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Effect of Protective Cover on the Buried Gas Pipe Line Subjected to Sub Surface Blast Loading

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***Abstract*—The transportation of resources like oil, gas, water etc., is being done mainly through underground pipe lines of different materials based on the material being transported. This research has been inspired by security concerns due to the recent activities happening as a threat to the oil and natural gas transportation sectors. The present work is done on the study of behavior of underground pipe lines under the effect of blast loading at a certain depth from the ground surface using ANSYS-Explicit Dynamics. The study of this work is validated from the recent studies done by (M. Mokharti, A. Alavi Nia). A combined Eulerian-lagrangian (CEL) method was developed for full coupled 3D finite element model. And the steel pipe is modeled in simplified Johnson cook model for the mechanical behavior of the pipe and air is considered for accuracy. Hence the work is further being carried with high grade steels like X-65, X-70 and the results are satisfactory such that as the grade of the steel increases the amount of strain and deformation produced are decreasing gradually. The observations from the study shows that the change in diameter-to-thickness ratio (D/t) and the pressure in the pipe line is varied from non-pressurized to pressurized in the pipe line and behavior varies under the blast load.**

Since the foam materials are in limelight in recent years their applications are being used extensively. The use of foam materials as panels of protective cover has been taken in to considerations because of their ability to absorb shock energy and this has been proved by some works which are having very limited availability of data.

***Index Terms*—ANSYS-Explicit Dynamics, combined Eulerian-lagrangian (CEL), diameter-to-thickness ratio (D/t), X-65, X-70, Aluminum foams**

I. Introduction

Closed-cell aluminum foam offers a unique combination of properties such as low density, high stiffness, strength and energy absorption that can be tailored through design of the microstructure. During ballistic impact the foam exhibits significant nonlinear deformation and stress wave attenuation (Hanssen, A. et al, 2002). Metallic foams are excellent impact energy absorber, and they can convert impact energy into deformation energy and absorb more energy than bulk metal at low stress (Kathryn, A, D. et al, 2000).

The experimental study by (Dyga.R et al 2012) confirms that the prominent role of the foam skeleton in the heat transfer through a metal foam-fluid system. A fluid may however be considered as a medium which is insignificant from the viewpoint of thermal conductivity and its presence inside the foam cellular structure may be neglected in case of gas-filled metal foams.

Liquids may not be considered negligible as their omission may produce considerable errors; a liquid can increase the value of the effective heat transfer coefficient in aluminum foams even by a dozen or so percent.

The material model for Aluminum foam was done by considering high strain rate dependence in ANSYS-Explicit Dynamics. The Johnson cook model was used to model the foam material. The parametric values are taken from the work done by (Vignesh Sampath, et al, 2017) in quasi static compression test, the graph stress vs. strain can be used to find out the parameters of Johnson cook model.

II. Simulation

Since we know that Aluminum foam is used as protective cover to the steel pipe under blast. First, the simulation work each and every case of the pipe without protective cover is done then protective cover is applied. In the present generation safety along doesn’t matters but with cost effective. Hence, we have to create the model with thin surface body and then optimum condition can obtained from the observations. Since protective cover also works in dynamic condition it is modeled in Johnson cook model for the first time and tested. The values of the Johnson cook model are obtained from the previous work by extracting them from the graph drawn in it. The model of aluminum foam circular panel over the steel pipe is shown below.

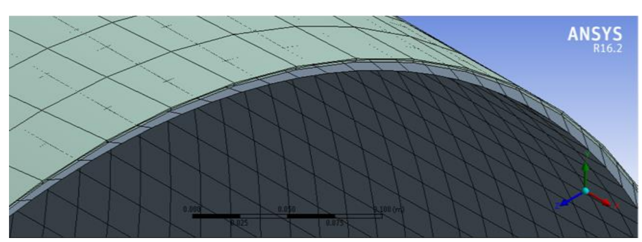

Fig. 1. Aluminum foam as protective cover

After the application of the foam material simulation of the

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pipe line for under the influence of sub surface blast load is carried out for different D/t ratios and operating pressure conditions. The results are then analyzed and compared to previous works for underground pipe lines without protective covers and results are shown below.

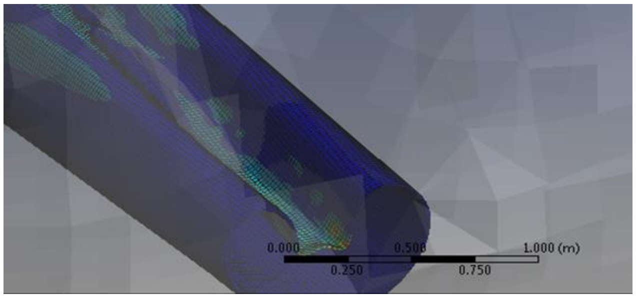

Fig. 2. Deformed shape of X-65 steel pipe at no pressure without protective cover applied

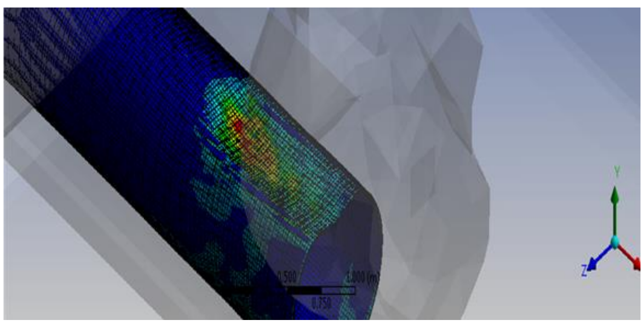
Fig. 3. Deformed shape of X-65 steel pipe at no pressure with protective cover applied

III. RESULTS

After the application of protective cover to the underground pipe line which is under the influence of the sub surface blast load, the results are presented in this section.

Simulation is done with different grade of steels, D/t ratio and different operating pressures is done with the help of ANSYS Explicit Dynamics

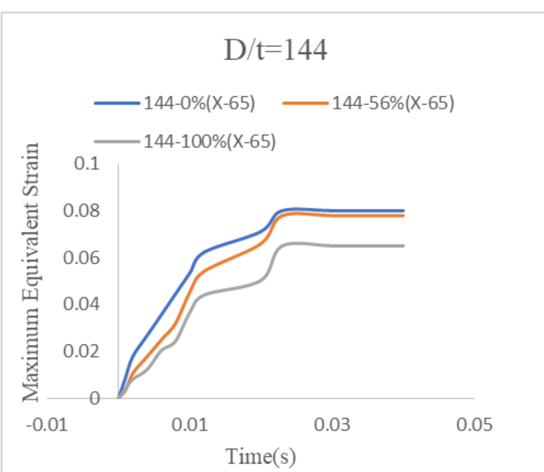

Fig. 4. Variations of X-65, D/t=144 under blast loading with protective cover and different operating pressures

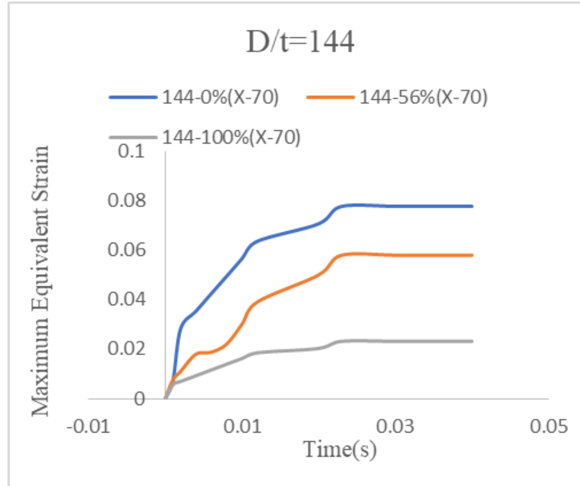

Fig. 5. Variations of X-70, D/t=144 under blast loading with protective cover and different operating pressures

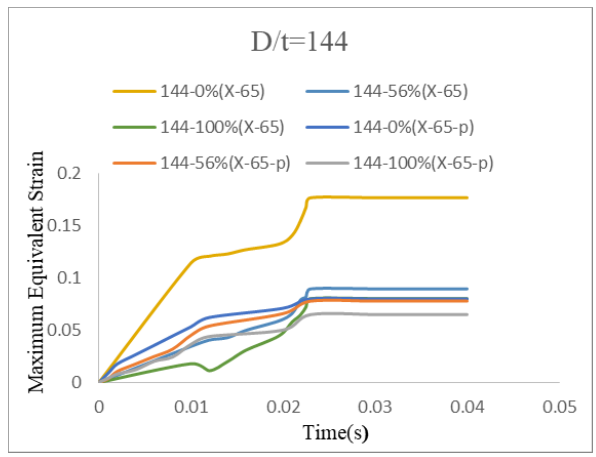

Fig. 6. Comparison of X-65 pipe line, D/t=144 under blast loading, with and without protective cover at different operating pressure (P- Protective Cover)

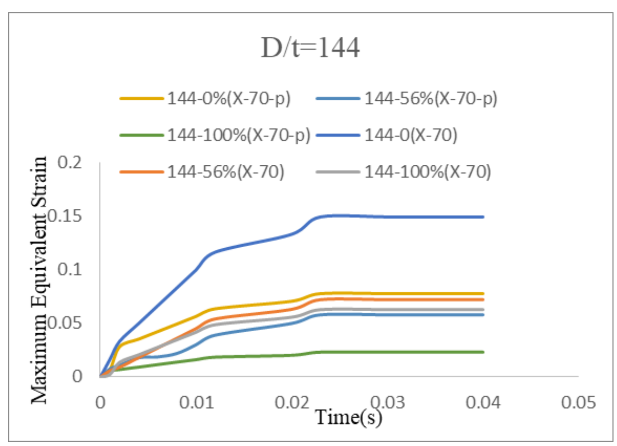

Fig. 7. Comparison of variations of X-70, D/t=144 pipe line under blast loading, with and without protective cover at different operating pressure

From the above simulated results, we can observe that the application of protective cover significantly reduces the amount of deformation and strain produced on the surface of the pipe. Thus, by the satisfactory results from the simulation in ANSYS helps us to conclude that protection can be provided upto certain extent for blast loading on the underground pipe line. This should be practically tested and results are to be analyzed.

IV. Conclusion

The whole work deals with the analysis of the underground pipe line with protective under buried blast load with varying thickness condition and pressure condition. At first the pipe of X-65 steel pipe is analyzed with protective cover and then X-70 is analyzed. Then both the pipes are compared with each other and then it is extended with each type of steel pipe with and without protective cover. From the analysis of each pipe and then the comparison of each pipe with protective cover helps us to find out that applying protective cover really helps us to protect the pipe form blast to reduce the deformation and strain values. Then we compared the results of each steel with and without protective cover individually in each condition with varying thickness and pressure conditions. By comparison with the before stated conditions that aluminum foam plays a prominent role in protection of the pipe line.

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