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Exploration of Analytical Technologies to Control and Predict the performance of Post Consumer Recycled (PCR) Polyethylene materials

Master thesis presented by

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ABSTRACT

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NOMENCLATURE

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FIGURES AND TABLES

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1. INTRODUCTION

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2. SCOPE OF THE PROJECT

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3. STUDENTS ROLE IN THE COMPANY

3.1. Company description

Dow is an American multinational chemical leading organization in the field of advanced materials and polymer science, specializing in the development and production of high-performance resins and compounds. The company leverages extensive experience and understanding of chemistry, engineering and physics to develop solutions of the world's toughest challenges [18].

The company is headquartered in Midland, Michigan, United States. It was Founded in 1897 by chemist Herbert Henry Dow, who created the company to leverage his innovative method of extracting bromine from brine. This innovation laid the foundation for Dow's growth and diversification into various chemical products [19].

The Dow strategic vision is to be a global leader in the development of sustainable and innovative polymer solutions. Its mission is to deliver high-quality products that enhance the performance and sustainability of its customers' applications while minimizing environmental impact.

“Every answer starts with the right question”. Therefore, the diverse Dow team collaborates with customers and other stakeholders to find solutions to the world's toughest challenges. The ambition is to be the most innovative, customer-centric, inclusive, and sustainable material science company in the world. To achieve this ambition, Dow is deeply committed to promoting social and environmental responsibility by developing long- and short-term goals, which are crucial to supporting key elements of Dow's business strategy [20, 21].

The company's 2025 sustainability goals aim to accelerate its sustainability strategy as well as the global one. The world needs solutions for global challenges, and Dow is committed to delivering solutions that help customers and society do the same. The company will build a more sustainable future not only by reducing unsustainable actions but by proactively collaborating with different groups to reach a better tomorrow [22, 23]. Through these goals, Dow will collaborate with like-minded partners to maximize the economic, environmental, and social value of its efforts to advance the well-being of humanity. Over the next decade, Dow will continue to reduce its own operational footprint, deliver ever-increasing value to customers and society through its handprint of products and solutions, and develop and deliver a blueprint for a sustainable planet and society [24].

Inclusion and Diversity (I&D) defines the company's identity, embodies its core values (respect for people, integrity, and protecting the planet), and aligns with the company's strategy. It allows every employee to contribute and feel valued, encouraging everyone to bring their whole self to work each day for a more fulfilling career.

Dow's ability to innovate at the intersection of chemistry, engineering, and material science has brought solutions that differentiate its customers while positively impacting the world. These include lightweight carbon fibers for cars, technology to more efficiently produce cleaner water, and packaging solutions that help make food safer and stay fresh longer. With a strong commitment to innovation and sustainability, the company leverages cutting-edge technologies to create products that meet the evolving needs of various industries, including packaging, automotive, and construction.

Dow operates six business that align its integrated materials portfolio with three attractive market verticals where it holds unique competitive advantages: packaging, infrastructure, consumer care and mobility [20].

Dow Packaging and Specialty Plastics (P&SP) is the largest business unit within Dow. The business combines core strengths of research and development (R&D), global reach, broad product lines and industry expertise to deliver high performing technologies for end use markets in food packaging, personal hygiene, infrastructure, consumer goods and transportation while considering environmental impact, where a key objective is designing packaging compatible with existing recycling infrastructure. Dow P&SP unit represents one of the world's most extensive and differentiated plastics portfolios, offering a robust suite of high performing polyethylene resins, adhesives and specialties. This unit leads in creating innovative packaging solutions that enhance product performance and customer experience. [25].

Nowadays, Dow combines one of the industry's broadest technology portfolios with asset integration, specialized innovation, and global scale to achieve profitable growth and become the most innovative, customer-centric, inclusive, and sustainable materials science company. Dow operates 104 production centers in 31 countries and employs approximately 35,700 people [26]. One of the European company subsidiaries, Dow Chemical Ibérica, has been present in Spain since 1960. Today, the company has around 710 employees, serving customers in the development of low and high-density polyethylene resins, research and development of plastic film technologies, and the implementation of polyurethane systems, among other technologies and applications [27].

As a key part of the company, since 2020 part of the Dow P&SP is done in Pack Studios Tarragona. Pack Studios is an initiative designed to accelerate packaging innovation by enabling brands to quickly bring recyclable packaging designs to market. It engages a connected network of best-in-class packaging expertise from every aspect of the packaging value chain and is backed to global facilities tailored to design, test, and develop packaging. Pack Studios locations around the world offer pilot-scale production capabilities and diverse testing equipment, ensuring efficient innovation and quick development of sustainable packaging.

Recognizing that packaging can contribute to a safe world and a vibrant circular economy, Dow has been committed to improving the sustainability of packaging for over a decade. The team at Pack Studios ensures that the industry can make material choices based on lifecycle data and meet sustainability targets. Dow offers a portfolio of high-performance polymers and utilizes materials expertise to help reduce the amount of material used in packaging, thereby lowering costs and carbon footprint [28].

3.2. Student role

The internship was conducted within the Technical Service and Development (TS&D) department, as a part of the Industrial Innovation Campus (I2C) program. This department is responsible for driving innovation by developing new technologies and improving existing ones. The TS&D department is a key driver of Dow's commitment to sustainability, working on projects that aim to reduce the company's environmental footprint, while developing advanced materials and chemicals that can improve the performance of a wide range of products and processes.

The primary objective was to work on a complex, scientifically driven research and development project aligned with one of Dow P&SP's markets, with clear goals and objectives.

This was achieved under the mentorship of experienced technical supervisors and with the support of scientist partners from the P&SP organization.

Within the I2C program, the student workflow involved working autonomously, to prepare and develop various challenges and parts of the project following industrial and the company methodologies. This included developing a project that allowed to have multiple responsibilities within the company, encompassing different roles in Pack Studios, TS&D and R&D/TS&D technician positions. This approach helped improve and acquire abilities in different sectors within the same field, such as scheduling, facing challenges like equipment unavailability, market pressure and compliance with new regulations.

During the project development, literature research was conducted to understand the state of the art of the proposed project: what had been done, what needed to be done, and why. By understanding the scope and limitations of test methods, several hypotheses were developed. To evaluate and validate these hypotheses, a design of experiments was created for each one, with a clear and consistent path to follow, and specific tests to solve technical problems.

As the project progressed, it was crucial to collaborate with different cross-functional teams to discuss and effectively implement the new findings. This involved preparing, presenting and delivering presentations and reports that effectively communicated complex ideas and results.

Weekly or bi-weekly meetings were held with project supervisors and technical advisors within the company to discuss the results obtained and monitor the progress of the project. These discussions helped maintain a clear and focused path toward the main objective. Additionally, monthly meetings were held with a technical panel of experts in the technology used and material rheology to present the project's progress and explain the rationale behind the decisions made, supported by scientific data obtained from laboratory experiments.

It was essential to independently conduct laboratory experiments and analyze the results obtained. This involved managing laboratory tasks, including methods and procedures, and ensuring the safe operation of laboratory-scale equipment. Throughout the development of the project, various challenges were faced, which led to the innovation of different techniques to evaluate and achieve the desired results.

Following the I2C program, various internal departmental deliverables related to the main project were prepared and presented. In addition to the main project, there was also the opportunity to develop and collaborate on different projects related to innovation and market demand. These are briefly presented below.

- Scale-down: This project aims to scale down film production to a laboratory scale to predict mechanical performance on an industrial scale. By replicating industrial studies in the lab scale, the goal is to produce the same film configuration with 25 kg instead of 500 kg, saving material, money, and time. This approach allows for pre-screening configurations before industrial production.
- Quality Notifications: To understand the Customer Technical Center (CTC) operations through collaboration with a TS&D Scientist focused on product quality and customer notifications. This involved communication with customers, sample analysis, and identifying the cause of product malfunctions to ensure the product remains best-in-class.
- Learning virtual platform: Developing a virtual platform to facilitate learning in the Food & Specialty Packaging Academy. The platform, coded in Python, aims to enhance educational experiences and provide a comprehensive learning tool.

- Saving Material: Addressing the discrepancy between the sample amount requested by engineers and the actual amount needed for testing. The goal is to reduce leftover material, increase production efficiency, save materials, and reduce environmental impact by developing a tool to accurately determine the necessary film length for tests.
- Different PE families study: Studying the effects of two different polyethylene families on blown film technology and how they impact film properties.
- Phoenix project: Aims to generate short-term fast-growing business on the basis of Dow's old but gold knowledge.

In summary, my internship at Dow Chemical Iberica has provided me with a unique opportunity to witness how a leading company operates to deliver best-in-class performance in all its endeavors, with safety as the foremost priority. This experience has allowed me to grow both personally and professionally, enhancing my technical skills as a chemical engineer.

Throughout my time at Dow, I have been immersed in a culture of innovation and excellence, where I have witnessed firsthand the company's commitment to sustainability. The mentorship and support from experienced professionals have been invaluable, enabling me to tackle complex projects and develop solutions that contribute to the company's goals.

Moreover, the collaborative environment at Dow has fostered my ability to work effectively with cross-functional teams, enhancing my communication and problem-solving skills. This internship has not only solidified my passion for chemical engineering but also equipped me with the knowledge and experience to excel in my future career.

Additionally, Dow's commitment to inclusion and diversity has been evident throughout my internship. The company actively promotes a diverse and inclusive workplace, where different perspectives and backgrounds are valued and respected. This inclusive environment has not only enriched my learning experience but also highlighted the importance of fostering diversity in driving innovation and achieving excellence. Being part of such a diverse team has broadened my understanding and appreciation of different cultures and viewpoints, further preparing me for a successful career in the global chemical industry.

4. METHODOLOGY AND EXPERIMENTAL PLAN

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5. RESULTS AND DISCUSSION

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6. CONCLUSIONS

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7. RECOMMENDATIONS / FUTURE WORK

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8. REFERENCES

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A. APPENDICES

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