International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Artificial Intelligence based Revolutionary Non-Traditional Energy and Time-Saving Ghee Manufacturing Method for Dairy Industries to boost Profitability

Dr. Sushant M. Patil[1], Mrs. Priyanka S. Patil[2], Mr. Santosh T. Ghutukade[3], Mrs. Amruta P. Awati[4], Mrs. Priyanka P. Suryawanshi[5]

[1]Craft Instructor, Government Industrial Training Institute, Gadhinglaj
[2,3,4,5]Assistant Professor, Annasaheb Dange College of Engineering and Technology, Ashta.

Abstract:
The main goal of the research article is to offer a substitute technique that reduces the amount of time and energy needed to melt the blocks of butter needed to produce ghee in the dairy processing business. This research attempts to address the several drawbacks of the current butter melting technique. Nowadays, each dairy facility uses melting vats to carry out the melting process, which uses high-temperature steam and a heat exchange phenomenon. The entire output and profitability of the dairy facilities are being significantly impacted by this system's excessive energy losses, increased labour costs, and longer turnaround times. This study describes a machine that can melt hard butter blocks at low temperatures using preheating, saving time on subsequent butter melting for manufacturing of ghee. It also reduce the amount of heat required for butter melting by increasing the surface area for heat exchange between butter blocks. This revolutionary technology could help the dairy industry increase profits while saving time. Furthermore, the use of AI in this new technique will again lead to increased profitability of dairy firms.

Keywords: AI, Innovative Technique, Ghee, Milk Industry, Manufacturing, Time, Energy saving, Profit.

Introduction:

Since ancient times, ghee—the Indian term for clarified butter fat—has been used as a significant source of fat in Indian diets. It is made by heat clarifying and desiccating sour cream, cream, or butter. A foundation of fat-soluble vitamins, ghee's flavour and pleasant aroma make it one of the furthermost widespread milk foods in India. Ghee is well-defined as uncontaminated heat elucidated fat that is made entirely of milk or curd, desi-butter, or ointment to which no colouring or additives have been added.

Outline of Ghee Processing:

The standard convoluted in ghee manufacture is to concentrate milk fat in the form of cream and butter, shadowed by heat interpretation of the fat-rich milk component, dropping the quantity of liquid to less than 0.5 percent. The dark remainder (curd) is subsequently separated as ghee remainder from simplified fats.

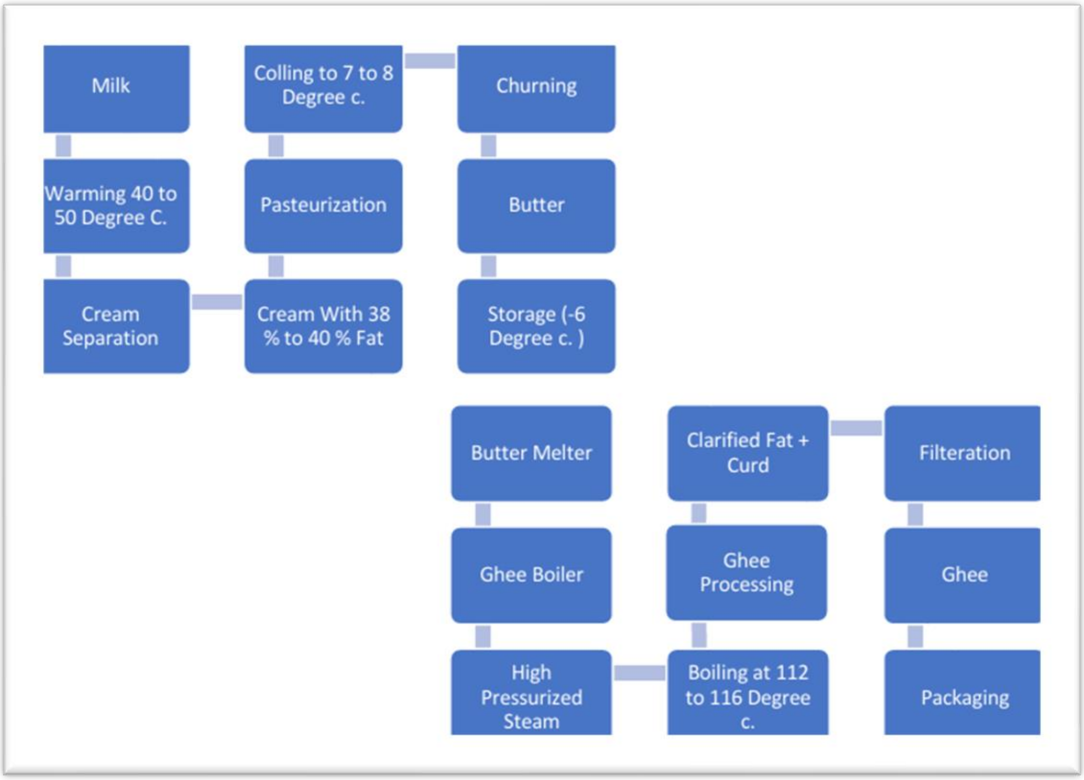

Figure 01: Ghee Processing Overview

Literature Review:

An alternate technique for melting butter to produce ghee is presented in this paper. The production chain of milk products is studied during tours of milk processing facilities. It was discovered that the manual method of liquefy butter to make ghee was exceedingly time-consuming and unprofitable. There are drawbacks to this traditional method of melting butter, including significant energy forfeiture and labour-intensiveness. The modern melting is conceded out in melting vat which operates on the basis of heat-exchange. However, this process uses steam that is heated to a high temperature for melting [1-2].

Steam is formed traditionally in a fire-type steam boiler and further fed to the melting vat via conduit. According to industry technical statistics, the steam required to melt a 20 kg butter block is around 9.28 kg, and it costs around Rs.13.92 every 20 kg. Furthermore, due to a lack of systematic production, one melting task requires the involvement of around five personnel [3-4]. To enhance efficiency in the butter melting process while conserving energy, time, and labour, an alternative method was explored. Research indicates that employing an electrical heating technique for melting butter can significantly reduce both time and energy consumption. Based on sample calculations for a daily output of 3 tons, it is estimated that annual savings could reach Rs. 10 lacs.

Present-day Methodology:

When butter blocks are produced, they are kept in a cold storage room for five to six months before being used to make ghee. Conventional butter melting vats are typically used to melt the butter.

The illustration shows a melting vat featuring internal tubing embedded within its side walls. Steam at a temperature of 150℃ circulates through these pipes to convey heat to the well's surface, which is approximately 100℃. During this heat transfer process, a considerable portion of the steam's thermal energy is lost. Two workers are tasked with introducing butter blocks, each weighing 20 kg and maintained at a temperature of -6℃, into the melting vat. Furthermore, some butter blocks are sliced, as the total duration for the melting process extends to about two and a half hours. This extended timeframe is primarily due to the reduced surface area of the butter available for effective heat exchange.

Restriction of Present-day Method:

The current technique of butter melting has several drawbacks/limitations, making ghee production uneconomical in terms of energy, labour, and time. This results in inefficient use of accessible resources such as currency, energy, and manpower. These boundaries are outlined underneath.

1. Greater Heat Loss:
2. Greater Time Loss:
3. The Drawback Cycle Proceeds:
4. Additional Work Needed:
5. Absence of systematic processing:
6. Higher fuel consumption:
7. Higher production costs:
8. Lower production and efficiency rates:

Methodology: Engineering Process of Projected Unit:

This paper introduces a novel system designed to address and mitigate the challenges and financial setbacks faced by the dairy industry, while also tackling issues related to energy and time inefficiencies. The proposed approach presents a ground-breaking concept for the butter melting process, offering a cost-effective alternative for melting butter in the production of ghee. The fundamental principle underlying this project is outlined as follows,

1. The surface area available for heat exchange is directly proportional to the rate of heat exchange.
2. The time needed for butter to melt is negatively correlated with the rate of heat exchange.
3. The amount of heat loss closely correlates with the amount of time needed for butter to melt.

It is evident from the preceding discussion that quadrupling the surface area of the butter block enhances the rate of heat exchange, leading to a reduction in the time needed for the butter to melt and consequently decreasing heat loss. By applying this principle, heat loss can be effectively minimized through the use of electrically preheated cutting tools. In this setup, heat is conducted from an aluminum heating coil to a stainless steel blade, which then transfers the heat to the butter.

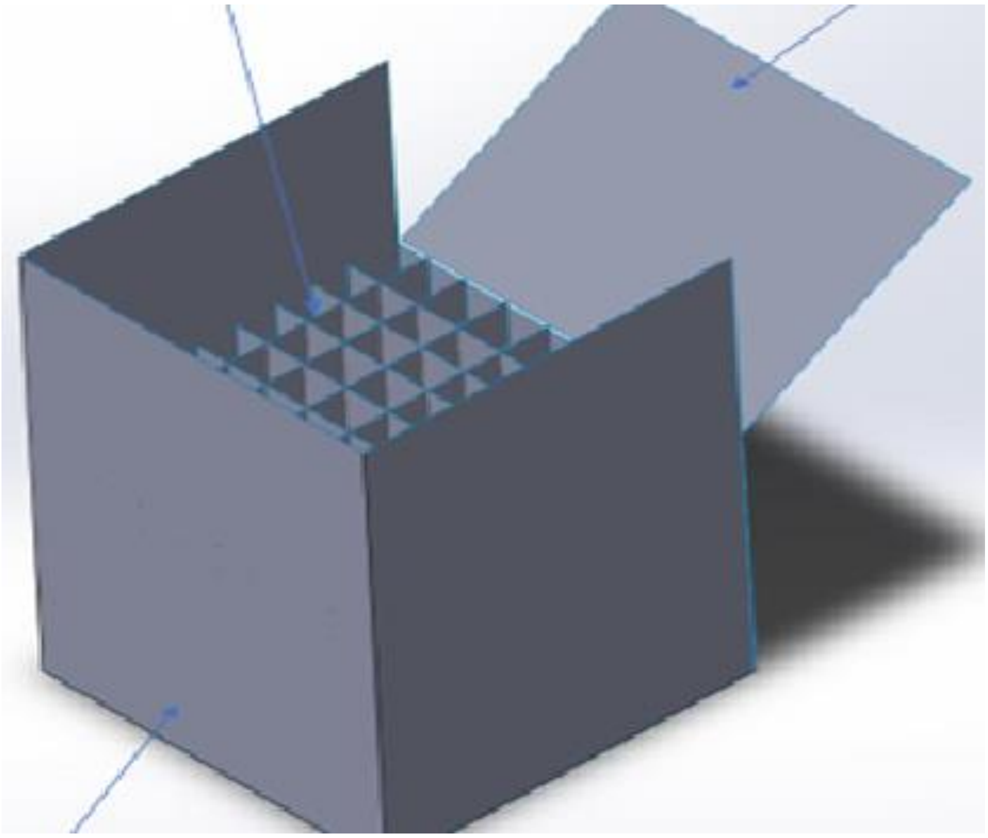

Figure 02: 3D view of proposed set up

Construction Details:
As seen in figure 2, the proposed unit for melting butter is constructed with several key parts, including the main body (a), glass wool (b), blade (c), heating coil (d), and taper (e).

Established Process of Manufacturing:

a) **Main Body:** Dimensions: 70cm x 30cm x 35cm initially, the hydraulic press machine cuts the necessary size of stainless steel sheet, which is then bent into a C shape. The remaining side of the sheet is then covered with another piece of stainless steel sheet, which is gas-welded to leave space for a taper at the topside. A thick layer of glass wool, which will serve as a thermal insulator, is then applied to the main body, and finally, another 1.5mm thick stainless steel sheet is used to complete the main body construction. Two supports are securely affixed at the base to provide enhanced stability for the stainless steel structure. These supports are designed to ensure that the stainless steel remains firmly in place, preventing any unwanted movement or shifting that could compromise its integrity. By anchoring the base, the supports help distribute weight evenly and absorb any external forces, thereby increasing the overall durability and longevity of the stainless steel installation. This thoughtful design not only enhances safety but also contributes to the aesthetic appeal of the structure, allowing it to maintain its sleek and polished appearance while functioning effectively in its intended environment.

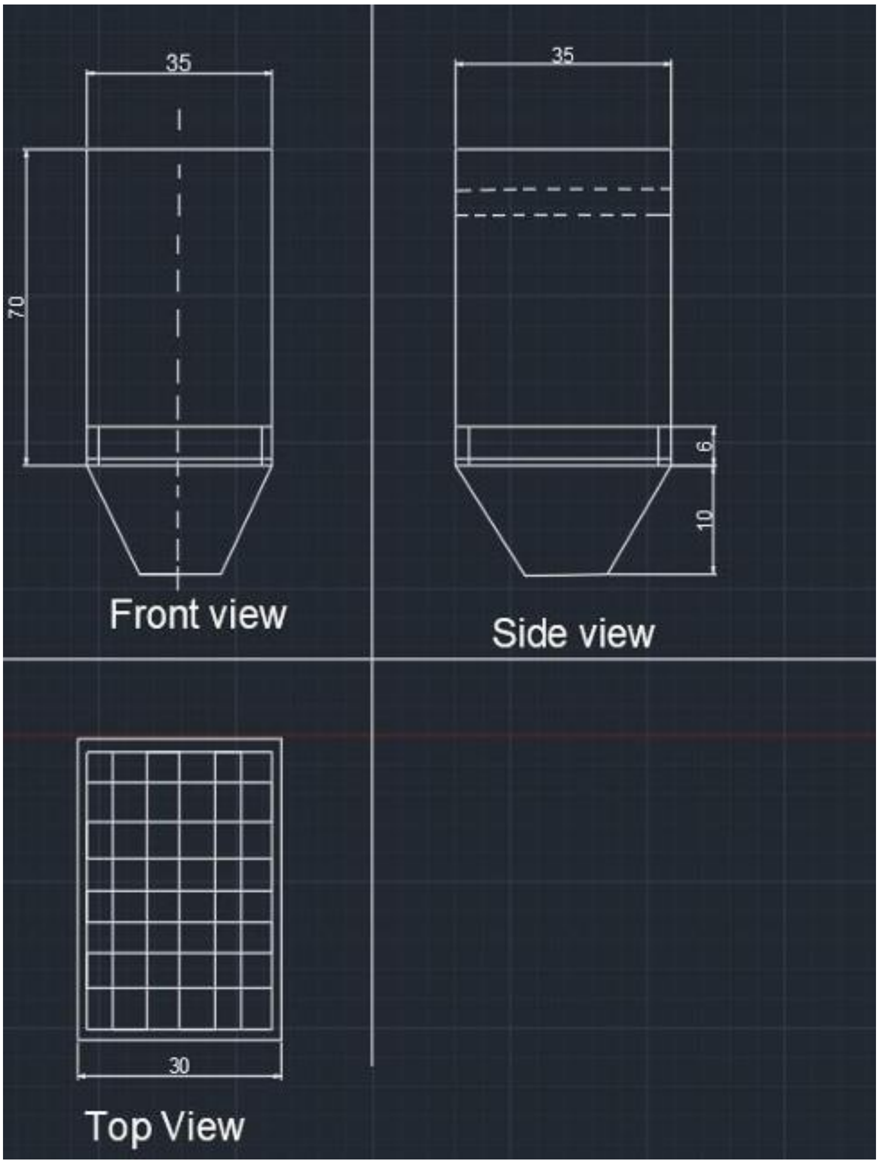

Figure 03: CAD Drawing of Proposed set up

b) **Blade: Dimensions:** 43 x 30 cm the stainless steel sheet is initially cut into seven 43 cm x 6 cm strips and ten 30 cm x 6 cm strips in order to manufacture the blade. These strips are then ground on one side to produce a sharp cutting edge. These strips are then slotted and welded together to create a structure that resembles a blade. The final stage in the preparation of the blade involves a thorough process of buffing and polishing to achieve a refined finish.

c) **Heating Coil and Electrical Circuit:** Measurements: 6 cm by 70 cm (2 pieces) the heating coils are fastened to the stainless-steel blade using a nut-bolt arrangement once it has been completed. The blade and coil assembly is then prepared for use. The electric circuit is constructed using a controller and actuator, interconnected through electrical wires and various small components. This assembly is subsequently integrated into a main body composed of stainless steel.

Figure 04: Manufactured Blade of system

d) **Taper: Dimensions:** The component measures 44 cm by 25 cm and is fabricated from a stainless steel sheet of the same dimensions, which has been precisely cut using a hydraulic press machine. Subsequently, a plate corresponding to these dimensions is affixed to the front side of the main structure, where a designated space has been allocated for its installation. This plate is secured to the main body through gas welding at a 45-degree angle relative to the horizontal plane. The angled plate serves a crucial function by providing a stable surface for placing a 20 kg block of butter, facilitating its unwrapping prior to the melting process. This design ensures an organized method for introducing the butter block into the unit.

e) **Funnel:** Here, a hydraulic press machine is used to cut four pieces of stainless steel to the necessary size. These parts are then shaped by bending and hammering. These parts are fastened to one another by screws. The funnel's primary function is to collect all of the melted butter in a smaller area, and it is fully leak-proof.

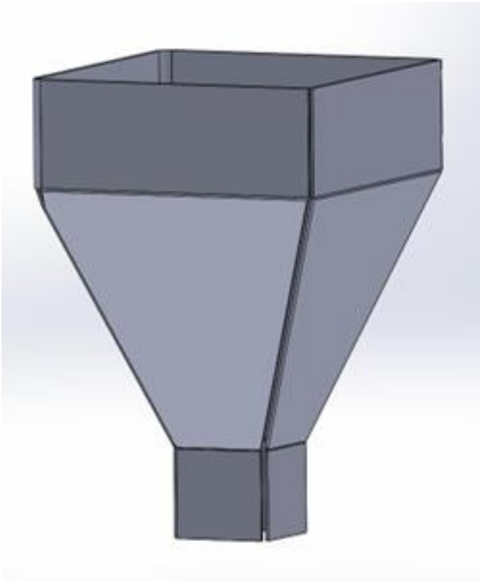

Figure 05: Funnel

Working Cycle:

All of the components of the proposed system have been designed and developed, and they are all well-assembled and ready for use. The system's working cycle is shown in the Figure 06.

Operation of the Unit:

Turn on the machine's electricity supply first. The heating coil begins to heat through the resistance heating phenomena as soon as the supply is turned on. When the coil reaches a temperature of 150°C after approximately 30 minutes, the regulator will interrupt the circuit, as this is the target temperature. The transfer of heat from the coil to the stainless-steel blade occurs over a period of about forty-five minutes, ensuring that the blade is uniformly heated. Once the blade has reached the desired temperature, the monitor will display the achieved temperature. The butter block remains on the taper plate provided with the unit until the blade has sufficiently warmed up.

The worker will begin to unwrap the butter block while it remains on the taper, and then properly insert the block into the unit. After the first 20-kg block is placed into the device, the subsequent two blocks are added one at a time. This method is used to boost the total weight of the lowest butter block, which in turn enhances the melting rate. As the butter block makes contact with the heated air contained within the unit, heat transfers from the warm air to the solid butter block at a temperature of -6°C, leading to its softening. Therefore, the melting process becomes quicker and more efficient.

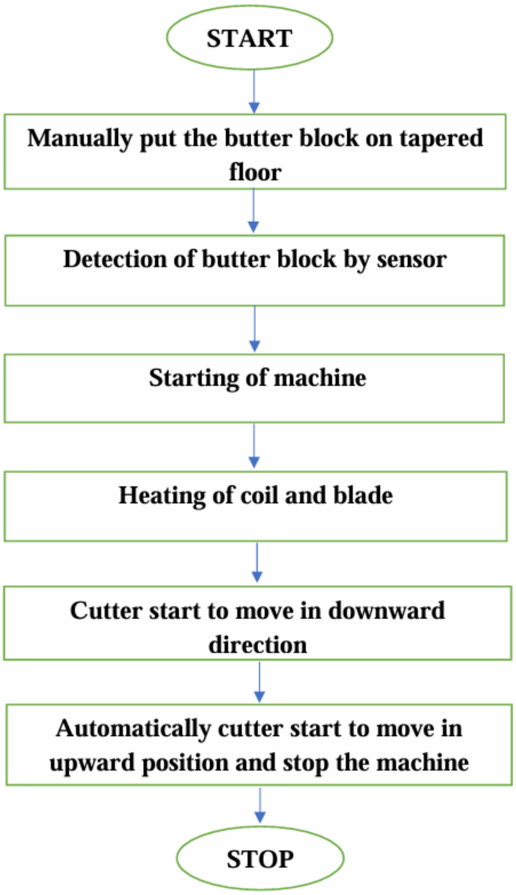

Figure 06: Work Flow

By utilizing a glass wool covering to stop heat loss to the surroundings, the air inside the unit is kept at a great temperature. The butter block begins cutting as soon as it makes contact with the sharp-edged blade, which is heated to 125°C. The cutting increases the butter block's surface area available for heat exchange. Consequently, at this temperature, the block of butter begins to melt. The little blocks that are in the pre-heating stage will then be transformed into molten butter as the molten butter passes down a funnel whose interior surface temperature has already reached a very high level. The molten butter can be gathered in a tiny container using the funnel.

Moreover, stainless steel piping can be placed at the base of the funnel to deliver the molten butter directly to the ghee boiler. As the molten butter flows through the funnel, it gains additional heat. By channelling this high-temperature molten butter into the ghee boiler, the energy required for the next processing steps can be greatly minimized.

Benefits over the Current System:

a) Lowest time-consuming method: b) Lowest energy loss: c) Lowest energy consumption: d) Minimized labour work: e) Lowest operating costs: f) Minimal butter handling and waste: g) Well-being and care of labour: h) Higher production rate: i) Improved production system efficiency:

Cost-Reduction Estimates:

Particulars	Cost Saved/year	Remark
New system	6,09,750.75/-	Innovative technique saves this cost
Labour charges	.4,38,000	Reduction in labour saves this cost
Total	**10,47,750**	

Artificial Intelligence based system:

In addition to mechanical modification of the system, if one can add the artificial intelligence and few IOT based devices in the modified system then the efficiency as well as cost reduction of the traditional method will go on increasing. In ghee manufacturing unit if number of sensors and actuators are installed with proper programming of the electronic control unit, these installation can be done depending on the system requirement then the dairy firms may avail more benefits out of it.

Result and Discussion:

The results of the comprehensive chemical analysis conducted on the molten butter produced through the proposed method provide compelling evidence that the end product is not only safe for human consumption but also suitable for a variety of subsequent processing applications. The organization responsible for this analysis has meticulously verified the quality of the molten butter, ensuring that it meets all necessary safety and quality standards.

The findings from the extensive chemical tests performed on the melted butter, which were carried out using an innovative and energy-efficient system, further reinforce the product's readiness for further processing. These tests have evaluated various parameters, including the presence of harmful contaminants, nutritional composition, and overall stability of the molten butter. The results indicate that the product is free from any harmful substances and possesses the desired characteristics for processing.

Moreover, the energy-efficient system employed in the analysis not only highlights the organization's commitment to sustainability but also ensures that the testing process is both effective and environmentally friendly. This approach not only enhances the reliability of the results but also aligns with modern industry standards that prioritize both safety and ecological responsibility. AI based integrity in the system will further lead to more profit and time savings.

In conclusion, the thorough chemical analysis and the subsequent verification of the molten butter's quality affirm its safety for human consumption and its suitability for further processing. This positions the product as a viable option for various culinary and industrial applications, paving the way for its integration into the market with confidence in its quality and safety.

Conclusion:

Revolutionary and improved non-traditional energy and time-saving ghee manufacturing method for dairy industries to boost profitability is effective. The application of the electrical preheating technique for heat generation on composite walls, specifically utilized in the melting process of butter for ghee production, has been shown to decrease the associated melting costs by nearly 80%. Additionally, the proposed melting unit reduces labour costs by 75%, The implementation of the proposed unit significantly reduces the expenses associated with the existing melting process. As a result, both the production rate of the system and the efficiency of the ghee production unit are nearly doubled. Work carried out in this paper is fully successful by providing energy saving, thereby cutting costs. In future additional techniques can be added with the use of Artificial Intelligence and IOT devices to smoothen the process of ghee manufacturing.

References:

1. Dairy Product technology textbook, class XII, CBSE.
2. Textbook of Machine Design by V.B. Bhandari.
3. USDA (United States Department of Agriculture) Guidelines for the Sanitary Design and Fabrication of Dairy Equipment.
4. FSSAI (Food Safety and Standard Authority of India) Guidelines.
5. Patil, S. M., Desavale, R. G., and Kumbhar, S. G. (January 22, 2021). "Roller Element Bearing Fault Size Estimation Using Adaptive Neurofuzzy Inference System." ASME. *ASME J. Risk Uncertainty Part B*. March 2021; 7(1): 011001. https://doi.org/10.1115/1.4048656
6. Patil, S.M., Desavale, R.G., Shinde, P.V., Patil, V.R. (2021). "Comparative Study of Response of Vibrations for Circular and Square Defects on Components of Cylindrical Roller Bearing Under Different Conditions", In: Gascoin, N., Balasubramanian, E. (eds) Innovative Design, Analysis and Development Practices in Aerospace and Automotive Engineering. Lecture Notes in Mechanical Engineering. Springer, Singapore. https://doi.org/10.1007/978-981-15-6619-6_20
7. Sushant M. Patil, R.R. Malagi, R.G. Desavale, Sanjay H. Sawant, (2022). "Fault identification in a nonlinear rotating system using Dimensional Analysis (DA) and central composite rotatable design (CCRD)", Measurement, Volume 200, 111610, ISSN 0263-2241, https://doi.org/10.1016/j.measurement.2022.111610.
8. Patil VR, Patil AB, Patil SM, et al. "Vibration signature analysis technique for detection of faults in gearbox system", *Int J Trend Res Develop* 2016; 3(3): 627–629.

9. Jamadar, I. M., Patil, S. M., Chavan, S. S., Pawar, G. B., & Rakate, G. N. (2012). "Thickness Optimization of Inclined Pressure Vessel Using Non Linear Finite Element Analysis Using Design by Analysis Approach", *International Journal of Mechanical Engineering & Technology (IJMET), 3*(3), 682-689.
10. Shinde, P.V., Desavale, R.G., Patil, V.R. *et al.* "Modeling, attenuation and flow field analysis of diesel engine muffler using fluid structure interaction approach and experimental analysis", *SN Appl. Sci.* **2**, 920 (2020). https://doi.org/10.1007/s42452-020-2683-6
11. Sushant M. Patil, Ramchandra G. Desavale, Imran M. Jamadar, 2013, "Conceptual Structure Design Through Thickness Optimization Of High Pressure And High Temperature Self Regulated Pressure Valve Using Non- Linear Transient Finite Element Method", International Journal of Engineering Research & Technology, Vol. 2, pp. 2043-2049.
12. Patil, S. M., R. G. Desavale, P. V. Shinde, V. R. Patil, "Comparative Study of Response of Vibrations for Circular and Square Defects on Components of Cylindrical Roller Bearing Under Different Conditions", Lecture Notes in Mechanical Engineering, Innovative Design, Analysis and Development Practices in Aerospace and Automotive Engineering." (2021), Springer, Singapore, pp. 189-198. https://doi.org/10.1007/978-981-15-6619-6_20
13. Mrs. Jayshri Pawar, Dr. Ravindra R. Malagi, Dr. Manoj Jadhav, Dr. Sushant Patil, "Natural Fiber Thermoplastic Composites For Mechanical And Biodegradability Properties", *AJBR*, vol. 27, no. 3S, pp. 5241–5247, Oct. 2024, doi: 10.53555/AJBR.v27i3S.3306.
14. Sushant M. Patil, Dr. R. R. Malagi, R. G. Desavale, "Investigation of vibration levels of antifriction bearing with right-angled faults on inner race and rolling element under diverse load conditions", *AIP Conf. Proc.* 2716, 030014 (2023), https://doi.org/10.1063/5.0129979
15. Suyash A. Jangam, Aniket A. Patil, Sushant M. Patil, "Modeling and Development of Multi-Arm Robot Using CATIA for Pick and Place Operation to Adapt Ease in Work", International Research Journal of Engineering and Technology (IRJET), Volume: 08 Issue: 05, May 2021, pp- 2822-2827. https://shorturl.at/8OZs3
16. I.M.Jamadar S.M.Patil, S.S.Chavan, G.B.Pawar, G.N.Rakate, 2013, "Thickness Optimization Of Inclined Pressure Vessele Using Non Linear Finite Element Analysis Using Design By Analysis Approach", International Journal Of Mechanical Engineering And Technology (IJMET), Volume-3, Issue-3, Pages 682-689.
17. Sushant Mohan Patil, "Studies on the Non-linear Dynamic Modelling of Antifriction Bearings for Fault Diagnosis", Ph.D. Thesis, 2022, VTU, Belagavi. http://hdl.handle.net/10603/543017