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ANALYSIS & MITIGATION OF PIPING VIBRATIONS IN THE FOOD AND BEVERAGE INDUSTRY

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ABSTRACT

Piping vibrations pose a significant challenge in maintaining the integrity and efficiency of industrial processes, especially in sensitive environments such as the food and beverage industry. This study conducts a comprehensive analysis of piping vibrations within this industry, aiming to identify their sources, assess their impact on equipment and product quality, and propose mitigation strategies. Through a combination of experimental investigations and numerical simulations, the research identifies critical points in the piping network prone to vibrations and evaluates the effectiveness of damping mechanisms and isolation techniques. Additionally, the study examines the role of material properties, pipe supports, and installation practices in mitigating vibrations. The findings of this analysis provide valuable insights for engineers, maintenance professionals, and stakeholders in the food and beverage industry to optimize piping system design, installation, and maintenance practices. Ultimately, the research aims to enhance the overall operational efficiency, reliability, and product quality in the context of piping vibrations in the food and beverage processing environment.

Keywords: Beverage Industry, FFT Analyzer, Vibrations, Mitigation, CAD Models.

I. INTRODUCTION

In industrial plants and pipelines, a vibration of exposed pipe sections or systems is expected to be caused by external and internal fluid movement. The vibration of piping systems is commonly used to quickly check that a plant operates by listening for the humming sound or placing a hand on a pipe for the vibration feel. Pumps, valves, strainers, fans, pressure variations, weak foundation and support structures, external crossflows, and internal fluid flow could all be sources of vibrations in a piping system.

Piping Vibration causes dynamic stresses (fatigue) in a piping system. If this stress is more than the critical value, it may initiate a crack that may propagate slowly and end in the failure of the item in concern. The vibration of plant piping is a significant risk to asset integrity and safety. So, it must be addressed. Various analysis and measurement services are carried out to manage the risk of piping vibration.

In piping industries, vibration reduction methods include using flexible supports, isolators, dampers, and vibration-absorbing materials to mitigate and control vibrations in piping systems. Proper design, material selection, and installation are crucial in minimizing vibrations and ensuring system integrity. Several ways can be implemented to reduce pipe vibration. Some of the common ways to reduce pipe and pipeline vibration at operating plants are outlined below:

- Support addition.
- Adding vibration damping to the main Piping
- Supporting rigid bodies (Valves)
- Increase pipe size.
- Increasing the pipe wall thickness
- Reducing vibration due to pulsating equipment.

II. METHODOLOGY

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A. Identifications of Problem:

We recently visited Thote Dairy and Chitale Milk to determine the problem statement and learn about how the vibrations in the pipes develop and how they are managed. We discovered they were unaware of the piping vibration and had never performed a vibration analysis.

Fig 1. Thote Dairy Visit

B. Collecting related data/ information:-

After recognizing the actual problem statement, the required data/ information may be collected from various sources. A thorough assessment of the literature on piping vibration and its mitigation is carried out.

- Collected data/ information from different websites and also from different YouTube channel etc.
- Collection of data regarding pipes which are used in our project from our project visits to piping industries and piping related factories, dairies and pipes manufacturer or suppliers.

C. Design and Analysis:

Initially, three to four piping sections with more vibration-prone sections from the milk industry are identified, and a test rig is to be designed for vibration analysis of these piping sections used in the milk industry. These piping sections' CAD models are generated, and CFD and ANSYS are utilized to analyze the fluid flow and static and dynamic analyses of these piping sections. A few examples of the piping sections are cited as follows,

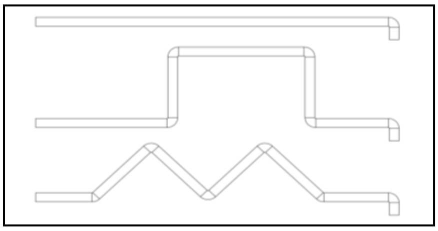

Fig 2. All Sections of Pipes

D. Manufacturing of Setup:

After the design & analysis, the manufacturing/ fabrication of the piping section, bumbling and test rig for performing experimental analysis.

- Fabrication of frame & structure
- Manufacturing of SS pipes with different sections
- Assembling of all equipment's to the structure

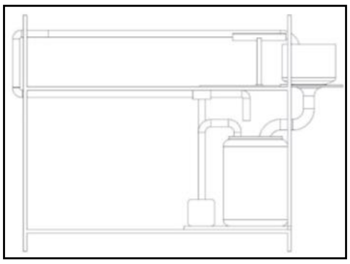

Fig 3. Cantilever-type pipe without support

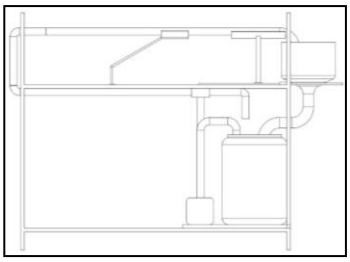

Fig 4. Cantilever-type pipe with support

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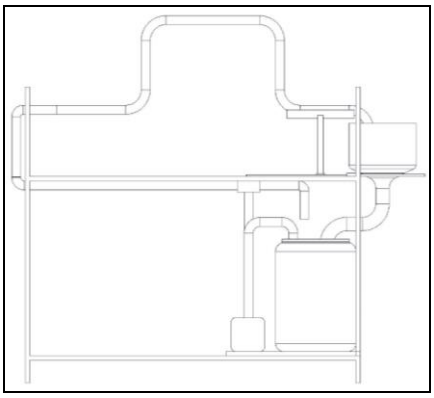

Fig 5. Inverted U-type pipe without support

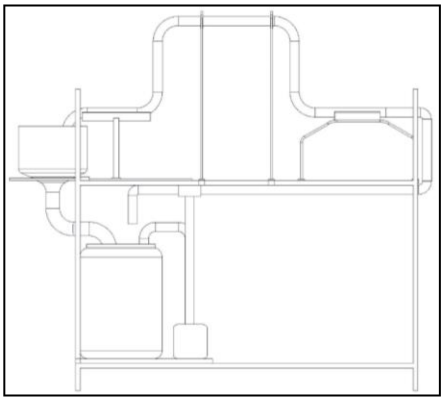

Fig 6. Inverted U-type pipe with support

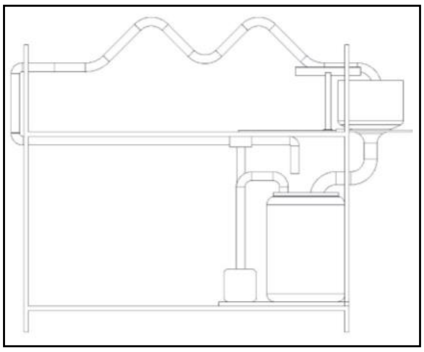

Fig 7. Inverted W-type pipe without support

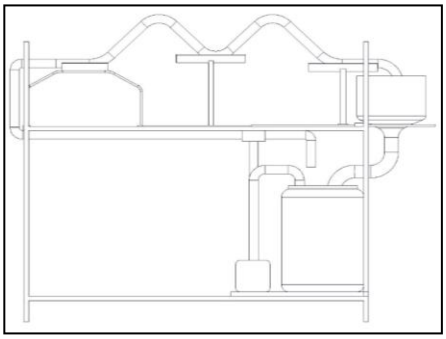

Fig 8. Inverted W-type pipe with support

E. Report writing and publication:

After performance testing of project setup & analysis the results, we will move towards to publish paper on our project.

III. PROBLEM STATEMENT

Vibration in pipes with fluid flow refers to unwanted oscillations or movements that occur in the pipe due to various factors. These vibrations can harm the structural integrity of the pipe system and lead to fatigue, wear, and even failure over time. The problem typically involves understanding the causes of vibration, such as fluid turbulence, pressure fluctuations, or resonance with external forces, and finding ways to mitigate or control these vibrations to ensure the safe and efficient operation of the pipe system.

The problem of vibration in the piping industry arises when various factors lead to unwanted oscillations and movements in pipes used for fluid transport. These vibrations can result in significant challenges and risks, including:

1. Structural Integrity: Vibrations can lead to fatigue, stress, and accelerated wear on the pipe material, potentially leading to cracks, leaks, and even pipe failure.
2. Operational Disruption: Excessive vibrations can disrupt the regular operation of the piping system, causing issues with fluid flow, pressure regulation, and control systems.
3. Safety Hazards: Vibrations can compromise the safety of personnel working around the piping system. If severe, they might result in the detachment of pipe supports or even catastrophic failures.
4. Energy Loss: Vibration-induced friction and turbulence can cause energy loss and decrease the overall efficiency of the fluid transport system.
5. Noise Generation: Vibrations can produce noise that may exceed acceptable levels, leading to worker discomfort, violation of noise regulations, and potential damage to sensitive equipment.
6. Maintenance Costs: Frequent repairs and replacements due to vibration-related damages can increase maintenance costs and downtime for the piping system.

7. Environmental Impact: Leaks or failures caused by vibrations can result in fluid spillage, potentially harming the environment and leading to costly cleanup efforts.

The piping industry must determine the fundamental causes of vibration, including fluid flow rates, pressure changes, resonance frequencies, mechanical interactions, and external influences. Solutions might involve redesigning pipe supports, utilizing vibration-damping materials, optimizing flow patterns, adjusting operational parameters, and implementing predictive maintenance strategies to monitor and mitigate vibration-related issues.

When we approach one of the leading milk industries nearby Ashta, the management is unaware of any such vibration problems and is ignored mainly through the milk industry. This ignorance may lead to an industry with higher maintenance costs which can be reduced significantly.

IV. OBJECTIVES

- To identify the piping vibrations of flowing fluids in the food and beverage industry.
- To identify critical piping sections, piping bends, expansion loops, and cantilever piping sections for vibration analysis from the food and beverage industry.
- To identify the source of mechanical vibration in the identified piping section.
- To suggest various damping methods to mitigate the piping vibrations in the food and beverage industry.
- Increase the durability of the pipes employing reducing the vibration of flowing fluids.
- To ensure piping systems' safe, reliable, and efficient operation while minimizing the detrimental effects of vibrations.
- To perform vibration analysis of piping sections used in the food and milk industry.
- To propose the vibration mitigation techniques in selected piping sections.
- To reduce the maintenance cost of piping sections.
- To help the milk and food industry in rural western Maharashtra.

V. RESULTS & ANALYSIS

Analysis is given below in the forms of different graphs and tables which show the percentage reduction of accelerations and velocity:

Table 1: Result from Cantilever type pipe

	Without Supports	With Supports	Reduction (%)
Acceleration	0.02775	0.0265	4.50
Velocity	0.97375	0.918	5.72

Table 2: Result from Inverted C-type pipe

	Without Supports	With Supports	Reduction (%)
Acceleration	0.03175	0.02675	15.75
Velocity	1.54	0.9342	39.33

Table 3: Result from Inverted W-type pipe

	Without Supports	With Supports	Reduction (%)
Acceleration	0.036	0.03125	13.20
Velocity	1.345	0.8495	36.84

Analysis graphs of the above readings are given below:

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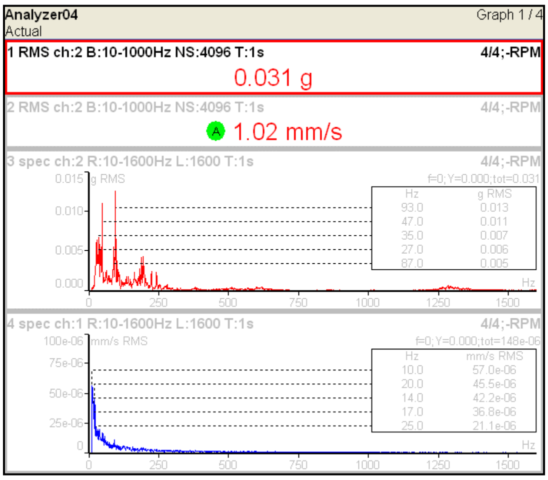

Fig 8. Cantilever type pipe without support

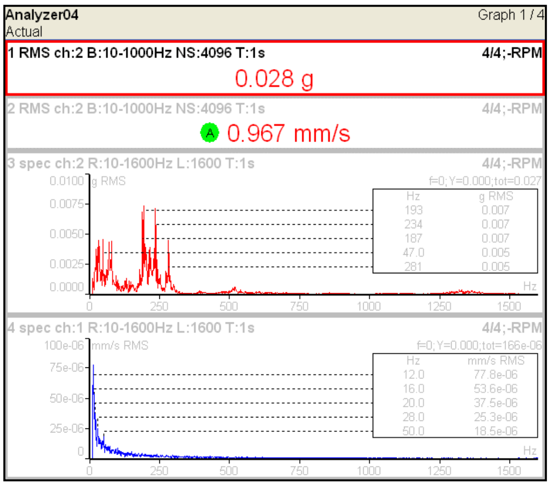

Fig 10. Cantilever type with support

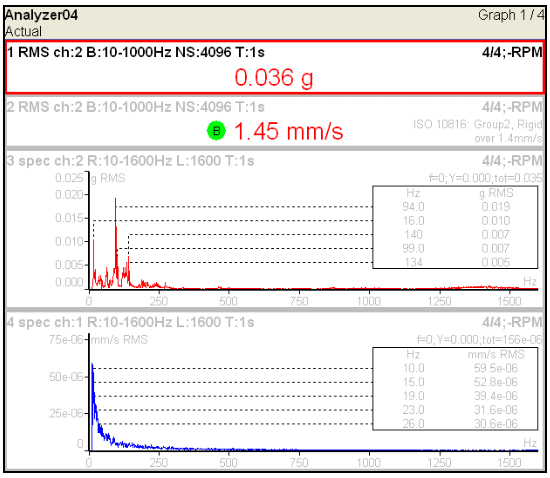

Fig 11. Inverted U type pipe without support

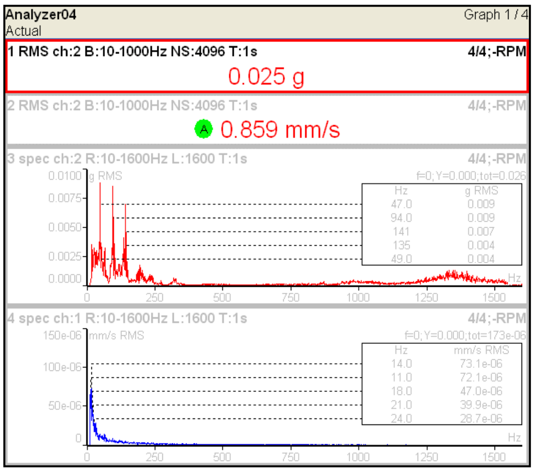

Fig 12. Inverted U type pipe with support

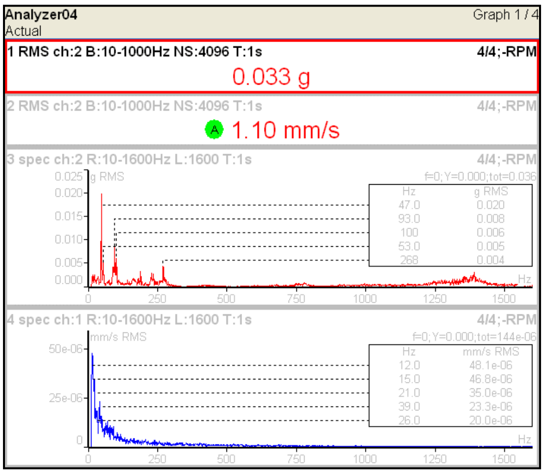

Fig 13. Inverted W type pipe without support

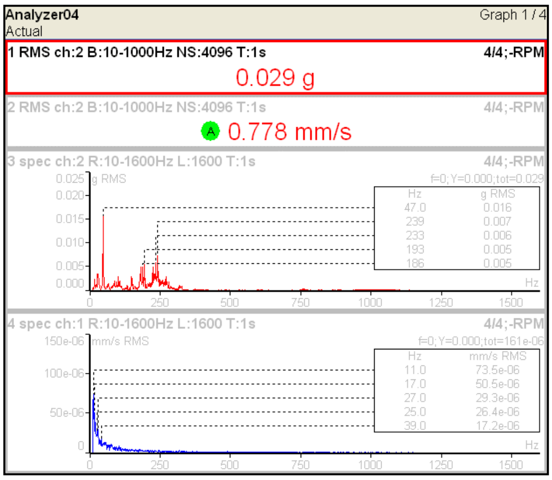

Fig 14. Inverted W type pipe with support

VI. CONCLUSION

The analysis and mitigation of piping vibrations in the food and beverage industry requires a multifaceted approach that integrates engineering principles, risk management strategies, and regulatory compliance measures. By identifying root causes, implementing effective mitigation strategies, and maintaining ongoing monitoring and maintenance programs, organizations can minimize the impact of vibrations on product quality, operational efficiency, and worker safety.

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