PREDICTIVE MAINTENANCE

SUBMITTED BY

Madhav (2022EEB1188)
Palakpreet Kaur (2022MEB1327)

SUBMITTED TO

Dr. Kamal Kumar Choudhary

Date of submission: 09-04-2024

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Certificate

This is to certify that the B. Tech project titled “Predictive Maintenance”
Prepared by :
Madhav: 2022EEB1188
Palakpreet Kaur: 2022meb1327

is approved for submission for the course on Human Geography and Societal Needs in the Department of Humanities and Social Sciences, Indian Institute of Technology, Ropar.

Signature of Examiner and Guide/s

Dr Kamal Kumar Choudhary
Department of Humanities and Social Sciences
IIT Ropar

Declaration

I hereby declare that the report entitled “Predictive Maintenance” submitted by us, for the partial fulfillment of the course on Human Geography and Societal Needs (HS 202) in the second year of the B. Tech programme in IIT, Ropar. The work carried out by us under the supervision of Dr Kamal Kumar Choudhary, Department of Humanities and Social Sciences. We further declare that this written submission represents our ideas and other’s ideas or words have been included. We also have adequately cited and referenced the original sources in the case of other’s ideas or words. We have not misrepresented anyidea/data/fact/source to the best of our knowledge. Therefore, we affirm that our group has adhered to all principles of academic honesty and integrity.

Place: Ropar
Date: 27/04/2023

Madhav: 2022EEB1188
Palakpreet Kaur: 2022meb1327

Acknowledgement

We would like to thank our seniors Sanket Wadhwa and Vedant Sati from third year and final year respectively of electrical department for supporting us with the technological support and guidance provided to us. Also we thank our first year juniors for their help in doing the research for the project.

We would also like to thank our teaching assistant Shalu S for timely assisting us and her valuable inputs for the project.

2. Abstract

Predictive maintenance (PdM) is maintenance that measures the performance and condition of equipment of in-service equipment during normal operation to identify any faults developing. It provides cost savings and better reliability over routine or time-based preventive maintenance. Here we are exploring those industries which are not using the latest technology and hence suffering a high maintenance loss. We found that the existing textile industry uses preventive maintenance and importing the technology from the foreign companies. Our motive is to promote the indian technology which is much cheeper than the foreign ones. We would like to build a startup to promote our technology with the support of a full stack team.

3.1 PROBLEM STATEMENT

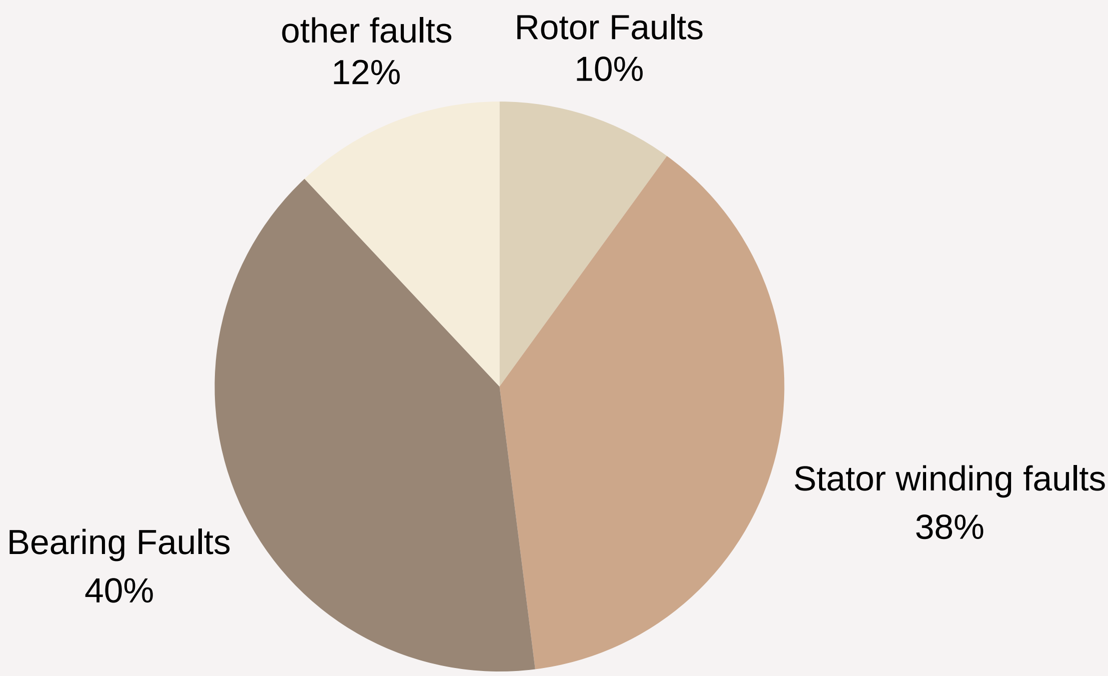
In today's world, textile industry is growing in terms of technology and thus large motor driven machines are used. These machines undergo frequent disruptions and downtime due to mechanical and electrical faults. Here we come with our IoT based predictive maintenance and health monitoring system for these devices. The cost of the product is thus reduced with the help of predictive maintenance.

3.2 DETAILED DESCRIPTION OF THE PROBLEM

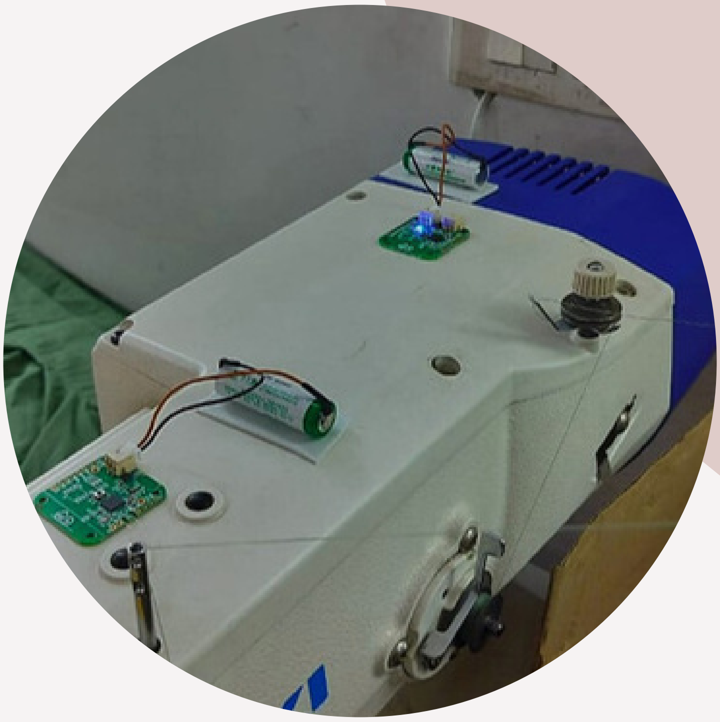
Machine failure gives arise to the following problems:

1. **Disruptions in supply chains**: Whenever there is breakdownof any equipment, it can lead to delays in the production and delivery of textile products. This eventually disrupt the supply chain which causes the shortages of goods in market. As a result, consumers may face difficulties in finding the products they need, leading to frustration and inconvenience.
2. **Quality of Products**: Equipment failures can compromise the quality of textile products. For example, if a machine responsible for dyeing fabric malfunctions, it may result in inconsistencies or defects in the finished products. Customers who buy these inferior products might be disappointed with their quality, which could result in bad experiences and possibly harm the manufacturer's or brand's reputation.
3. **Increase in Price**: The costs associated with equipment maintenance and repairs, as well as the losses brouht on by downtime, are often passed on to consumers in the form of higher prices for textile products. This implies that while producers attempt to recover their costs, consumers would have to pay more for items. Price increases can put a pressure on people's finances, especially those with little extra money to spend.
4. **Product Availability**: Unplanned downtime can result in production delays, leading to shortages of specific textile products in the market. As a result, consumers may face challenges in finding the items they want, especially if they have specific preferences or requirements. This can lead to frustration and inconvenience for consumers who are unable to access the products they need in a timely manner.

3.3 Identification of the problem

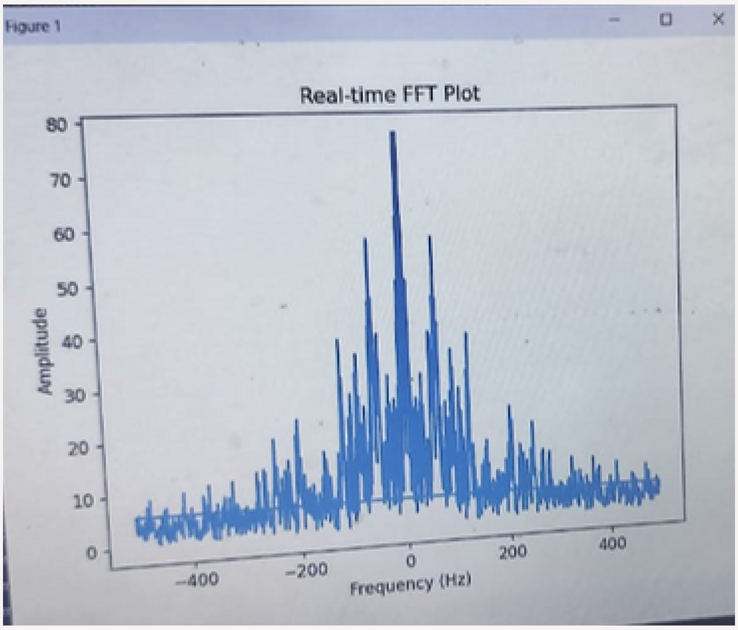


Most of the textile manufacturers, machine downtime is the largest source of production loss. The term downtime means when a machine is not in production . Where 80 % of the textile industries are unable to calculate their true downtime costs correctly as they have large data interface, which is unable to trace time to time. It was noted that in the studies of textile manufacturing industries, manufacturers may face average down time of 800 hours per year and had a loss of 5 % annually. The total down timecost for the manufacturer ranges between Rs. 25 and 45 lakhs per hour. This means the downtime can cost the company budgeted between Rs. 85 crore and Rs. 200 crore a year.
The research comprises a study of manufacturing of LK 1900BN on JUKI sewing machine with standard machine parameters. The data was collected by our own designed sensor and collected with the FFT (Fast Fourier Transform) graph. We took samples from three types of machines. First one was new, second was old, third was faulty. With the help of this graph we can differentiate between a healthy and a faulty machine which gives the proof of concept of our project.

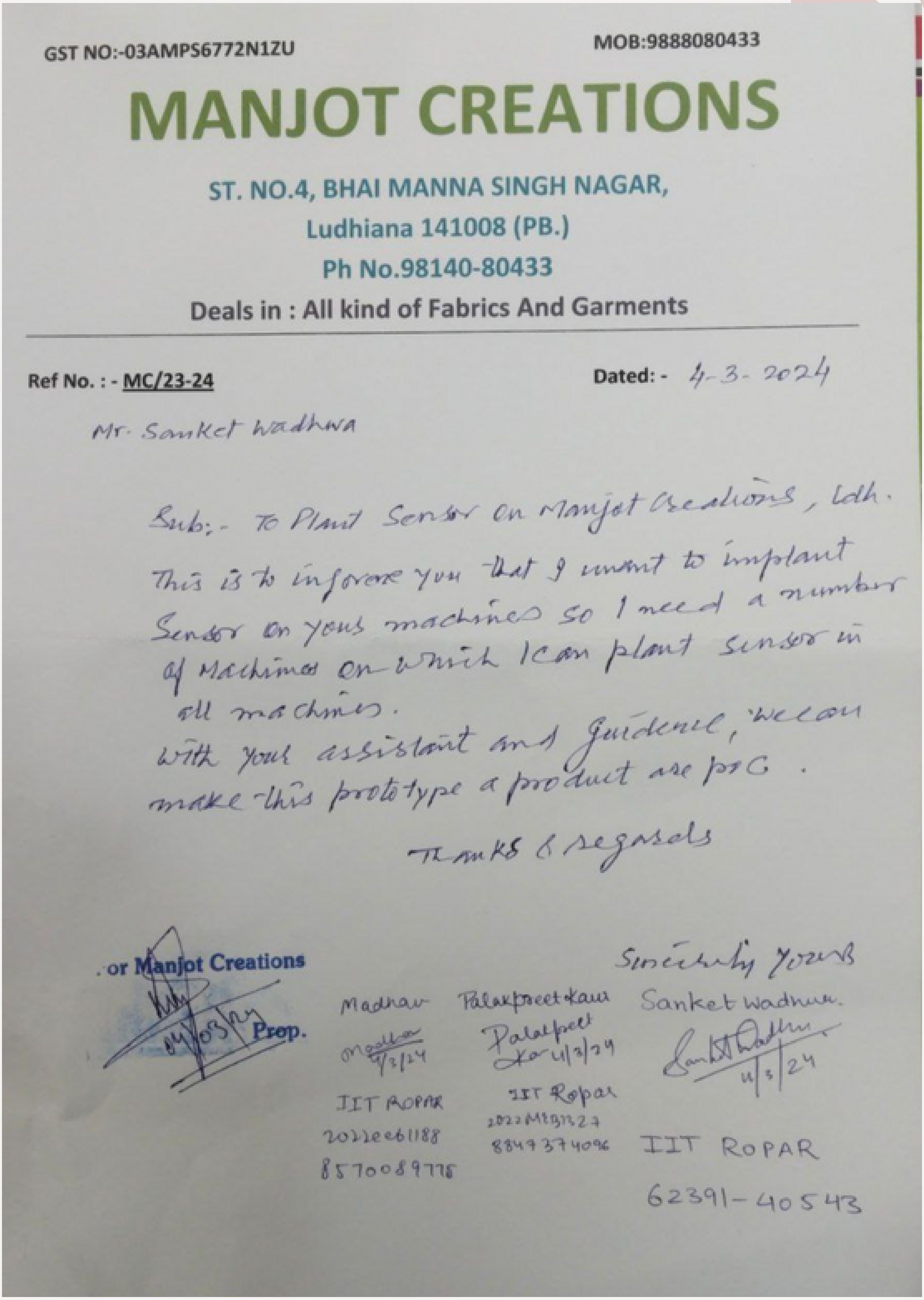


Survey Conducted and data collected by our sensor

We went to a Garment manufacturing factory in Ludhiana where we conducted a survey from the workers about the machine’s down time, loss due to down time, repair cost, damage frequecy, cause of damage, critical parameters and parts of machine which are most frequently damaged.



Here is the permit of our industry visit in Ludhiana and the permition to install our sensors on their machines for future Research and Development of the product.



GST NO:-03AMPS6772N1ZU

MOB:9888080433

MANJOT CREATIONS

ST. NO.4, BHAI MANNA SINGH NAGAR,
Ludhiana 141008 (PB.)
Ph No.98140-80433

Deals in : All kind of Fabrics And Garments

Ref No. : - MC/23-24

Dated: - 4-3-2024

Mr. Sanket Wadhwa

Sub:- To Plant Sensor on Manjot Creations, Ldh.

This is to inform you that I want to implant Sensor on your machines so I need a number of Machines on which I can plant sensor in all machines.
With your assistant and guidence, we can make this prototype a product are p&G.

Thanks & regards

For Manjot Creations
Prop.

Sincerely Yours

Madhav
Madhav 4/3/24
IIT ROPAR
2022eeb1188
8570089778

Palakpreet Kaur
Palakpreet Kaur 4/3/24
IIT Ropar
2022MEB1327
8847374096

Sanket Wadhwa.
Sanket Wadhwa 4/3/24
IIT ROPAR
62391-40543

3.4 CURRENT DEVELOPMENTS IN THE DOMAIN

1. **IoT Integration**: IoT sensors provide real-time data on equipment health and enables active maintenance minimizing downtime in textile manufacturing.
2. **Machine Learning and AI**: Advanced algorithms analyze equipment data to accurately predict failures, optimizing maintenance schedules and reducing costs for textile companies.
3. **Predictive Analytics Platforms**: Tailored platforms integrate data sources for comprehensive insights into equipment performance, empowering informed decision-making and resource allocation.
4. **Cloud-Based Solutions**: Scalable cloud platforms offer flexibility and accessibility, allowing textile manufacturers to deploy predictive maintenance tools without significant upfront investment.
5. **Remote Monitoring and Diagnostics**: Remote access to equipment data enables proactive troubleshooting and maintenance, improving uptime and operational efficiency in the textile industry.

3.5 Need and Significance of resolving the problem

Not using predictive maintenance for machines can lead to several problems and challenges, including:

1. **Increased Downtime**: Without predictive maintenance, machines are more likely to experience unexpected breakdowns and failures. This can result in unplanned downtime, causing delays in production schedules and impacting overall efficiency.
2. **Higher Maintenance Costs**: Reactive maintenance, which is the alternative to predictive maintenance, tends to be more costly. Emergency repairs and replacement of parts often come with premium prices compared to planned maintenance activities.
3. **Reduced Equipment Lifespan**: Continuous operation without proactive maintenance can accelerate wear and tear on machines, leading to premature failure and shorter lifespans. This can result in the need for frequent equipment replacements, further increasing costs.
4. **Safety Risks**: Unplanned equipment failures can pose safety hazards to operators and workers. Malfunctioning machinery may cause accidents or injuries if not properly maintained and monitored.
5. **Decreased Product Quality**: Equipment that is not properly maintained may produce lower quality products or services. This can result in customer dissatisfaction, loss of business, and damage to the reputation of the company.

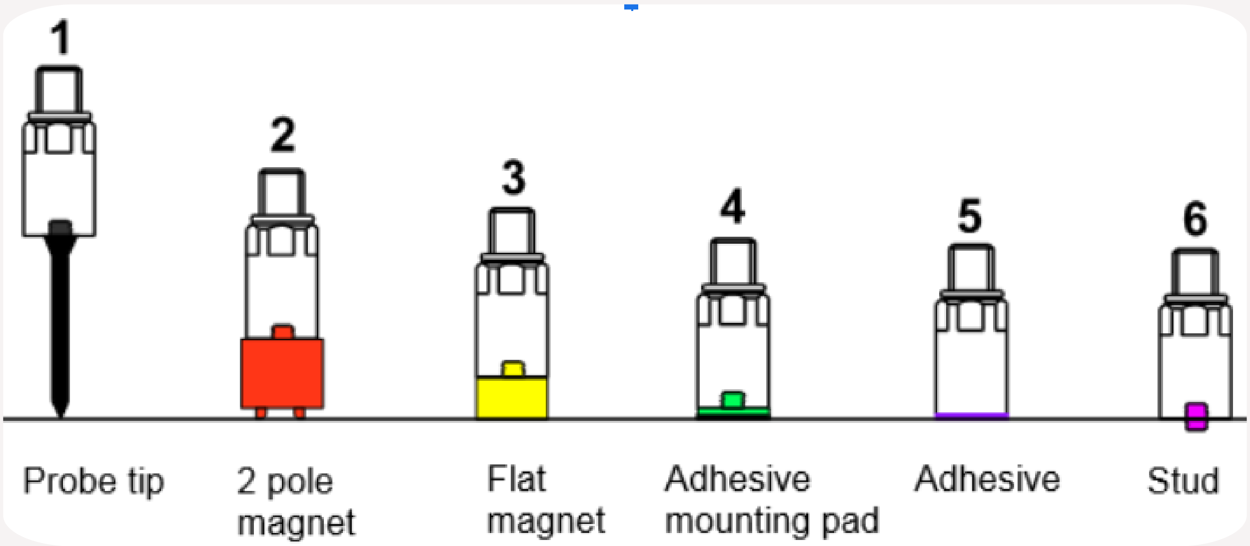
4. GOALS PERTAINING TO REMOVE THE PROBLEM

1. **Worker Well-being:** Ensure that predictive maintenance strategies prioritize the well-being of workers by minimizing the need for manual inspections in potentially hazardous environments. This goal aims to improve working conditions and reduce the risk of injuries or health issues among employees.
2. **Skills Development:** Provide training and skill development opportunities for workers to adapt to new predictive maintenance technologies and methodologies. This goal fosters workforce empowerment and enhances employability in a rapidly evolving industrial landscape.
3. **Environmental Sustainability**: Incorporate environmental considerations into predictive maintenance practices to minimize resource consumption and waste generation. This goal aligns with broader sustainability objectives and helps mitigate the environmental footprint of textile manufacturing activities.
4. **Ethical Supply Chains**: Ensure ethical sourcing and production practices throughout the textile supply chain, including the implementation of responsible predictive maintenance strategies that uphold labor rights and environmental standards. This goal contributes to building trust and credibility within the industry and among consumers.
5. **Affordable Goods**: Ensure that the benefits of improved operational efficiency and cost savings resulting from predictive maintenance are passed on to consumers in the form of affordable textile products. This goal promotes consumer welfare and enhances access to essential goods for common people, particularly those from low-income households.

5. TOOLS AND TECHNIQUES PERCEIVED TO BE EFFECTIVE FOR RESOLVING THE ISSUE

.In the realm of predictive maintenance for the textile industry, various areas of expertise can contribute to development:

1. PCB Sensor:
- Accelerometer LIS3DH
- Nrf BLE chip
- SHT40
- SMD’s
- Each node transmits data with frequency = 3kHz
- Adhesive or Magnet
2. Gateway:
- It should support a frequency = 3kHz * no. of nodes per gateway
- BLE 5.2
- LE
- MQTT API through EC200
3. https://wiki.analog.com/resources/eval/user-guides/industrial_wireless_cbm_evaluation_tool_3axis
4. Accelerometer mounting methods:



Magnetic mounts are typically used in situations where the monitored equipment does not include a threaded hole.

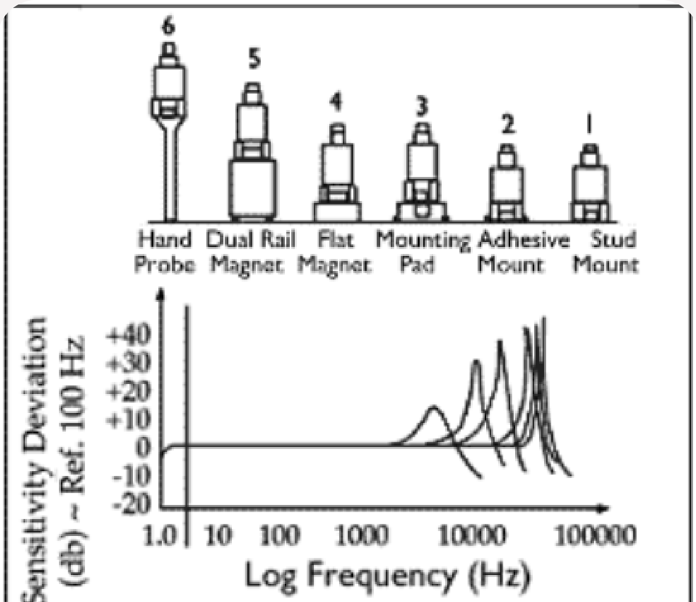
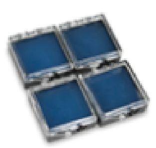


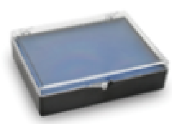
Fig. 6 - Mounted Resonance Change

5. The piezoelectric vibration sensor must be as close as possible to the machine's surface.
6. The sensor should be mounted in a location as close to the bearings as possible.
7. Avoid mounting the sensor on thin sections, guards, cantilevers or vibration-free areas (antinodes), or areas with extreme temperature variations.
8. Regular adhessives:



Model 080A24

Model 080A109

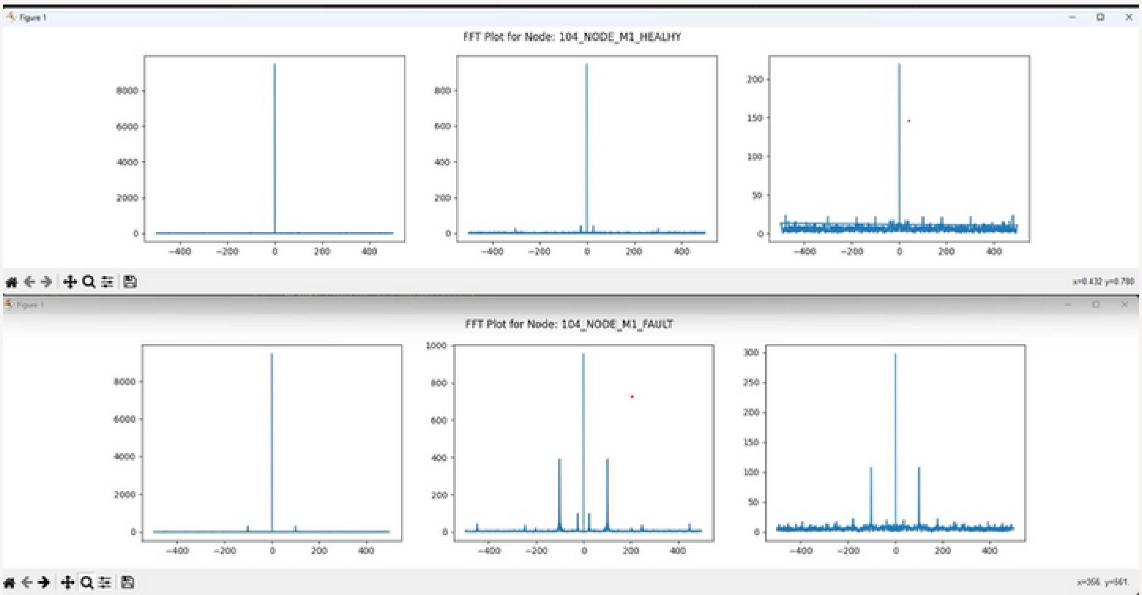


Model 080A47

Model 080A90

6. DETAILED WORKING PLAN AND TECHNOLOGICAL INTERVENTIONS

Data Collection and Analysis: Gather data from various sources such as sensors, machines, historical maintenance records, and other relevant systems. Analyze this data to identify patterns, anomalies, and potential failure points.



Sensor Deployment: Install sensors on critical machinery to monitor parameters like temperature, vibration, pressure, and humidity. These sensors provide real-time data for predictive analysis.

Machine Learning Algorithms: Utilize machine learning algorithms to analyze the collected data and predict potential equipment failures. Algorithms such as regression, classification, and clustering can be applied to detect patterns and trends indicative of impending failures.

Feature Modelling and SVM(Support Vector Machine):-

Without the need for FFT, machine status can be categorized into normal, warning, and failure by extracting values such as variance, range, mean, standard deviation, and other relevant features. These extracted values can be plotted, and based on the points on the plot, the machine status can be effectively divided into three clusters, allowing for accurate classification. This approach provides a practical alternative to FFT, utilizing statistical features for machine health assessment

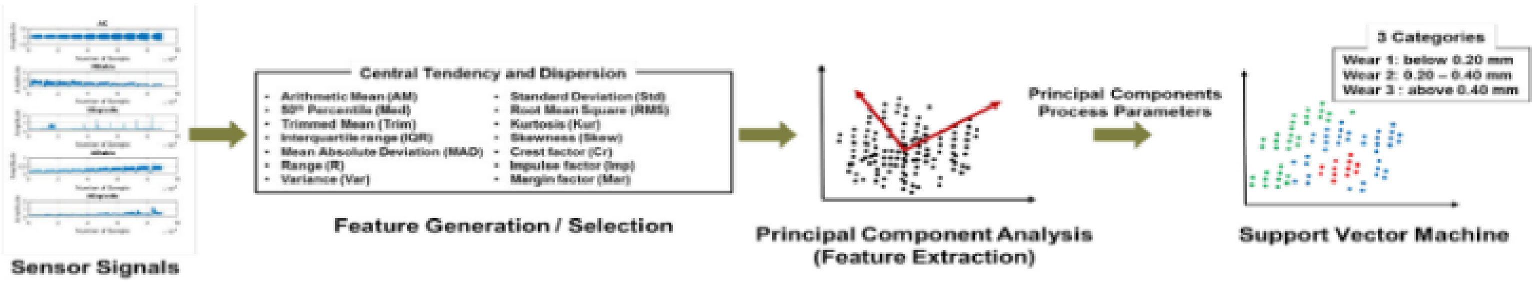


Fig. 5. Schematic diagram of the SVM-based tool condition classification.

RNN

A Recurrent Neural Network (RNN) is a suitable choice when dealing with real-time data. It proves particularly useful when dependencies over a period of time need to be observed. In this type of neural network, nodes from the previous layer are stored, creating a cyclic order rather than a linear one.

The raw signal undergoes a conversion through Fast Fourier Transform (FFT). Following this transformation, three features are extracted in both the time domain and frequency domain. The data processing involves dividing it into overlapping chunks, which serve as nodes in the neural network. Ultimately, the neural network aims to predict the health of the machine.

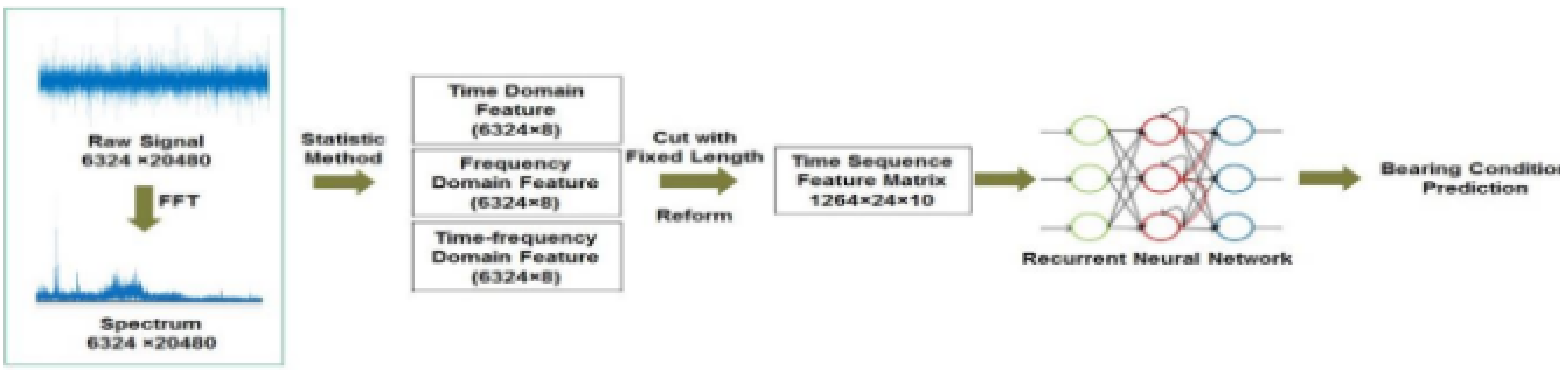


Fig. 7. Schematic diagram of the RNN-based bearing condition classification.

Comparison of results achieved with different models:

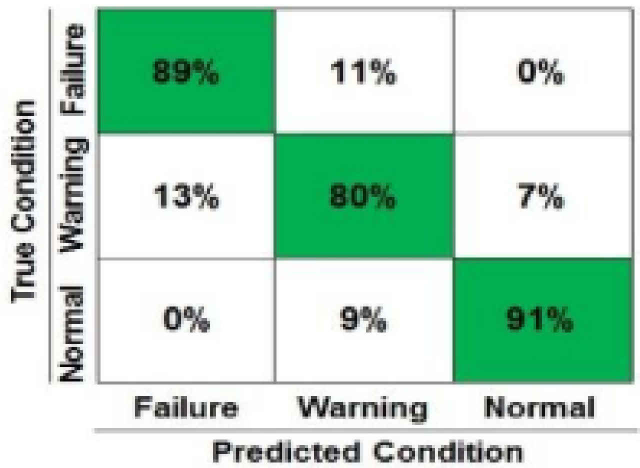


Fig. 6. Confusion matrix for the classification of cutting tool conditions using SVM.

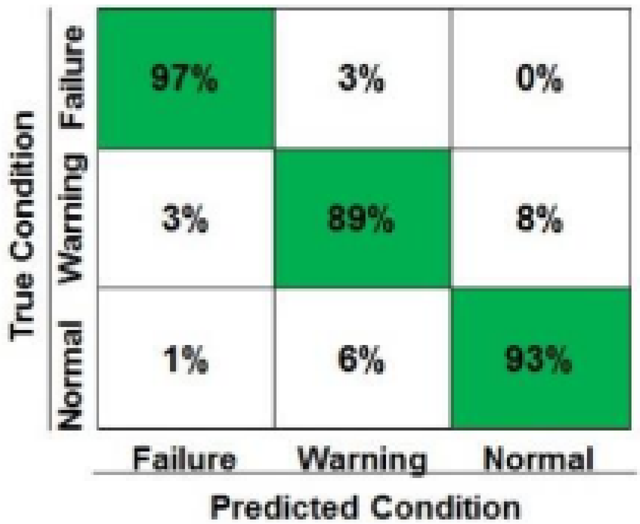


Fig. 8. Confusion matrix for the classification of bearing conditions using RNN.

Root Cause Analysis: Conduct root cause analysis to understand the underlying reasons for equipment failures. This helps in refining predictive models and improving maintenance strategies over time.

Continuous Improvement: Implement a culture of continuous improvement by regularly reviewing predictive maintenance processes, analyzing performance metrics, and incorporating feedback from maintenance personnel and operators.

Cost-Benefit Analysis: Conduct a cost-benefit analysis to evaluate the return on investment (ROI) of implementing predictive maintenance. Consider factors such as reduced downtime, extended equipment lifespan, and improved productivity.

7. NOVELTY/INNOVATION OF THE PROPOSED INTERVENTIONS

Novelty in the product is the real time 24 x 7 monitoring of the machine. Also the sensor does not require any external power supply from the user, we already have replacable battery with the node. The bluetooth technology we use gives a more range to cover and also the case of the box we are designing is made keeping in mind that the vibrations that have to be read by the sensor does not get absorbed by the external case.

The ML algorithm we are using gives an accuracy above 85 %. Also the master node used to send the collected signal of set of 30 nodes to the cloud server with a faster and more efficient way in term of packets.

8. Approaches that can be taken to implement intervention plans

- Define the outcome: Before starting a new thing, we must look at all the outcome aspects so that we can progress in the right direction keeping all the scenarios in mind.
- Carefully plan your intervention: Before starting implementation physically, we have to plan all the logistics and other aspects of the product, whether be it its design, its market, cost and reach to people.
- Start small: Initially, we will build a small startup kind of industry where we will build our product for fewer people and check how well it works.
- Scale up your intervention: As production increases, we need to enhance the product for large-scale industries and a large volume of milk testing.
- Make sure you're monitoring progress: As the demand increases, we need modifications in the product so we need to check for the progress in demands and further specifications needed.

9. POSSIBLE CONSTRAINTS AND BARRIERS TO IMPLEMENTATION

Certainly, here are non-technical constraints in the field of predictive maintenance for the textile industry:

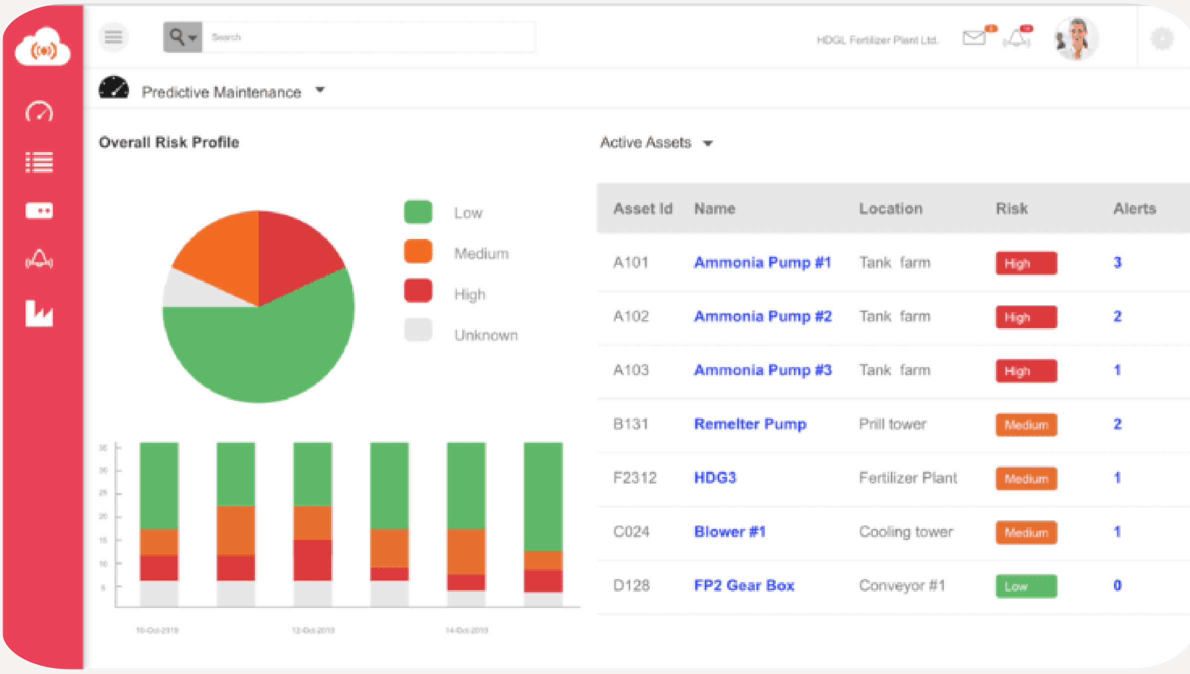
1. **Budgetary Constraints**: Limited financial resources may hinder the adoption of predictive maintenance technologies, especially for small and medium-sized textile companies. The initial investment required for implementing predictive maintenance systems, including hardware, software, and training, can be significant.
2. **Organizational Resistance**: Resistance to change within the organization can impede the adoption of predictive maintenance practices. Employees may be accustomed to traditional maintenance approaches and reluctant to embrace new technologies or methodologies.
3. **Lack of Awareness and Education**: Some textile industry stakeholders may lack awareness of the benefits of predictive maintenance or have misconceptions about its effectiveness. Educating decision-makers and personnel about the value proposition of predictive maintenance is essential for overcoming skepticism and fostering buy-in.
4. **Risk Aversion**: Fear of failure or disruption to operations may deter textile companies from implementing predictive maintenance initiatives. Concerns about the potential for false alarms or inaccuracies in predictive models may lead to a preference for reactive maintenance practices.
5. **Resource Allocation**: Prioritizing predictive maintenance initiatives amidst competing priorities and resource constraints can be challenging for textile companies. Allocating sufficient human resources, time, and attention to planning, implementation, and ongoing optimization of predictive maintenance programs is essential for success.
6. **Environmental Factors**: Environmental conditions in textile manufacturing facilities, such as dust, humidity, or temperature fluctuations, can affect the performance and reliability of sensors and equipment, requiring specialized solutions and maintenance.

10. Expertise available with each student to contribute to the development of the intervention

Name	Expertise
Madhav	Market Research, PCB Designing, Business analysis, Management of the team
Palakpreet Kaur	CAD Modelling to design the case of sensor, building connections in the market for the overall sales, basic ML, python

11. Expected Outcomes

The expected outcome of the project will be a desktop application which will look like a figure shown below:



This will result in the following outcomes:

BE PROACTIVE NOR REACTIVE
Latest AI and Machine Learning models to accurately predict the risk of failure and detect anomly.

INCREASES EFFICIENCY
Increases asset availabilityby reducing unexpected downtime ar optimizing planned maintenance intervals.

REDUCE STRESS
With 24 x 7 autonomous monitoring and prediction you can plan maintenance and your time better.

REDUCE COST
Reduce overall maintenance costs up to 30% through reduced downtime and better planning.

12. SUGGESTED PLAN OF ACTION FOR UTILIZATION OF OUTCOME EXPECTED FROM WORK

1. **Market Research and Vendor Selection**: To find suppliers and products that provide predictive maintenance technology and services, we will start by performing market research and consider criteria like accuracy, scalability, cost-effectiveness, ease of installation, compatibility with current systems, and reliability while evaluating the various offerings.
2. **Pilot Testing**: Pilot testing will be done to assess a predictive maintenance solution's feasibility and effectiveness in before committing to full implementation.
3. **Data Management and Analytics**: To gather, store, and evaluate the massive volumes of data produced by predictive maintenance sensors and systems, we'll establish data management procedures. Make strategic use of modern analytics approaches, such as artificial intelligence and machine learning, to identify trends, abnormalities, and possible failure occurrences.
4. **Performance Monitoring and Optimization**:To increase accuracy and dependability, we'll monitor predictive maintenance solution's performance and adjust its parameters as necessary.
5. **Training and Change Management**: Employees such as technicians, engineers, and maintenance personnel who will be utilizing the predictive maintenance system will receive thorough training.
6. **Vendor Partnerships and Collaboration**: To stay up to date on new trends, best practices, and advancements in predictive maintenance, we'll establish strategic alliances with suppliers, technology companies, and colleagues in the sector and work together with other interested parties to exchange knowledge, success stories, and perspectives
7. **Continuous Improvement**: We'll consider the application of predictive maintenance as a continual process of improvement and ask users for comments, examine performance indicators, and apply the knowledge gained to improve the predictive maintenance program over time.

13. CONCLUSION

With the help of this project we were able to find out how the industry work as we had two industry visits. We talked with a lot of technitians, PhD scholars regarding the current developments in the domains. We were able to build a leadership quality by forming a team of first yearites and learnt management skills. We found a problem that would actually resolve industry issues and would like to build a startup upon this idea.

In future we are planning to incorporate and incubate our startup in AWADH, IIT ROPAR.

14. Contribution of each student of the group to complete the assignment

Name	Contibution
Madhav	Project Report, Novelty of proposed intervention,Objectives to solve the problem, Current development in the domain, Approaches to implement intervention plans,Conclusion
Palakpreet Kaur	Project Report, Collecting, Photos for database, Abstract, Possible, constraints and barriers, Title, Project Report, Collecting Photos, Idea,Tools and techniques to solve the problem.

15. References

1. https://en.m.wikipedia.org/wiki/Predictive_maintenance
2. https://neurosys.com/blog/predictive-maintenance-using-machine-learning
3. https://www.sensegrow.com/?gad_source=1&gclid=CjwKCAjwzN-vBhAkEiwAYiO7oMyw7MogzzPkgZQOoPbnz53EfPec2uIULZbMDczH_raD3nZYzm_ZpBoCZtQQAvD_BwE