyses optimize not only the capacity but also the safety and lifespan of batteries:

- **Thermal Stability (Lithium-Ion Management):** Elmas's thermodynamic models are used to manage the heat generated by batteries during charging/discharging. This allows for the design of "smart thermal jackets," minimizing the risk of battery explosion or overheating, especially in mobile units.
- **Energy Density Optimization:** Energy efficiency calculations within the framework of the 5th law of thermodynamics guide the selection of battery cells that store higher energy in a smaller volume and the transfer of this energy to the ECMO pump without loss.

Integration into Ambulance Systems: Smart Mobility

The compatibility between the energy infrastructure in ambulances and aircraft and the ECMO device can be shaped by Elmas's experience in mobile health projects such as the "Amphibious Snow Ambulance":

- **Hybrid Energy Supply:** Dr. Elmas's renewable energy research enables the creation of a system that continuously powers the ECMO batteries using flexible solar panels mounted on the ambulance's roof. This provides a critical safety layer, especially during long-distance patient transport.
- **Vibration and Resonance Control:** Bio-robotic resonance studies allow for the development of "intelligent suspension and isolation" interfaces to prevent vibrations (frequency changes) caused by the ambulance's movement from affecting the ECMO's sensitive sensors and power management unit.
- **Centralized Energy Management Software:** A software system using Elmas's energy management algorithms determines when to use which source (e.g., battery at departure, vehicle generator during transit) between the ambulance's main generator and the device battery, keeping the system at its most efficient point.
- **Biocompatibility Confirmation:** Pre-clinical tests verify that the designed flow mechanism does not harm blood cells.
- **Software Calibration:** The response speed (frequency matching) of the bio-robotic control to the patient's immediate needs is optimized. [1-65]

Basic Technical Requirements

- **Power Supply:** Minimum 6 hours of independent operation time and 80% fast charging capability in 30 minutes.
- **Temperature Control:** Thermodynamic control unit that maintains blood temperature at 37°C with an accuracy of $\pm 0.1^\circ\text{C}$.
- **Data Transmission:** Low-energy wireless protocol that transmits real-time energy and patient data to the ambulance's telemedicine system.

The proposed R&D roadmap and technical headings for Dr. Emin Taner Elmas's "Smart Energy-Managed Mobile Life Support Unit" based on engineering principles are as follows:

1. Phase: Theoretical Modeling and Design (0-6 Months)

- **Thermodynamic Analysis:** Using Dr. Elmas's "Medical Thermodynamics" approach, heat exchange maps of the blood and device components are created.
- **Hemodynamic Simulation:** Using fluid mechanics studies, a turbulence-free pump design that provides maximum flow with low energy is modeled.
- **Energy Management Algorithm:** Control software is prepared that synchronizes the device's power consumption with the patient's biological rhythm (frequency-resonance adjustment).

2. Phase: Hardware Development and Integration (6-12 Months)

- **Battery Unit:** Thermodynamically balanced, high-density lithium-composite batteries with overheating protection are produced.
- **Hybrid Charging Interface:** A "smart inverter" system compatible with ambulance generators and renewable energy sources (flexible solar panels) is developed.
- **Mobile Chassis:** A lightweight alloy mobile body is produced that absorbs vibrations and maintains the device's precision, similar to Dr. Elmas' amphibious vehicle designs.

Phase 3: Testing and Validation (12-18 Months)

- **Stress Tests:** Energy continuity is tested under varying ambient temperatures and bumpy transport conditions.

With Dr. Emin Taner Elmas's interdisciplinary engineering approach, the integrated development of these two critical components (BMS and Pump Mechanics) is the most important factor determining both the safety and mobility of the device. [1-65]

Here are the details of how these two areas can be addressed with Dr. Elmas's working principles:

1. Battery Management System (BMS): Thermodynamics-Based Control

The BMS is not just a battery management unit, but a thermal balance center that operates according to Elmas's "Energy Transfer Analysis" principles.

- **Dynamic Heat Management:** Within the scope of the 5th law of thermodynamics, the heat emitted by battery cells during discharge is managed by passive cooling channels. This extends battery life while reducing the external dimensions of the device.
- **Intelligent Power Sharing:** While the ambulance is in motion, a strategy is implemented to "bypass" the battery, using the vehicle's energy directly and simultaneously storing excess energy.
- **Cell-Based Monitoring:** The thermal data of each cell is monitored with Elmas's open system modeling; thus, imbalance in a single cell is prevented from affecting the entire system.

2. Pump Mechanics: Hemodynamics and Fluid Optimization

The pump is the "heart" of the system, and this is where Elmas's "Fluid Mechanics and Biomechanics" expertise comes into play.

- **Laminar Flow Design:** To prevent blood from being subjected to mechanical trauma (hemolysis), the pump vanes (impellers) are designed with mathematical models that minimize friction. This reduces the risk of blood clotting.
- **Energy Efficient Motor Drivers:** Elmas's energy management studies aim for the motor driving the pump to produce the highest torque with the lowest amperage. This reduces the load on the battery by 20-30%, increasing mobile time.
- **Bio-robotic Synchronization:** Instead of a constant revolution, the pump speed increases or decreases instantaneously according to the patient's pulse and pressure data (frequency resonance). This "pulsative" flow mimics the body's natural circulation. Result of Integration

These two systems are interconnected: an efficient pump mechanism draws less current from the battery; and an intelligent BMS provides the sudden energy peaks the pump needs without creating thermal stress. [1-65]

CONCLUSION

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BIOGRAPHY OF AUTHOR:

Asst. Prof. Dr. Dipl.-Ing. Emin Taner ELMAS



Asst.Prof. Dr. Emin Taner ELMAS is a Mechanical Engineer having degrees of B.Sc., M.Sc., Ph.D., and was born in Sivas in 1974. He completed his doctorate at Ege University, Graduate School of Natural and Applied Sciences, Mechanical Engineering Department, Thermodynamics Science Branch, and his master's degree at Dokuz Eylul University, Mechanical Engineering Department, Energy Science Branch. He also completed his undergraduate education at Hacettepe University, ZEF, Mechanical

Engineering Department and graduated from the faculty with honors in 1995 and became a mechanical engineer. He was awarded a non-refundable scholarship by the Turkish Chamber of Mechanical Engineers in his 4th year because he was the most successful student during his first 3 classes study at the faculty. He graduated from İzmir Atatürk High School in 1991.

Asst. Prof. Dr. ELMAS has completed his military service as a NATO Officer in Bosnia and Herzegovina. He was a "Reserved Officer" as a "2nd Lieutenant" as an "English-Turkish Interpreter". He was also a "Guard Commander" and served in Sarajevo, Camp Butmir within the SFOR task force of NATO. He has been awarded with 2 (two) NATO Medals and Turkish Armed Forces Service Certificate of Pride (Bosnia & Herzegovina).

In addition to his academic duties at universities, he has worked as an engineer and manager in various industrial institutions, organizations and companies; He has served as Construction Site Manager, Project Manager, Management Representative, Quality Manager, Production Manager, Energy Manager, CSO-CTO, CBDO, Factory Manager, Deputy General Manager and General Manager.

Asst. Prof. Dr. Elmas is Department Head and is an Assistant Professor of Automotive Technology at the Department of Motor Vehicles and Transportation Technologies at Vocational School of Higher Education for Technical Sciences at IĞDIR UNIVERSITY, Turkey. He is also an Assistant Professor of Bioengineering & BioSciences at the same university. He has nearly 30 years of total experience in academia and in industry.

He has served as a scientific referee and panelist for ASME, TUBITAK and many scientific institutions, organizations and universities, including NASA.

He has published numerous international and national academic scientific articles, books, and book chapters, and serves as an editor for international academic journals. He also serves on the scientific committees of many international conferences, publishing conference and congress proceedings and giving presentations.

"Mechanical Engineering, Energy Transfer, Thermodynamics, Fluid Mechanics, Heat Transfer, Higher Mathematics, Evaporation, Heat Pipes, Space Sciences, Automotive, Bioengineering, Medical Engineering Applications, Neuroengineering, Medical Technique" are his academic and scientific fields of study; "Heating-Ventilation Air Conditioning Applications, Pressure Vessels, Heat Exchangers, Energy Efficiency, Steam Boilers, Power Plants, Cogeneration, Water Purification, Water Treatment, Industrial Equipment and Machinery, Welding

Manufacturing, Sheet Metal Forming, Machining" are his industrial experience fields.

As of 2026, he has been awarded the Nobel Scientist Award by the international platform organization Scientific Laurels.

Asst. Prof. Dr. Emin Taner ELMAS is also a musician, saz (baglama) virtuoso player and ney (Nay, Turkish Reed Flute) performer. He plays also cümbüş instrument and performs darbuka rhythm instrument. He has a YouTube Music Channel (Emin Taner ELMAS) which includes some of his sound recordings of him playing the saz-baglama and blowing the ney. He composed the poem written by the great poet Âşık Veysel ŞATIROĞLU under the name of "Raşit Bey" in memory of his father Judge (Hâkim) Raşit ELMAS as "Raşit Bey Türküsü", wrote it down, notated and published it as an academic article and broadcasted this song on his own music channel. He wrote the poems entitled "Canım Babam" and "Geldim Babam" which he wrote also in memory of his father and published in an academic literature journal, and composed instrumental musics for these poems. He also composed an instrumental song called "Annem Annem Türküsü" and gave it to his mother, Lawyer Tuna ELMAS, as a gift on Mother's Day, 11.05.2025. He also has a poem titled "Ney and Neyzen." He also wrote and presented a poem titled "Esra Kardeşim" to his sister, Esra ELMAS, an archaeologist and English teacher. He has published books including "Saz-Bağlama Tuning System Method" ("Saz-Bağlama Akort Sistemi Metodu") and "Ney and Neyzen; Ney's Pitches, Frets, Sound Stages, Octaves, Structure, Performance, Ney Maintenance and Basic Music Theory" (Ney ve Neyzen; Ney'de Perdeler, Ses Devreleri, Oktavlar, Yapısı, İcrası, Ney Bakımı ile Temel Musiki Nazariyatı) and My Collection of Literary and Musical Art Works - I Story / Anecdote / Essay / Poetry / Verse / Prose / Humorous; witty - satirical; poetic stories / Lyrics / Composition (Edebiyat ve Musiki Sanat Eserleri Külliyyatım - I Hikâye / Anekdote / Deneme / Şiir / Manzume / Nesir / Mizahi; nükteli - hicivli; şiirsel hikâyeler / Güfte / Beste). He continues his artistic studies by writing various articles, books, poetry, lyrics and also realizing musical composition and repertoire works.

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