

Entrepreneurship of the CAFS Fire Extinguishing System: A Technology-Based Solution to Prevent the Death of Low-Wage Female Workers in Clothing Factories and the Fashion Industry with the Approach of Attrition Entrepreneurship Theory & UN Sustainable Development Goals

Safoura Moradi¹, Mehdi Farzpourmachiani², Mehrdad Fojlaley³, Snjezana Baroness Rajacic⁴

¹Member of the Club of Innovative Minds of the European Academy of Sciences, Postdoctoral in Entrepreneurship, Technofest Institute of Technology University (TITU), Erquelinnes, Belgium

²Academician of the European Academy of Sciences, Associate Professor in entrepreneurship, department of entrepreneurship, Technofest Institute of Technology University (TITU), Erquelinnes, Belgium

³Academician of the European Academy of Sciences, Professor in entrepreneurship, department of entrepreneurship, Technofest Institute of Technology University (TITU), Erquelinnes, Belgium

⁴Academician & President of the European Academy of Sciences, Professor in entrepreneurship, department of entrepreneurship, Technofest Institute of Technology University (TITU), Erquelinnes, Belgium

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Abstract

The apparel and fashion industry around the world has repeatedly faced devastating fire tragedies that have particularly affected low-wage female workers. This paper aims to review the potential of Compressed Air Foam Systems (CAFS) as a technology for addressing fire safety issues in the apparel industry and its implementation in the context of sustainable entrepreneurship and the United Nations Sustainable Development Goals (SDGs), particularly SDG3 - Health & Well-Being, SDG5 - Gender Equality, SDG8 - Decent Work and Economic Growth, and SDG9 - Industry, Innovation, and Infrastructure. The paper aims to synthesize scientific and policy research in addressing issues related to industrial fire risk in apparel manufacturing, workplace safety infrastructure, gender and work vulnerability, and sustainable technological innovation. The paper argues that the implementation of CAFS in addressing fire safety issues in factories can be viewed as a model of socio-technical entrepreneurship in addressing fatality risk in the workplace and reducing turnover rates due to death. The paper aims to identify the potential barriers in the implementation of sustainable fire safety technologies in emerging apparel manufacturing economies.

Keywords: Apparel industry, garment manufacturing, industrial fire risk, Compressed Air Foam Systems (CAFS), fire-suppression technology, sustainable development

I. Introduction

The Sustainable Development Goals are not being implemented in an effective manner in a number of different industries and sectors of science. The Sustainable Development Goals are of critical importance for the world as a whole. Yet in a number of different industries and sectors of science, the SDGs are more of a symbolic gesture rather than a part of a policy framework. This in itself goes to highlight the need for a better level of cross-sectorial accountability and implementation. It is a fact that a better level of cooperation and coordination between different industries and sectors of science is necessary for a better level of environmental sustainability. Industrial fires in the textile and apparel industry, such as those in the textile industry, cannot be viewed in isolation but must be understood in the context of the systemic failure to address the concerns of the workers, especially low-wage female employees. The tragic fire at the Dhaka garment factory in 2012, where over 117 employees lost their lives, with over 200 employees injured, is a glaring example of the lack of safety infrastructure and the absence of effective firefighting mechanisms in the industry.

Though multifarious measures need to be taken to address the problem, the Compressed Air Foam Systems can be viewed as a technological means to mitigate the extent of the fire and the loss of life.

Fire Risk and Vulnerability in Apparel Manufacturing

The apparel industry, especially in low- and middle-income countries, operates with thin profit margins and minimal investment in safety infrastructure, contributing to frequent hazardous events. The characteristics of garment factories including large accumulations of combustible materials, inadequate exit routes, and poor alarm systems have been documented as core risk factors for catastrophic fires. In addition to general industrial risks, fire vulnerability intersects with gender, class, and socio-economic status: women often constitute a significant share of the workforce, yet are disproportionately exposed to unsafe working conditions and have limited agency within factory safety governance structures.

This gendered vulnerability resonates with disaster risk frameworks that recognize social conditions, not just physical hazards, as determinants of harm. Understanding fire risk through a *gendered lens* reveals that women may face distinct safety challenges and barriers to escape, reinforcing the need for targeted safety interventions.

CAFS Technology: Mechanisms and Fire Suppression Capabilities

Compressed Air Foam Systems (CAFS) represent an advanced fire-suppression technology that combines water, foam concentrate, and compressed air to produce a dense, adhesive foam blanket capable of cooling, smothering, and insulating fires. Scientific studies examining CAFS performance demonstrate that it can achieve effective fire knockdown with reduced water usage and mitigated environmental impact.

In contrast to traditional water streams, CAFS foams cling to surfaces, limit radiant heat transfer, and can be tailored by adjusting air-to-solution ratios for different fire classes, making them suitable for complex industrial environments like textile mills, where rapid fire spread poses extreme risks. While some firefighting studies caution about limitations in certain settings, the overall potential of CAFS for large-scale industrial fire suppression remains significant.

Entrepreneurship in Fire Safety: Sustainable and Attrition-Focused Models

Entrepreneurship in the development of safety technologies such as CAFS can be understood through the lens of sustainable entrepreneurship, where the focus is the creation of economic value while addressing issues of social and environmental sustainability. Sustainable entrepreneurship is characterized by the creation of social value, where the focus is the engagement of stakeholders in the entrepreneurial process, the

creation of ethical governance, and the promotion of innovations that benefit society. In the case of fire safety in the garment industry, entrepreneurship must be understood in the context of the creation of linkages between technological innovations and the need for safety, the fight against attrition through the promotion of investment in prevention technologies.

For instance, the application of frugal innovations in the development of CAFS technologies can help address the challenge of fire in the garment industry, where the focus is the creation of technologies that can benefit the industry in the context of inclusive development objectives. Entrepreneurs, social enterprises, and technology developers can develop technologies that can benefit small and medium-sized enterprises in the garment industry through the application of CAFS technologies, where the focus is the creation of cost-efficient technologies for the prevention of fires in the industry.

This idea resonates with the emerging theories of attrition entrepreneurship, in which entrepreneurial actors engage in addressing persistent systemic issues such as worker fatalities through purpose-oriented innovation and sustainable value creation. Even though the term itself has not been established in literature, its underlying logic resonates with entrepreneurship for sustainable social impacts and crisis-oriented innovation.

Linking CAFS Entrepreneurship to United Nations SDGs

The direct contribution of the integration of CAFS technology into the safety infrastructure of factories aligns with the following UN SDGs:

- SDG 3: Good Health & Well-Being: It minimizes mortality and injury due to industrial fire hazards through better control of fire risks.
- SDG 5: Gender Equality: Entrepreneurial approaches to CAFS technology prioritize safety initiatives for women-dominated workforces, promoting gender equality by empowering women workers.
- SDG 8: Decent Work & Economic Growth: It ensures safe work environments that support workers' rights, promoting sustainable work conditions in an important industry.
- SDG 9: Industry, Innovation & Infrastructure: It promotes the adoption of robust industrial technology, including CAFS, for enhancing industrial infrastructure.

Research on fire safety in the apparel industry indicates that efficient risk mitigation, apart from saving lives, contributes to industrial resilience,

which aligns with SDG 9: Industry, Innovation & Infrastructure, as well as SDG 8: Decent Work & Economic Growth. Another significant contribution of the UN SDGs, as argued by researchers, is the promotion of sustainable fashion, considering the principles of SDGs, including gender-just sustainable fashion.

Barriers and Challenges to Adoption

However, despite the benefits, the adoption of CAFS in the garment industry is also associated with certain challenges, such as:

- **Cost and Infrastructure:** The cost of investing in CAFS, training, and maintenance is a challenge for factories in low-income countries that lack safety capital.
- **Regulatory and Policy Gaps:** The lack of regulatory measures in the form of fire safety regulations in the region, where the factories are located, makes it difficult for the owners to adopt the technology.
- **Awareness and Knowledge:** Lack of awareness among the people, including the owners of the factories, about the benefits of the new technology and the knowledge required to use the CAFS is also a challenge.

The entrepreneurial plan will need to address these issues by providing education, financial options, and partnerships to the stakeholders.

II. Discussion and Future Directions

As global supply chains increasingly place pressure on labor conditions and sustainability, the incorporation of life-saving technologies such as CAFS represents not only a business opportunity but also a moral responsibility. Future research could seek to empirically examine the cost-effectiveness of CAFS in the garment industry, sociocultural factors related to safety adoption by factory owners and workers, and how entrepreneurial intermediaries can facilitate the bridge between technological possibilities and social needs.

Policy research could also aim to examine incentives such as tax credit premiums that can encourage technology adoption. In addition, participatory research with workers' organizations could help shed more light on gender issues related to safety and risks.

III. Conclusion

The apparel and fashion industry has seen devastating fire tragedies that expose underlying structural inequalities and safety gaps, especially for low-wage female workers. Compressed Air Foam Systems (CAFS) is an emerging technology that, if

effectively utilized through strategic entrepreneurial sustainability, may result in life-saving scenarios that align with the United Nations' Sustainable Development Goals. Conceptualizing CAFS application through a socio-technical entrepreneurship approach that is grounded in responses to attrition (the constant loss of life) is crucial because it allows for an integrated approach that incorporates innovation, gender equality, and industry sustainability. Yet, it is crucial to address economic challenges that may impede its application.

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