DEVELOPMENT OF VIBRATION DAMPER TO REDUCE GENERATED STRESS DUE TO FLOW INDUCED VIBRATIONS IN PIPELINE

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ABSTRACT

The aim of the paper is to investigate the capability of the damper system in limiting the vibration in the pipelines which are specific to the oil and gas industry. Fracture related to pipeline stress is an issue that has impacted many industry quite a lot and the implications have led to huge amounts of times and costs being spent on constantly monitoring and ensuring the lifetime of the pipelines. Most of these pipelines though are very old and cannot be considered to be a part of the new technologies that are in place which means that it becomes crucial for the need for new technologies to tackle the problems related to the system. This paper is an exploration of those issues and tries to make use of dampers and to see the impact on the vibration in the pipelines. The study explores the various other technologies used and recommends future changes that might help in the further reduction of vibration-related stress that is a result of the flow of the liquid in these pipelines. It is found that the vibration dampers have significant effects on reducing the vibration related issue with the help of ANSYS related testing on simple design.

KEYWORDS: Flow Induced Vibrations, Vibration Damper, ANSYS, Pipeline

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INTRODUCTION

Generally, the pipe penetration piece is responsible for the transport of energy, momentum, temperature and pressure of fluid. To accomplish the transportation, some pumps and valves must be supplies the system with power and control it. Thus, the flow state of the high-temperature fluid mostly alters frequently owing to the effects of the mechanical instruments in the pipeline, which makes firm pulsation excitation and causes the flow-induced vibration [1]. Whenever, the vibration factors are grant with parameter of pipeline, strong resonance will go on and can damage the pipeline [2]. Li Wei-gang and Wang Jian-chun detected that the mechanical vibration spectrum of the pipeline is the same as the mechanical equipment [3]. The dynamic influence of the fluid flow via shells was examined and authors analyzed the damping capabilities of visco-elastic shells and plates [4]. Also, Qatu investigated the effect of straight pipe line vibration with relation to its material and coarseness [5].

The pipeline networks are considered to be the most economical means of transportation when it comes to oil and natural gas. Most of pipelines are often designed such that they do last for a long duration of around 25 to 30 years. Hence, the existing pipelines are quite old and they are susceptible to failure. Because of the poor construction, the cracks in the material and fatigue, there is more chance of breakage and fault in the pipeline [6]. The prevention of the failure of these pipelines is very crucial for the safety of the environment and also the safety of the public and for this, continuous monitoring of pipeline is highly crucial. The failure of pipelines is

known to lead to serious accidents that would cost a lot of loss in terms of money and in some cases lives [7]. A recent review that was attempted to determine the major reasons for the failure of the pipelines got that the biggest two factors for this would be vibration and fatigue failure [8]. The leakage of gases is even more of a serious threat as these gases would then mix with the gases in the atmosphere and this could turn more toxic. One example of vibration leading to damage is the vortex shedding which could lead to continuous vibrations specifically in the underwater pipeline which could impact it and reduce its lifetime [9]. Also, there is damage caused due to underwater earthquakes which leads to stress in the pipeline that could damage the pipeline [10]. Therefore, it is highly significant to take necessary precautions to keep the systems safe. There are many types of research on the topic but there are very few that addresses the reduction of the vibration transfers through active methods [11].

Recently, the stress relation using fluid interactions was investigated. Intemperate vibration is one of the main sources of high cycle weariness in procedure channeling. Whenever the vibration level was beneath the plan line, not many disappointments happened. Consequently, these vibrations versus recurrence criteria can fill in as a decent beginning stage in assessing funneling vibrations to screen those frameworks that need further examination. The development was ruled by two frequencies which are 3.60Hz and 4.56 Hz [12]. Another study focus on using vibration signal analysis to identify the structural fatigue life was conducted by [13]. they exhibited the aftereffects of explores identified with the advancement of a strategy for anticipating a weakness harm of SBC model. The technique depends on estimations of current symptomatic sign (vibrations), without mulling over the historical backdrop of past burdens or recurrence examination of blackmails. The investigation demonstrated that it is conceivable to anticipate the weariness quality of the example during the activity by watching certain mixes of vibration parameters. Active and passive methods and how they will impact or influence the system was studied. In the vitality and transport designing, in oil and gas transportation frameworks, it is regularly important to decrease the vibration move through the pipelines. The utilization of compensators in pipelines isn't sufficient for compelling vibration separation of hardware [14]. A similar research was done on the use of vibroacoustic sensing for pipeline fracture detection and maintenance by [15]. Recording and handling of vibroacoustic information is a rising strategy continuously of the serving of liquid pipelines. The checking of pipeline wellbeing is finished by utilizing acoustic waves. it was found that the method can be utilized to measure pipeline dividers, distinguish gas defilement, measure stream, and distinguish gas spills and auxiliary deserts in the pipe.

In this paper, ANSYS and MATLAB for design and construction of the equipment are used to investigate the piping vibration control making use of dampers. The ANSYS is used to recreate the flow vibrations in the pipe and to explain how they are able to control. The damping systems is used along with join clamps at the specific location of the pipeline and the flow induced vibration control is analyzed under the same conditions. The equations of the pipeline flow and the material used for the pipelines as well as the type of dampers is conducted and submitted as images. In part of the research where the vibrations did the measurements through ANSYS is converted to graph and tables which shows the vibrations and the damping control with wave graph will be utilized in providing the answers to this research.

RESEARCH METHODOLOGY

The research on the dampers and their impact on the reduction of the vibration caused issues in Oil and Gas Plants looks to achieve the following objective to check the impact of dampers on reducing the vibration related issue with the help of ANSYS related testing on simple design. Before taking on the design phase some of the design aspects are to be mentioned. Now, first we go into the design of the damper. We know that we would be making use of the Vibrotek damper

and the damper design is as shown in Figure 1. the specification of the pipeline which is for the Vibrotek Pads which are:

- Temperature Range = -65 to 400-degree Fahrenheit
- Coefficient of Friction ≤ 0.10
- The dimension is the same as that of the width of the clamp.
- The Vibrotek washer assembly is unique and is presented below:
- The clamp and the rest of the bottom plate is made of carbon steel A36 that is galvanized.
- The pipe support ISO standard 139 A is made use of.
- The Maximum compressive strength is around 20000 pounds
- The material is a mix of the Vibrotek unique rubberized system with that of HB-Teflon.

Figure 1: Damper Front and Assembled.

In the next part we look at the modelling of the pipeline and the design which will be used would be that of a pipeline design with bends and is a simple design of a pipeline which is done as shown in Figure 2:

Figure 2: Pipeline Design.

The internal of the pipeline is as shown in Figure 3:

Figure 3: Internal Design of the Pipeline.

The outside radius of the pipeline is 160mm, the divider thickness is 2.5mm, and the two closures of the pipeline are set to fix. The edge of the corner is at first set as 120 degrees, and the length of the three straight pipelines is 0.806m, 1.191m and 0.806m. Considering of cross section, the range of the corner cannot be excessively little, so it's set to 0.0931m. What's more, subsequent to lattice, the complete number of the components is 4448 and the hubs are 8960 as shown in Figure 4.

Figure 4: Corner Mesh.

RESULTS AND ANALYSIS

The FSI method is made use of for solving the pipe deformation influence that is a result of the stress that comes from the flow in the pipeline which leads to vibration and stress. The resulting vibration and pipeline stress are given in Figure 5 and the same image under cropping we look at the stress on the midsection as shown in Figure 6.

Figure 5: Flow Pressure.

Figure 6: Midsection Cropped Image.

Next, we look at the shear stress which is a combination of a cropped image of the shear stress in the full pipeline and across the midsection and the images are as shown in Figure 7 and for the midsection shear stress see Figure 8. Also, Figure 9 can show the normal stress in the pipeline with the fixed endings.

Figure 7: Shear Stress on Pipelines.

Figure 8: Midsection Shear Stress.

Figure 9: Normal Stress in the Pipeline with Fixed Ends.

The separation between the sections and fixed endings to 455.50mm, changes the point of the corner, and get the stress of the pipeline with the bend being that of 120 degrees. The related stress image is as shown in Figure 10:

Figure 10: Static Stress With No Support Or Damper.

Table 1 shows the stress, strain and the deformation in the system at the said angle.

Table 1: Deformations in the Pipeline

Stress/MPa	3.43
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Strain/ $\times 10^{-5}$	1.672
Deformation/ $\times 10^{-2}$ mm	7.3421

Now the dampers 2 to 3 of them are fixed on to the pipeline at different intervals of 455mm from each other or the fixed end which leads to the stress diagram that is as shown in Figure 11:

Figure 11: Stress Deformation With Fixed Dampers At Points.

Now, based on the previous Figures the deformations in the pipe and stress are summarized in Table 2:

Table 2: Deformation with Dampers

Stress/MPa	1.685
Strain/ $\times 10^{-5}$	8.312e
Deformation/ $\times 10^{-2}$ mm	2.8164

By comparison of the two tables 1 and 2 that deformation and stress is relatively lower in the pipeline with the dampers and allow for free flow of the fluid and reduce the risk of crack in the pipeline. This shows that damping factor has an impact and would help in the reduction of the vibration which would be arising in the system due to the flow of the liquid through the pipeline and any attached system to the pipeline considering that the major vibrations are all from these sources.

In this research the Limited component Pipe16 was utilized for pipeline, limited component Combin14 – for backings, limited component Mass21 – for concentrated mass. The component Combin14 permits utilizing a gooey damping, anyway MR material has dry grinding. Comparability gooey damping coefficient was acquired for correspondence of hysteretic circle zone for gooey damping framework and dry rubbing framework. This coefficient is $C_v = \Psi C / (2\pi\omega_0)$ (here ω_0 is reverberation recurrence) as shown in Figure 12.

The estimation technique needs bolster attributes: firmness C and vitality dissemination coefficient Ψ . It is conceivable to discover it for MR material (as some other dry grinding framework) from hysteretic circle under static burden in organizes "twisting x – load P ".

Attributes of solidness and damping of MR are:

- center cycle solidness $C_{cp} = P_a / A$ (where P_a is sufficiency of static burden, A – adequacy of relocation);

- energy dissemination coefficient $\Psi = W/\pi$, (here W is hysteretic circle region, it is equivalent to a dispersed vitality during one distortion cycle, π is potential vitality of twisting, it is equivalent to a territory of triangle OAB

Figure 12: Hysteretic Dry Fiction Loop.

It is assumed in the paper that static and dynamic attributes of dry rubbing frameworks are equivalent. It is demonstrated by likeness of dynamic test and dynamic qualities of dry erosion framework determined by static research experimentation.

Equation for C and Ψ are:

$$C = 14(1 + 363\varepsilon_A^{3.5})(1 + 727\varepsilon_Q^{3.45})d_w^{1.2}H^{-0.33}(\varepsilon_Q / 0.626)^{0.063H}S(\bar{\rho} / 0.2)^{1.1+0.01H/d_w} \quad 1$$

$$\psi = 1.171(1 - 7.23H^{0.13}(\varepsilon_A - 0.048))(1 - 0.1(10.5\varepsilon_Q - 1)^2)d_w^{0.138}H^{0.15}(0.095 / \varepsilon_Q)^{0.057H}(0.2 / \rho^{0.37+0.015H/d_w})$$

Correlation of trial and count for MR component with $H = 2.1$ mm, relative static change or deformation $\varepsilon_Q = 0.14$ also, relative thickness of MR material $\bar{\rho} = 0.25$ is given in Tables 1 and 2. Amplitudes of pipeline vibration in a spot of damping backing are introduced on Figure 3. The strategy permits ascertaining of worry in the pipeline as well. For model a proportional worry in the pipeline at reverberation recurrence 207 Hz is exhibited, as shown in Table 3.

Table 3: Resonance Frequency and Calculation without Damping Support

Input acceleration $W_1, m/s^2$	30	50
Resonance Frequency, Hz	195.1	192.5
Error % chances	5.8	6.7
Vertical Vibration Amplitude, mm	0.042	0.073

The results with the damping calculations in place and summarized in Table 4 as following:

Table 4: Resonance Frequency and Calculation with Damping Support

Input acceleration $W_1, m/s^2$	30	50
Resonance Frequency, Hz	206	206
Amplitudes of pipeline Vibrations, mm	Vertical/Horizontal	Vertical/Horizontal
ANSYS Calculation	0.05/0.037	0.08/0.059

The determined estimation of removal close damping help permits revising distortion abundance of MR material, and solidness and vitality scattering coefficient individually. Along these lines it is conceivable to comprehend a vibration

state of pipeline and to get ideal qualities of MR material for help (thickness, fundamental static distortion and so on).

3D vibration of pipeline with complex shape has a few characteristics. For instance, it is conceivable that a maximal uprooting abundance is other way than heading of energize vibration. The present strategy permits acquiring this image. Since the pipeline moves not just toward energize vibration, the damping component ought to surround a pipe as a ring. Huge numbers of pipeline underpins in present time have holes between damping components, it implies it plan isn't right. The vibration amplitude at 30 m/s^2 is shown in Figure 13 and the amplitude vibration when W is 50 m/s^2 is shown in Figure 14.

Figure 13: W at 30 Vibrations Amplitude.

Figure 14: W at 50 Amplitude Vibrations.

In this case the U_y is for the vertical and U_z for horizontal and from the images the vibration can be seen as smooth wave without any jerks or issues which shows that system with damping does have an impact on reducing the vibration in the system and is important for the success of the system where there is vibration. It can be concluded that the damper could be considered to be a cost effective solution in comparison to the rest of the system.

CONCLUSIONS

In the paper, we look at how the vibration occurs as first we take a trip on understanding the role that is played by the oil

and gas refine and transport systems and what are the causes of the vibration and tend to focus on the vibration that arises mainly due to the flow in the pipeline. The research looks at various other studies that have explored the topic and this is different considering it looks specifically at the working of the damper and nothing more. Apart from the vibration stress analysis the pipes are analyzed for fracture and systems that could help in improving the overall lifetime of the system was also introduced and mentioned. The dampers are known to help reduce vibration and also reduce the stress that would be created in a pipeline due to the vibration in the system. The damper in this case was fixed at various points and this helped in the reduction of the vibration and stress considerably and the ANSYS calculation for resonance frequency was calculated along with an amplitude wave created on the smooth functioning. The paper helps in understanding the role and as to how the dampers could have an important role in reducing the stress and damages that are caused due to the vibration.

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