Design and Implementation of a Multi-blade Automated Cutter for Baked Products

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ABSTRACT

In the current industrialized period, automated machines have become an indispensable aspect of human existence. These machines help to reduce the amount of time needed to do a specific task. Human lives today will be increasingly violent and fast-paced than in the past. Automation through technology has drastically decreased the amount of time and human effort needed to complete work. In our hectic lives, slicing and cutting baked goods is a difficult and time consuming task. The Degree of Sharpness (DOS) is the force required by the tool to incise the reference body during an effective cutting operation in baked goods. To cut or incise the food particles, a food cutter is utilized. The primary objective of this research is to incorporate a multi-blade system that can be adjusted and modified to cut various baked goods, including cakes, sandwiches, jam rolls, coconut buns, pizzas, etc. Ordinary food cutters have the primary drawback of deforming food items during the cutting process. When cutting the same blade that has some leftover food item on to it, it also changes the structure of the subsequent result. Additionally, slicing allows for the creation of extremely thin food slices. An automatic food cutter reduces human error, participant time and operation time.

KEYWORDS: *Multi-blade, deformed, baked goods, slicing, sharpness.*

1. INTRODUCTION

Baked Products are consumed by people of all age groups and financial classes. The global bakery sector is one of the largest and fastest-growing food industries. In India, products like bread, biscuits, and cookies are the most widely consumed bakery goods. These items are essential food snacks for both adults and children. Bakery products, due to high nutrient value and affordability, are an item of huge consumption. Due to the rapid population rise, the rising foreign influence, the emergence of a female working population and the fluctuating eating habits of people, they have gained popularity among people, contributing significantly to the growth trajectory of the bakery industry. Bakery holds an important place in the food processing industry

and is a traditional activity. People of various ages and socioeconomic backgrounds eat baked foods. One of the biggest and fastest-growing food industries worldwide is the bakery sector. Among the baked items that people eat the most frequently are bread, biscuits, and cookies. Both adults and children can benefit from these goods as essential snacks.[13]. Traditional techniques that depend on specialized labor have several disadvantages, such as affecting accuracy, reducing job repeatability, increasing material waste and lengthening machining time [22]. Mechanical damage sustained during processing processes such as peeling and cutting is one of the primary factors affecting the quality and shelf life of fresh cut produce [11]. The development of automation technology offers an opportunity to address these constraints and enhance production productivity [22]. Cutting is a crucial step in the food production process since it divides food into different forms. Therefore, the development of new cutting techniques and creative modeling approaches needs to be accelerated in the food manufacturing sector. With advantages including superior cutting quality, little contamination, and simple operation, automated contemporary cutting techniques with numerous blades are thought to be more efficient for processing foods with varying consistencies [24]. In order to alter the cutting process, blade parameters, rotational speed, and food temperature are frequently used criteria [4]. Throughout the Industrial Revolution, automated devices have gradually become an indispensable aspect of everyday existence for humans. In comparison to their manual replacements, automated devices complete specific tasks rapidly. The speed and competitiveness of task completion methods have grown dramatically as a result of this development [19]. The advancement of technology goes beyond the practical and beneficial application of several manually operated technologies that were developed in the past. On the other hand, its primary goal is to create a wide range of devices, machinery, and mechanisms [6].

2. REVIEW OF LITERATURE

Cutting is a crucial process in food processing, determining the final shape of food products. Various solid foods, with differing consistencies and structures, pose challenges for traditional cutting methods. The sharpness of a blade is vital, allowing precise separation of food products. Slicing in industrial settings involves segmenting food based on weight, slice quantity, and shape, ensuring both qualitative and quantitative standards. Cutting typically follows four stages: (1) initial contact between the product and blade, (2) force application and deformation, (3) material separation, and (4) cutting force reduction to zero. A bread-slicing machine simplifies slicing, reducing human effort and improving efficiency. Compared to manual slicing, automated bread-cutting machines lower waste, enhance uniformity, and maintain structural integrity. The mechanism operates with a gravity loaf feeding system and reciprocating blade movement powered by a motor. Self-lubricating bearings and vibration-absorbing components support

smooth operation. The machine stops automatically once slicing is complete, saving energy. A crumb collection tray ensures hygiene. Automated pizza-cutting machines address inconsistencies in manual slicing. The device ensures uniform slices with a single press, improving productivity. The machine accommodates various pizza sizes and features stainless-steel blades for non-stick operation. Design modifications, including a stepper motor for precise blade movement and transparent acrylic walls for safety, enhance efficiency. A control panel with buttons simplifies operation. Developed to improve hygiene and efficiency in cutting coconut candy, this machine follows a Design Thinking approach. Controlled via the Blynk application, it integrates relay devices, linear motors, and microprocessors. Evaluations confirm its functionality for small and medium enterprises. High-speed slicing applies to cheese, sausages, candies, fruits, and meats. These products experience elastic and plastic deformation during cutting, with blade friction affecting the final texture. Cutting viscoelastic foods depends on material properties and speed, influencing the appearance and quality of slices. The development of an automatic cutter with multiple blades enhances efficiency, reduces manual labor, and ensures precise, uniform cuts. Its integration into food processing minimizes material waste while maintaining hygiene and consistency.

3. METHODOLOGY

The automated cutting system operates in a precise, controlled manner, ensuring consistent and high-quality cutting of baked products. The system begins by preparing the cutting blades to ensure that they are securely mounted, sharp, properly aligned, and lubricated. The blades are carefully inspected to confirm that they are in proper condition before beginning any cutting process. Moreover, lubrication reduces wear and tear and ensures that the system operates smoothly throughout its cycles. Once the cutting blades are ready, the baked product is positioned on a polypropylene platform. The material used for the platform is chosen for its stability and durability, which are critical for ensuring that the product remains in place during the cutting process. The system is powered on by supplying 12V DC to the motor. This motor is the core component that drives the cutting process. The motor is controlled by a microcontroller (Atmega 328), which is responsible for managing all the system's operations, including switching between motor directions, timing the cutting cycles, and ensuring synchronization of all components. A relay is used to switch the motor between forward and backward directions, allowing the cutting blades to move forward for the cutting operation and backward to reset to the home position after each cycle. Upon activation, the motor begins to rotate, transmitting mechanical power to the rack and pinion system. This system is responsible for converting the rotational motion of the motor into linear motion. The rack and pinion setup is designed for precision and reliability, ensuring that the motion is smooth and the cutting blades move with the necessary force

and accuracy. The linear motion generated by the rack and pinion drives the cutting blades forward, where they are positioned to engage with the baked product.

The Reciprocating Actuator Mechanism (RAM) is the core of the cutting system and essential for controlling blade movement. The RAM drives the connecting rod that regulates the movement of the cutting blades. With the conversion of the motor's rotational energy into linear force, the RAM offers the necessary mechanical advantage to guarantee that the cutting blades apply a consistent force throughout the cutting operation. This force is essential for guaranteeing clean, uniform cuts that do not harm the product. The RAM is meticulously adjusted to exert the ideal pressure, thereby avoiding both excessive force (which may lead to crushing or deforming the product) and insufficient force (which can result in uneven cuts or blade slippage).

Once the cutting operation is completed, the system initiates a backward movement of the motor. This reverse motion allows the cutting blades to retract and reset to the home position, ready for the next cycle. The retraction of the cutting blades is just as important as the forward movement, as it prevents any residual pressure or force from affecting subsequent cuts. It also ensures that the system is reset for the next cutting cycle, maintaining high throughput without manual intervention.

4. MACHINE DEVELOPMENT AND FABRICATION

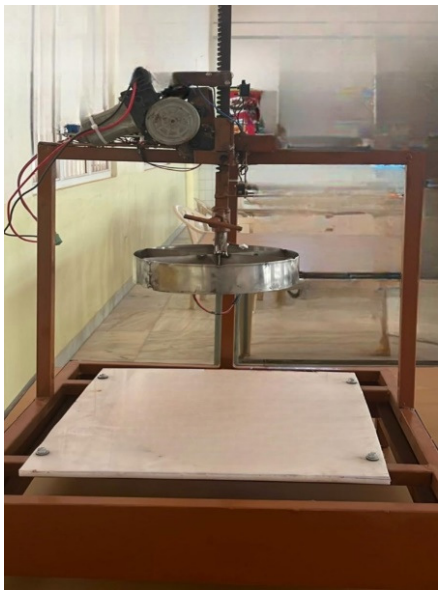

Figure 4.1 –*Automatic Cutter with Multiple Blades*

4.1 SEQUENTIAL WORKFLOW OF THE SYSTEM

- **STEP: 1 Setting up the automatic cutter**
- **STEP:2 Fixing the blades securely**
- **STEP 3: Positioning the baked product**
- **STEP 4: Activating the cutting on the polypropylene platform mechanism using the relay switch**
- **STEP 5: The blade moves in downward**
- **STEP 6: After cutting,the blades direction to accurately cut the baked product retract to home position**

5. MECHANISM OF THE MACHINE

The rack and pinion mechanism is a simple yet effective mechanical system used to convert rotational motion into linear motion. It consists of two key components:

1. Rack – A flat, straight bar with evenly spaced teeth along one edge.
2. Pinion – A circular gear with teeth that mesh with the rack.

When the pinion rotates, its teeth engage with the rack, causing it to move in a straight line. If the pinion turns clockwise, the rack moves in one direction; if it turns counter clockwise, the rack moves in the opposite direction. The rack and pinion mechanism plays a crucial role in the food industry, especially in automated cutting machines used for slicing, dicing, and portioning food products. It provides precise, controlled linear motion, ensuring accurate and consistent cutting. The rack and pinion system provides high efficiency, accuracy, and simple construction. It is preferred for applications requiring quick and direct linear movement. The system's efficiency depends on tooth design, lubrication, and material strength. Overall, the rack and pinion mechanism is an essential part of various mechanical and automotive applications due to its simplicity and reliability.

6. SPECIFICATION OF THE MACHINE

The cutting machine designed for baked products operates on the principle of converting electrical energy into mechanical motion to execute precise and efficient cutting actions. It is powered by a DC motor, ensuring controlled speed and smooth operation. The power supply unit, equipped with an SMPS (Switched Mode Power Supply), efficiently converts AC to DC, providing a stable and regulated power source for the system. The machine’s operation is controlled using an

Atmega 328 microcontroller, which ensures precise control over cutting parameters, enhancing accuracy and efficiency. A relay-based on/off mechanism allows seamless switching of the machine, optimizing energy consumption and providing a user-friendly interface. The core cutting mechanism employs a rack and pinion system, which translates rotary motion from the motor into linear motion for the cutting tool. This setup ensures smooth and accurate movement of the cutting tool, allowing for precise cutting of various baked goods without compromising their structure. The mandrel, which serves as a support shaft, holds and guides the food cutter, maintaining alignment and stability during operation. The ram mechanism, driven by the rack and pinion system, facilitates the controlled movement of the cutting tool, ensuring uniform and consistent cuts. The food cutter, made of high-speed steel (HSS) or food-grade stainless steel (SS304), is designed to slice through bread, cakes, pastries, and cookies with minimal crumbling or deformation. The machine's base is constructed from food-grade polypropylene, providing a hygienic and durable surface that prevents contamination and ensures compliance with food safety standards. A bearing block is integrated into the design to support rotating components, reducing friction and ensuring smooth movement of the cutting mechanism. The combination of a robust structure, precise cutting mechanism, and advanced control system makes this machine highly efficient and reliable for bakeries and food processing industries. Its energy-efficient operation, user-friendly controls, and durable components ensure high performance while maintaining hygiene and quality standards in large-scale food production.

7. RESULT & DISCUSSION

The fabricated automatic cutter for baked products with multiple blades efficiency was discussed in detail. These were calculated on the values observed during the field trails.

Table 4.1 Result obtained

S.No	**Name of the product**	**Weight of the product** (g)	**Weight of the product after cut** (g)	**Time taken to cut**(sec)
1	Coconut Bun (6 inch)	470	467	6
2	Tea cake	150	148	4
3	Pizza (7 inch)	270	265.5	10

4.1 DETERMINATION OF CAPACITY

The capacity of the automated cutter refers to the total amount of produce examined in the given time. Thus, the capacity is calculated using the formula. The capacity of the cutter was calculated on the formula given in Equation.

$$Capacity\ (C) = \frac{Feed}{Time\ taken} \quad kg/min$$

Table 4.2 Capacity Calculation of machine

S.No	Name of the Product	Capacity (C) (kg/min)
1	Coconut Bun (6 inch)	= 0.47 / 0.1 = 4.7
2	Pizza (8 inch)	= 0.27 / 0.16 = 1.7
3	Tea cake	= 0.15 / 0.06 = 2.5

4.2 DETERMINATION OF EFFICIENCY

The efficiency of the automated cutter refers to the initial weight of product by the final weight of the product, then multiplying the result with 100 to get value in percentage. Thus, the efficiency is calculated using the formula. The efficiency of the cutter was calculated on the formula given in Equation.

$$Efficiency(\eta) = \left(\frac{Initial\ weight\ of\ the\ product}{Final\ weight\ of\ the\ product}\right) * 100$$

Table 4.4 Efficiency calculation of machine

S.No	Name of the Product	Efficiency (ɳ)
1	Coconut Bun (6 inch)	= (470 / 467) * 100 = **99.4%**
2	Pizza (8 inch)	= (270 / 265.5) *100 = **98.3%**
3	Tea cake	= (150 / 148) *100 = **98.7%**

4.3 COMPARISON OF MANUAL AND MECHANICAL CUTTING

Table.4.4 Manual and mechanical cutting of baked products

S.No	Name of the products	Initial weight of the sample (g)	Manual cutting weight (g)	Mechanical cutting weight (g)	Manual time taken (sec)	Mechanical time taken (sec)
1	Coconut Bun (6 inch)	470	459	467	15	6
2	Pizza (8 inch)	270	262	265.5	12	10
3	Tea cake	120	115	118	7.8	4

8. CONCLUSION

In conclusion, this cutting machine is a highly efficient and precisely engineered solution for the bakery industry, designed to meet the demands of large-scale baked product processing while maintaining quality, hygiene, and efficiency. By utilizing a DC motor powered through an SMPS (Switched Mode Power Supply) for stable AC to DC conversion, the machine ensures seamless power delivery and smooth operation, allowing for consistent and precise cutting of various baked goods such as bread, cakes, pastries, and cookies. The integration of a rack and pinion mechanism, along with a mandrel-supported cutting system, enables smooth transmission of motion, ensuring accurate and controlled cutting while minimizing product deformation and waste. The ram mechanism, driven by the rack and pinion system, facilitates uniform and efficient movement of the cutting tool, optimizing the cutting process for various bakery products. The cutting tool, made of high-speed steel (HSS) or food-grade stainless steel (SS304), ensures compliance with hygiene and food safety standards while maintaining durability and sharpness for precise slicing. The polypropylene base provides a contamination-free surface, enhancing hygiene and ensuring a food-safe working environment. The machine's control system, utilizing an Atmega 328 microcontroller, offers precise control over cutting operations, enhancing efficiency and customization. A relay-based on/off mechanism simplifies operation, improving energy efficiency and reducing power wastage. Additionally, the integration of a bearing block minimizes friction and wear, extending the lifespan of the machine and reducing maintenance requirements. This cutting machine is a valuable asset for bakeries, confectioneries, and large-scale food production facilities, where precision, efficiency, and hygiene are critical. Its advanced engineering ensures

high production speed, consistent cutting quality, and reduced product wastage, making it an ideal choice for businesses looking to optimize their bakery processing operations. With an energy-efficient design that optimizes power consumption and reduces operational costs, the machine offers a sustainable and cost-effective solution for modern bakery operations. The combination of durability, precision, and compliance with food industry standards makes this machine a reliable and essential tool for enhancing productivity in baked goods manufacturing. As the bakery industry continues to evolve, investing in such advanced cutting technology will streamline production while maintaining the high quality and consistency that customers expect.

9. BIBLIOGRAPHY

1. Adesola, O. K., Adekunbi, T. K., Aderibigbe, A. D., & Afolabi, M. T. (2016). Bread-slicing machine. *Agricultural Engineering International: CIGR Journal*, *18*(2), 209-218.
2. Alyson Magee Labour savers: Meeting the challenge of automation in the slicing market, October 2019
3. Bread Pitt, Rye an-Reynolds, Crumbelina Jolie, Elon Crust, The Perfect slice - Cutting bread made easy v2, September 2024
4. Bremer, F., & Matthiesen, S. (2020). A review of research relating to food slicing in industrial applications. *Journal of Food Engineering*, *268*, 109735.
5. C.O.Mgbemen, C.E.Mgbemena, F.I. Idubor and A. Akene, Design And Implementation Of A Bread Slicing Machine 2021
6. Chandrasiri, G. S. M., Wijenayake, A. K. I., & Arachchige, U. S. (2022). Development of automated systems for the implementation of food processing. *J. Res. Technol. Eng*, *3*(1), 8-18.
7. Deily, N., Kiehne, J., & Condon, R. (2018). Automatic Pizza Cutter.
8. Dr.Pritam P. Kothari, Prof.Shivganga C.Maindargi, Comparative study of Local Bakery Products and branded Bakery Products: with Special Reference To Solapur City, August 2022
9. Ganyani, G. S., & Mushiri, T. (2019, July). Design of an automated vegetable cutter and slicer. In *Proceedings of the International Conference on Industrial Engineering and Operations Management, Pilsen, Czech Republic* (pp. 46-60).
10. Ikimi, J.A., Jewo, A.O., and Sule, Design of a Multipurpose Slicing Machine, Nigerian Journal of Engineering Science Research (NIJESR).2020
11. Incardona, A., Amodio, M. L., & Colelli, G. (2019, August). Monitoring the effect of cutting blade sharpness on quality of fresh-cut product. In *IV International Conference on Fresh-Cut Produce: Maintaining Quality and Safety 1319* (pp. 67-74).

12. Incardona, A., Fatchurrahman, D., Amodio, M. L., Peruzzi, A., & Colelli, G. (2024). Effect of Cutting Blade Sharpness on Physical and Nutritional Quality of Fresh-Cut'Golden Delicious 'Apples. *Horticulturae*, *10*(9), 955.
13. Mizar, M. A., Nasir, M. Z. M., Trifiananto, M., & Hardiatama, I. (2023). Design and performance test of multi intake foods product cutting machine. In *E3S Web of Conferences* (Vol. 432, p. 00020). EDP Sciences.
14. MUNIANDI, M., RATHAKRISHNAN, N., & PETER, G. (2022). INNOVATION OF BREAD CUTTING AND PACKAGING MACHINE FOR SMALL MEDIUM INDUSTRIES.
15. Nik Muhammad Syazwan Mohd Razali1, Azmanirah Ab Rahman, Tamil Selvan Subramania, Munirah Ahmad Azraai1, Coconut Candy Cutter Machine for Small Medium Enterprise (SMEs) Businesses 2021
16. Ruhasmadi, M. N. B., & Yasin, M. A. B. M. (2020). Automatic Slicer Machine.
17. Saeed, A., Sattar, S., & Ferguson, A. (2020). Automatic Pizza Cutting Machine. *3C Tecnologia*, 181-193.
18. Schab, D., Zahn, S., & Rohm, H. (2021). Development of a caramel-based viscoelastic reference material for cutting tests at different rates. *Materials*, *14*(14), 3798.
19. Schuldt, S., Arnold, G., Kowalewski, J., Schneider, Y., & Rohm, H. (2016). Analysis of the sharpness of blades for food cutting. *Journal of Food Engineering*, *188*, 13-20.
20. Schuldt, S., Schneider, Y., & Rohm, H. (2018). High-speed cutting of foods: Cutting behavior and initial cutting forces. *Journal of Food Engineering*, *230*, 55-62.
21. Shambhuraje Ghorpade, Rohit Jadhav, Rushikesh Muley, Sumit Sharma, Dr.Sachin Jambhale, Automation of special purpose of rolling and cutting machine in industries
22. Shradha Kadam, Mrudul Patle, Nikhil Dhage, Automated cutting machine, International journal of innovations in engineering research and technology march 27,2021
23. Teslim Adekunle Adio, Olufemi Oyedeji, Olaide Oluwaseun Adegbayo , Oladeji Oluniyi Olanrele, Ajewale Micheal Alajede , Akinwale Stephen Akintaro, Designing of an Automatic Soya Bean Cake Cutting Machine American Journal of Engineering Research (AJER) ,2024
24. Xu, W., Wang, J., Deng, Y., Li, J., Yan, T., Zhao, S., ... & Liu, D. (2022). Advanced cutting techniques for solid food: Mechanisms, applications, modeling approaches, and future perspectives. *Comprehensive Reviews in Food Science and Food Safety*, *21*(2), 1568-1597.