

The Development of a Long Fries Production Machine and Its Suitability

Mohamad Hanifah Abd Ghani^{1*}, Che Ku Ihsan Che Ku Abdul Satar¹, Mohd Shazwan Dahlan¹

¹Department of Mechanical Engineering, Politeknik Muadzam Shah, 26700 Muadzam Shah, Pahang

*Corresponding author E-mail: hanifah@pms.edu.my

Abstract

This study presents the development and evaluation of a semi-automatic long French fries production machine driven by a pneumatic system. The machine was designed to address ergonomic limitations, inefficiencies, and inconsistent output commonly observed in traditional manual extrusion methods. By replacing manual pressing with a pneumatic cylinder powered by a 30L oil-free air compressor, the machine significantly reduces physical effort, improves output uniformity, and enhances user comfort. Time cycle analysis demonstrated a 22.5% reduction in production time compared to manual operation, while structural simulation using Autodesk Inventor 2024 confirmed the mechanical reliability of the frame design. Informal user evaluations during teaching sessions also indicated improvements in operational ease, ergonomic posture, and maintenance accessibility. This innovation not only supports local SMEs with a practical and inclusive food processing solution but also serves as an effective educational tool for students studying pneumatic systems and machine design.

Key Words: *Pneumatic System, Long French Fries, Semi-Automatic Machine, Ergonomic Design, Time Cycle Analysis*

1.0 Introduction

The Long Fries Machine is an innovative project designed to produce long French fries through a semi-automatic system. This project was developed to address the growing challenges in the street food industry and small enterprises, especially in producing unique, high-quality foods that attract customer interest. It aims to solve the inefficiencies of existing manual machines that are not user-friendly, particularly for Persons with Disabilities (PWDs) or elderly women. Issues such as lack of physical strength, inconsistent output, and low productivity can negatively impact work comfort, motivation, and product quality (Ayini, 2021; Shobur & Indah Sari, 2019).

This innovation also supports Small and Medium Enterprises (SMEs) that require affordable food processing machines, easy to operate without the need for high technical skills (Norazman & Johari, 2021). The machine presents a unique approach and fills the gap in the local market, which lacks a dedicated semi-automatic machine for producing long French fries. Compared to conventional manual machines, this version ensures more uniform dough pressing and enhances the overall taste quality. The semi-automatic system allows for easier handling and is suitable for a wide range of users. These features make the Long Fries Machine an innovative solution aligned with current SME food industry needs (KPDN, 2023).

This machine also provides effective visual exposure for students, especially in areas related to design process, pneumatic equipment, material selection, fabrication, and testing methods (Salleh & Rahim, 2020). It further supports product Research and Development (R&D), particularly for lecturers teaching DJJ40182 Project 1. The machine serves as a benchmark and technical reference in the fabrication and assembly of components.

The machine has also been used for Teaching and Learning (T&L) purposes, helping lecturers deliver subtopics from the DJJ40153 Pneumatic & Hydraulics course in a more structured way. It can be used as a demonstration tool aligned with syllabus content, enabling students to build contextual understanding and relate classroom theories to real-world applications (Muhammad & Tan, 2022). The explanation and demonstration of the machine apply basic concepts of pneumatic systems and equipment, including compressor, valve, and double-acting cylinder, in line with Topic 1: Introduction to Pneumatic System

1.2 Problem Background

Traditional French fry production is already heavily mechanized, with dedicated machines common in both small-to-medium enterprises (SMEs) and large factories, but similar automation for producing extra-long (“long”) French fries is not yet widely implemented. Instead, long French fries are typically made using manual extrusion presses, a method used in multiple countries that has gained popularity along with the rise of foot-long fries as a trendy snack (Norazman & Johari, 2021). This manual approach requires workers to exert significant force repeatedly to press out the potato dough. Over time, such repetitive and forceful movements can strain workers’ muscles and lead to musculoskeletal disorders and other work-related injuries, underscoring serious ergonomic concerns (Ayini, 2021; Shobur & Indah Sari, 2019). Moreover, because the pressure applied by each worker can vary, the old manual machines often produce fries of inconsistent length and quality with each press operation, highlighting a lack of mechanical consistency in the process (Salleh & Rahim, 2020).

In addition to the ergonomic strain, these machines are also less inclusive, particularly for women, elderly vendors, or individuals with limited physical strength. The lack of standardization in output not only affects product quality but also limits the scalability of small enterprises seeking to expand. Furthermore, traditional machines often require manual cleaning and maintenance, which may compromise hygiene and increase downtime. These combined challenges highlight the urgent need for a practical, semi-automatic solution that improves efficiency, consistency, and user comfort. Therefore, the aim of this paper is to present the development, structural analysis, and performance evaluation of a semi-automatic pneumatic long fries production machine designed to address these ergonomic, operational, and quality-related issues.



Figure 1: Revolution in long French fries production

1.3 Objectives

- i. To design and fabricate a prototype machine for producing Long French fries using a pneumatic system.
- ii. To evaluate the machine’s performance through cycle time analysis and structural simulation for operational suitability

2.0 Literature Review

In 1856, the term “French fried potatoes” was first recorded in English print, appearing in Eliza Warren’s *Cookery for Maids of All Work* (Warren, 1856). Her recipe described cutting new potatoes into thin slices and frying them in hot fat until golden brown, exemplifying an early “French frying” technique of shallow-frying food. As fried potatoes gained popularity particularly in the United States by the late 19th and early 20th centuries, the need for more efficient production methods became apparent, leading to innovations such as mechanized potato slicers in commercial kitchens by the early 1900s (Smith, 2004). In the 21st century, novelty variations like long fries (extra-long French fries) have been introduced to attract

consumer attention (Norazman & Johari, 2021). The elongated shape of these fries provides a larger surface area for seasonings, thereby potentially enhancing their flavour profile.

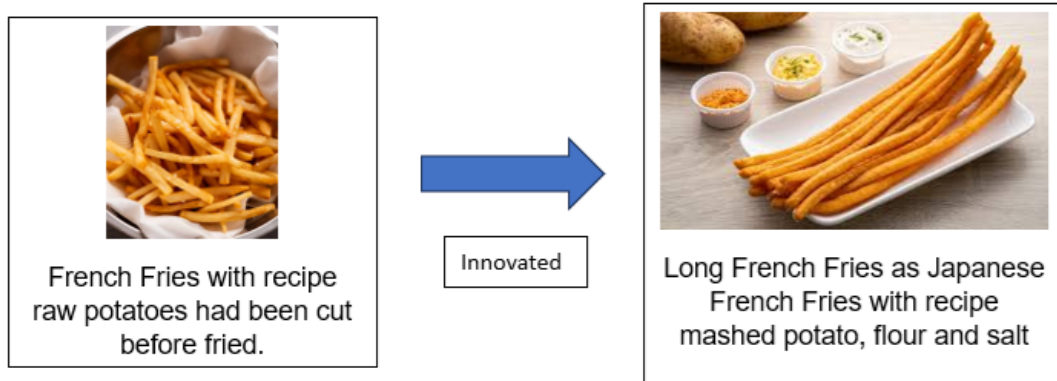


Figure 2: Potato fries innovation

Manual production of long French fries depends on human effort and basic tools, with each step done by hand. While it offers low start-up costs, customization, and artisanal appeal, it has clear drawbacks. The manual machine simplifies extrusion using a stick mechanism to shape mashed potato into long strips, reducing the need for hand mixing. However, this method is slow, labour-intensive, and often inconsistent in fry size, shape, and quality. These issues support the move toward semi-automation for better efficiency and consistency.



Figure 3: Manual long fries machine

The integration of a semi-automatic pneumatic system within the proposed machine design reflects a thoughtful balance between ergonomic functionality and mechanical efficiency. According to Kaljun and Dolsak (2012), applying ergonomic principles in machine development enhances user comfort and minimizes physical strain, which is an essential factor when designing tools for repetitive tasks. In this project, the pneumatic system plays a crucial role in reducing manual effort and streamlining operations, while the inclusion of a limit lever ensures consistent output, as supported by Sugiyanto et al. (2022) in their study on semi-automatic food processing systems. Structurally, the machine is assembled using a combination of MIG welding, nuts and screws, and epoxy adhesives, selected for their strength, flexibility, and resistance to environmental factors (Tikweld Welding Supplies, n.d.). Material selection also emphasizes hygiene and durability, with stainless steel components chosen for their non-corrosive and food-safe properties. Additionally, anodized aluminum is used in specific parts

due to its protective oxide layer, which enhances corrosion resistance and simplifies maintenance. These attributes are highly valued in food-grade machinery.

3.0 Methodology

This research was conducted through a design-based research approach in line with the objectives outlined. The first phase focused on designing a new concept machine for producing long French fries, incorporating a pneumatic system to improve efficiency and reduce manual effort. The development workflow followed a structured process flow, beginning with material selection, followed by machine design study and identification of suitable components. After that, materials and components were procured, and fabrication and assembly processes were carried out using MIG welding, nuts and screws, and epoxy methods. The completed machine was then tested to verify its functionality and consistency. Technical drawings were developed using CAD software (Autodesk Inventor 2024) and validated through simulations.

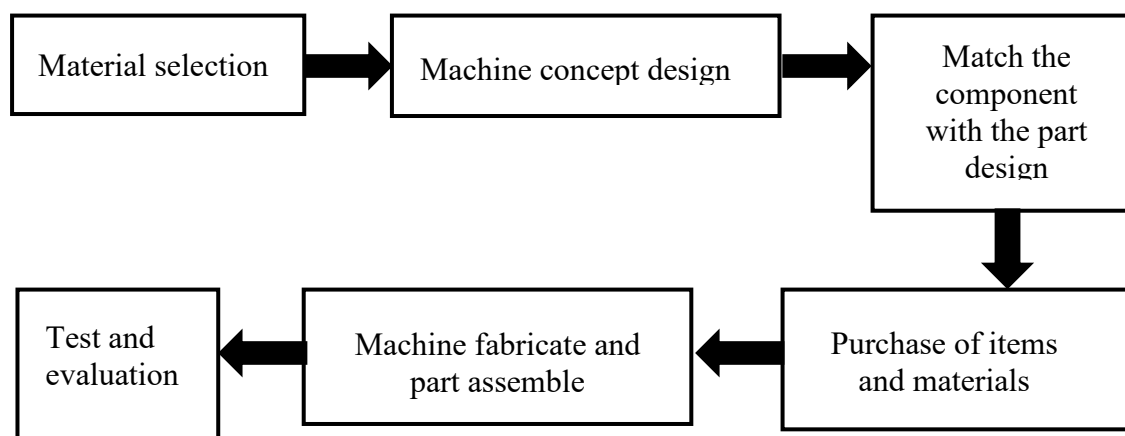


Figure 4: Flow chart for the long fries machine development

The test was conducted using a stopwatch method to record the time taken for each complete pressing cycle from button activation to full extrusion. Three repeated trials were performed for both manual and pneumatic machines under similar conditions. Each cycle consistently produced 12 fries per mould.

The simulation was conducted using Autodesk Inventor 2024, applying Linear Static Stress Analysis. Key parameters measured included Von Mises stress, displacement (deflection), and safety factor across different frame configurations. Loading conditions were applied based on estimated pneumatic pressure converted into axial load acting on the mold base, with fixed constraints set at leg base points.

Suitability and practicality of the machine were evaluated through informal observations and spontaneous feedback gathered during demonstration sessions with students and instructors. The assessment focused on several key aspects, including how easily users could operate the machine, the level of ergonomic comfort observed through user posture and reduced physical strain, the consistency of output in terms of fry shape and length across multiple trials, and the ease of maintenance based on how accessible components were during cleaning and disassembly. Although no formal questionnaire or quantitative instrument was used, these qualitative insights proved valuable in guiding improvements to the overall design.



Figure 5: Assembly drawing

4.0 Result and Discussion

4.1 Ergonomic Design with Pneumatic System

The prototype of the Long French fries machine is shown in Figure 6 below. This design is more compact and user friendly, ensuring that users can easily handle and lift the machine without difficulty. The updated design is also more ergonomic, offering improved comfort during use. Additionally, the machine takes some inspiration from the Fries Squeezer design, resulting in a practical and efficient machine that balances functionality with ease of operation.



Figure 6: Long fries semi-automatic machine

Semi-automatic machine use pneumatic system and easy to operate since the control is still manual via button and reduces physical effort as seen in Figure 7. The pressing process become more easier and save user energy. Although this concept design only depends on a high-pressure air supply, but the product output is consistent with more uniform shape and length compared to manual machines.

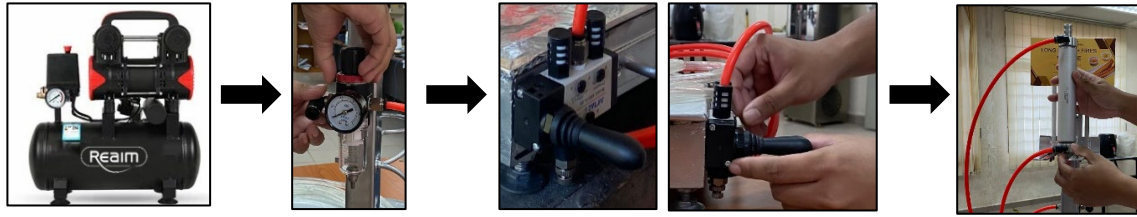


Figure 7: Pneumatic system handle the pressing process

The improved ergonomics of the current machine are evident in several aspects when compared to traditional manual machines. Firstly, the need for repeated physical force is eliminated by replacing the manual pressing action with a pneumatic cylinder, which significantly reduces strain on the upper limbs and shoulders. This is especially beneficial for users who are shorter in stature, women, or those with limited strength, enabling broader inclusivity.

Secondly, the machine's height-adjustable frame allows users to operate it while sitting or standing, promoting better posture and reducing prolonged stress on the lower back and knees. Unlike manual machines that require users to hunch over or exert awkward angles, this design supports a more natural body alignment during operation.

Thirdly, the control button for activating the pneumatic press is placed within easy reach, minimizing the need for overextension or repetitive hand motion. This reduces the risk of repetitive strain injuries (RSI), commonly associated with manual pressing mechanisms. Additionally, the non-slip working platform and strategically positioned mould bowl further enhance stability, safety, and operator confidence.

Collectively, these ergonomic improvements contribute to a safer and more comfortable user experience, promoting higher productivity with lower fatigue, and aligning with the principles of human-centered machine design.

4.2 Time Cycle Comparison Test

The machine was tested for operational efficiency by measuring the production time per cycle of long French fries as shown in Table 1. It can be seen that, the time consumption for produce 12 fries per mould is good for time saving and the production time will be more quickly.

Table 1: Time comparison for 1 cycle press

Number of Pressure (1 cycle = 12 fries / mould)	Time record (s)	
	Manual machine	Long French fries machine
First press	7.0	5.8
Second press	9.0	6.6
Third press	8.0	6.2
Average	8.0	6.2

4.3 Structural Test Analysis

A linear test analysis was conducted to evaluate the structural suitability of the frame base design. Mild steel was selected as the primary material due to its affordability, high strength, and durability when compared to alternatives such as aluminium and stainless steel. Its mechanical properties make it a practical choice for load-bearing applications in small-scale machine structures. Simulation tests were carried out to assess the stress distribution and overall stability of the frame under expected operational loads.

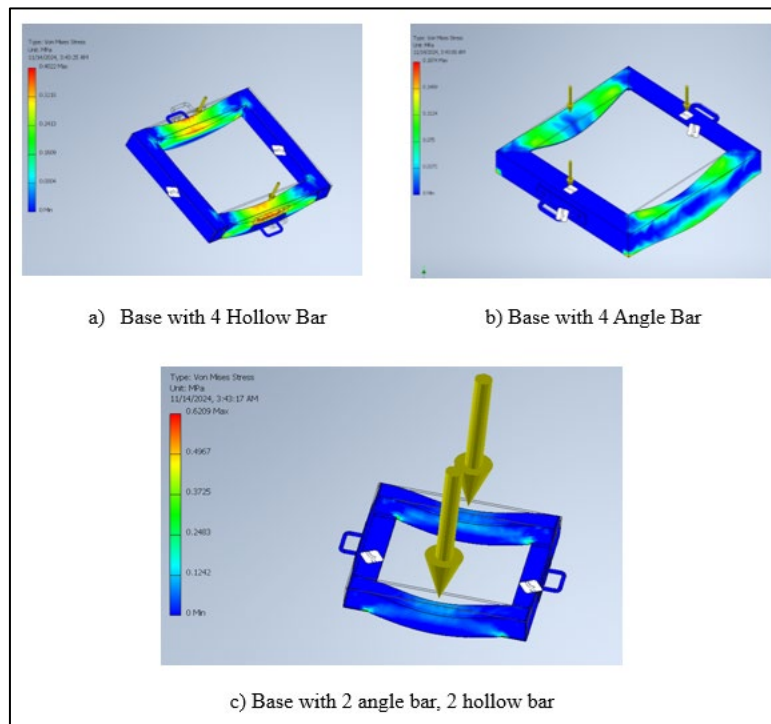


Figure 8: Simulation test for frame machine

These simulations enabled the identification of the most effective frame configuration, ensuring both safety and performance throughout the machine's operation. The base design using two angle bars and two hollow bars was found to be the most optimal choice for machine fabrication. This configuration offers improved structural strength, especially at critical stress points, while also being cost-effective. It strikes a balance between durability and material efficiency, making it suitable for long-term use in semi-automated food processing machinery.

Table 2: Description for frame design suitability

Criteria \ Design	a) Base with 4 Hollow Bar	b) Base with 4 Angle Bar	c) Base with 2 angle bar, 2 hollow bar
Von Mises stress distribution	Diagonal loading at two opposite corners	Four downward forces	Central loading
(loading set up)			
Maximum stress	0.4022 MPa	0.1874 MPa	0.6209 MPa

5.0 Conclusion

The long French fries machine offers a practical solution for small-scale food production through its semi-automatic pneumatic system, which simplifies operation and reduces physical effort. Its ergonomic, height-adjustable design suits both seated and standing users, enhancing comfort and accessibility.

The structural analysis using simulation tools validated the durability and load-bearing capabilities of the chosen mild steel frame, ensuring the machine's readiness for long-term and repeated use. Cycle time testing, as shown in Table 1, revealed an average production time of

6.2 seconds per press cycle using the new machine, compared to 8.0 seconds with manual operation that is reflecting a 22.5% improvement in efficiency. This substantial reduction in production time enhances overall productivity, especially for high-demand food stalls.

Table 2 simulations showed that the mixed frame with two angle bars and two hollow bars offered the best balance of strength and material use. Although it recorded the highest stress (0.6209 MPa), it remained safe and structurally sound for the machine's needs. The all-angle bar frame had the lowest stress (0.1874 MPa) but may be overbuilt for such a lightweight application. The all-hollow frame showed moderate stress (0.4022 MPa) with some weak points needing reinforcement. Overall, the hybrid frame was the most practical and cost-effective design, offering a strong, stable structure with efficient material usage.

To further improve the machine, stainless steel is recommended for durability and hygiene, along with a fully machined design for easier maintenance. Future upgrades should consider a PLC system, smart sensors, and servo or linear actuators to enable full automation and industrial-scale readiness.

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