

Experimental Studies and Vibration Analysis of Piping in the Food and Beverage Industry with Mitigation Strategies using a Scaled Model

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Abstract - Piping vibrations are the challenge in maintaining the efficiency and fluent working 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 piping and production process and quality. The Study also aiming to propose mitigation strategies, through a combination of experimental investigations and numerical simulations. The research identifies critical points of vibrations in the piping 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 pipelines, vibrations are observed in the exposed pipe sections, caused by external and internal fluid movement. The vibrations of piping systems are commonly observed at the turn of the fluid flow direction and at the change of pipe diameter. The vibrations are commonly checked by listening for the humming sound or placing a hand on the 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 fatigue in the 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. The vibration of plant piping is a disturbance to achieve good efficiency and safety. So, it must be recognized and minimized. Various analysis and measurement services are carried out to manage the risk of piping vibration.

In piping industries, vibration reduction methods include flexible supports, dampers and vibration absorbing materials to mitigate and control vibrations in piping systems. Conventional plumbing and supporting systems are used. Study of vibration and support planning, proper design, material selection are not practiced in many industries. Hence it is crucial in minimizing vibrations and ensuring system efficiency. Several ways can be implemented to reduce pipe vibrations. 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
- Before installation of piping, require identification and analysis of the scope of vibrations and the spot.

II. PROBLEM STATEMENT

Vibrations in pipes with fluid flow refers to unwanted oscillations or movements. There are various factors, effecting vibrations in the pipe. These vibrations are harmful to the pipe systems and lead to fatigue, wear, and even failure. The problem typically involves understanding the causes of vibrations, such as fluid turbulence, pressure fluctuations 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 vibrations 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 challenges and risks, including:

1. **Structural Reliability:** Vibrations can lead to fatigue, stress, and accelerated wear on the pipe material. Potentially leads to cracks, leaks and even pipe or the joint failure.
2. **Operational Disruption:** Excessive vibrations can disrupt the regular operation of the piping systems. It can cause issues with fluid flow, pressure regulation and control systems.
3. **Safety Hazards:** Vibrations can affect the safety of the personnel working around the piping systems. If severe, it might result in the detachment of pipe supports or even pipe or joint 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 vibrations, 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 approached some of the leading milk industries nearby Ashta, Dist. Sangli in Maharashtra State, it was observed that, 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.

III. METHODOLOGY

A. Identifications of Problem: -

Recently visited some milk and milk product industries (dairies) to determine the problem statement and learned about how the vibrations in the pipes develop and how they are managed. It was discovered that they were unaware of the piping vibration and had never performed any vibration analysis.

B. Collecting related data/ information: -

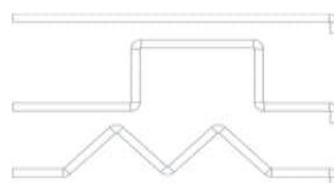
After recognizing the actual problem statement, the required data and information were collected from various sources. A thorough assessment of the literature on piping vibration and its mitigation is carried out.

➤ Collected data and information from different websites and also from different YouTube channels, etc.

➤ Collected data and information regarding pipes which are used for the project from various visits to piping industries, piping related factories such as dairies and ice manufacturers, pipes manufacturer and suppliers.

C. Design and Analysis: -

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



D. Manufacturing Setup: - After the design & analysis, the manufacturing / fabrication of the piping sections and test rig for performing experimental analysis, mainly as follows.

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

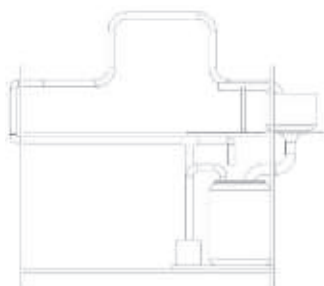


Fig. Cantilever-type pipe without support

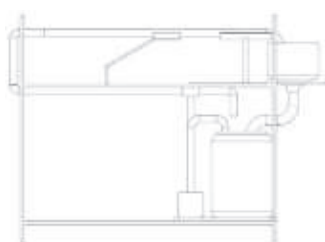


Fig. Cantilever-type pipe with support

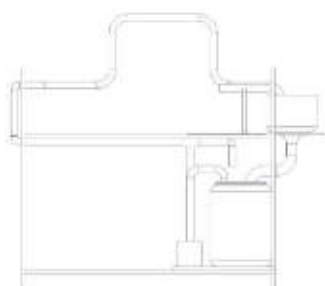


Fig. Inverted U-type pipe without support

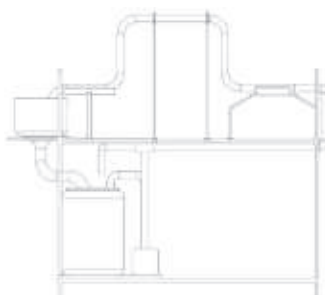


Fig. Inverted U-type pipe with support

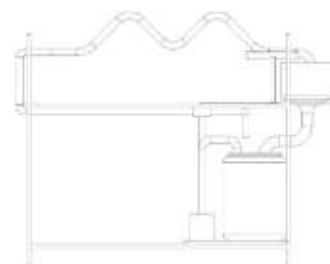


Fig. Inverted W-type pipe without support

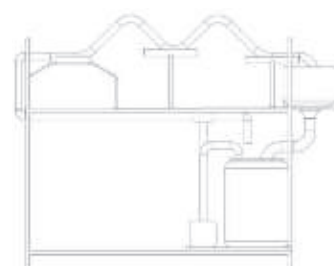


Fig. Inverted W-type pipe with support

E. Repor writing and publication: - After performance testing of project setup and analysis the results, moved towards for publish paper on our project.

IV. Results and anal sis

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

	Without Supports	With Supports	Reduction (%)
Acceleration	0.02775	0.0265	4.50
Velocity	0.97375	0.9180	5.72

Table: - Result from Cantilever type pipe

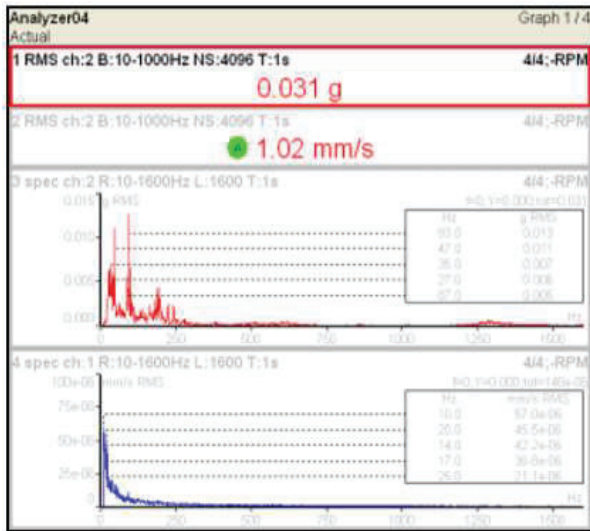
	Without Supports	With Supports	Reduction (%)
Acceleration	0.03175	0.02675	15.75
Velocity	1.54	0.9342	39.33

Table: - Result from Inverted C-type pipe

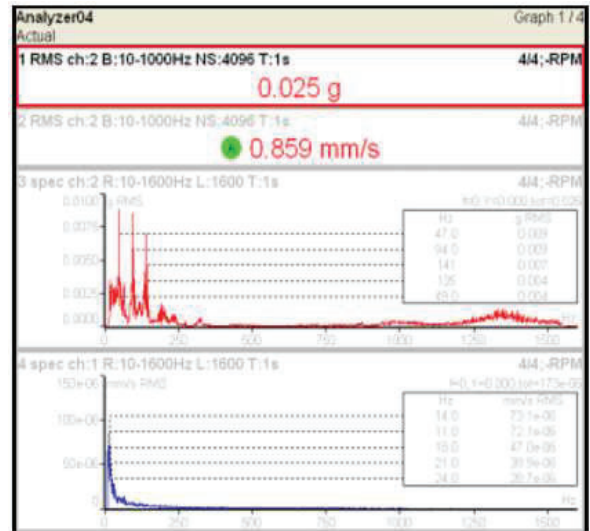
	Without Supports	With Supports	Reduction (%)
Acceleration	0.036	0.03125	13.20
Velocity	1.345	0.8495	36.84

Table: - Result from Inverted W-type pipe

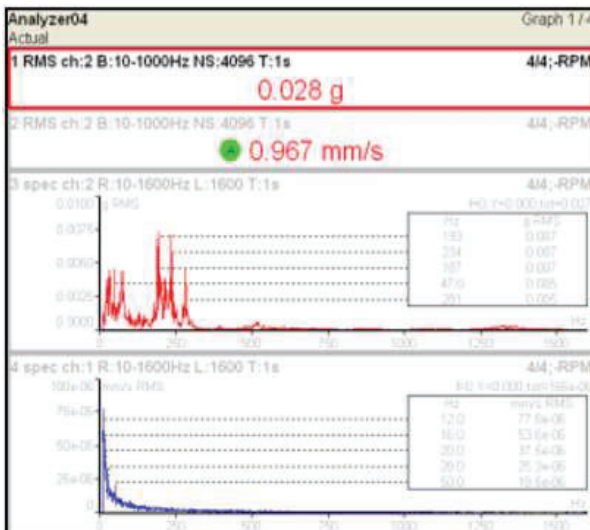
Analysis graphs of the above readings are given below.



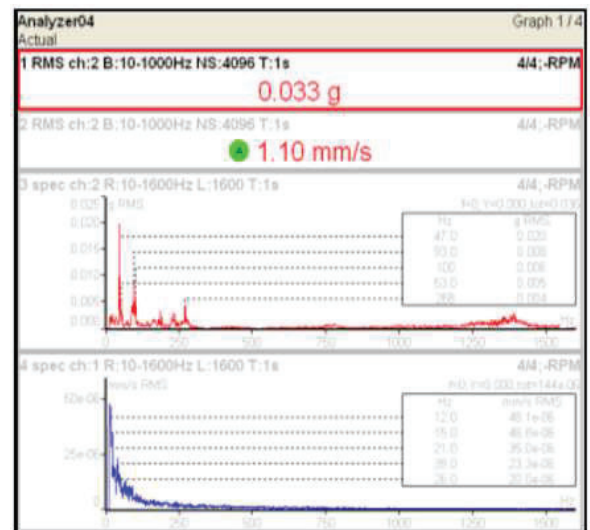
Graph - Cantilever-type pipe without support



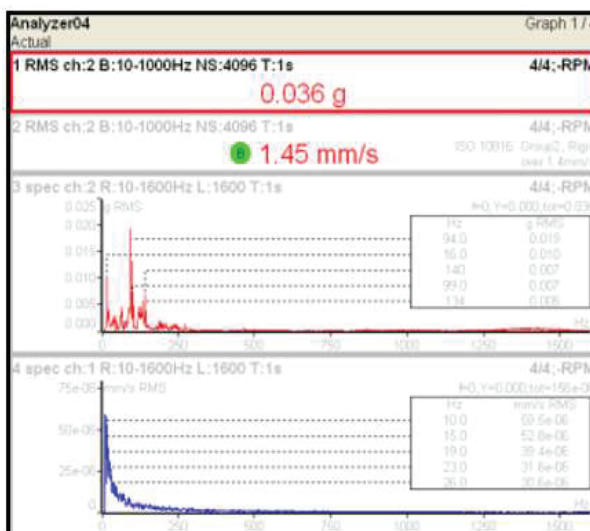
Graph - Inverted U-type pipe with support



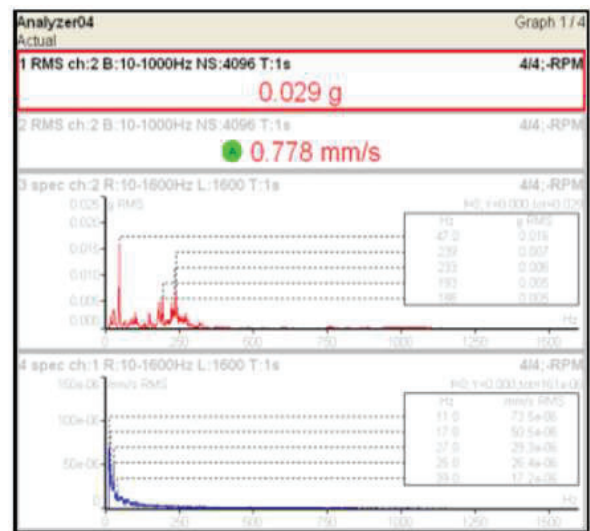
Graph - Cantilever-type pipe with support



Graph - Inverted W-type pipe without support



Graph - Inverted U-type pipe without support



Graph - Inverted W-type pipe with support

V. OBJECTIVES

From the experimental observations and analysis focused on the following

- To identify the piping vibrations of flowing fluids.
- To identify critical piping sections, piping bends, expansion loops, and cantilever piping sections for vibration analysis.
- 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 and to reduce the vibrations of the 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 in the area of efficient piping.

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 workers' safety.

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