International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 7 July 2022, pp: 684-689 www.ijaem.net ISSN: 2395-5252

Linear Regression Modelling of Induced Stress and Displacement along a Pipeline Due to Fluid Weight: Matlab Approach.

Engr. Ven. Rev. E.C. Olewuezi, Gaven Dipnap Vennim, Oparanozie Gospel U., Ahaotu Raymond O., Mr. Ewurum Tennison. I

Department of mechanical engineering, federal polytechnic nekede, owerri.
Department of mechanical engineering, federal polytechnic nekede, owerri.
Department of mechanical engineering, federal polytechnic nekede, owerri.
Department of mechanical engineering, federal polytechnic nekede, owerri.
Department of mechanical engineering, federal polytechnic nekede, owerri.

Submitted: 01-07-2022 Revised: 10-07-2022 Accepted: 13-07-2022

ABSTRACT
The study, linear modeling of induced stress and displacement along a pipeline due to fluid weight was successfully carried out. The researchers considered variable weight of fluid, diesel 7.997N, 6.164N, and 5.165N with the corresponding induced stress 1.679MPa, 1.294MPa, and 1.084MPa. The correlation coefficient of 1.000 and p-value coefficient of 0.0001 from MATLAB data analysis indicated that there is positive and significant relationship between induced stress and fluid weight in a pipeline. Standard error for the induced stress and fluid weight was observed to be 8.0162e-09. The P-value 0.00013356 and degrees of freedom 1 of the linear regression model are consistent with the P-value and degrees of freedom of ANOVA model, that proves correctness of the model. The same variable fluid weight yielded corresponding pipe displacement of 0.00014mm, 0.00011mm, and 0.00001mm. The correlation coefficient of 0.8917 and p-value coefficient of 0.2990 from MATLAB data analysis of fluid weight and displacement indicated that there is positive and insignificant relationship between pipe displacement and fluid weight in a pipeline as the study indicated. The standard error for displacement and fluid weight was observed to be 2.1445e-05. The P-value 0.29897 and degrees of freedom 1 of the linear regression model are consistent with the P-value and degrees of freedom of ANOVA model, that proves correctness of the model. The researchers made the following recommendations: To avoid failure and fluid leakage in pipelines, induced stress due to fluid weight must be computed to make appropriate choice of pipe material, Pipeline displacement must be computed before pipe joining is done to ensure appropriate displacement accommodation, etc.

Keywords ---- MATLAB, regression model, pipeline, linear modeling, fluid weight, induced stress, displacement.

I. INTRODUCTION

Background of the Study

Rajput (2012) opined that the combined effects of flow-induced stresses and displacement of pipes due to fluid weight and flow pressure can initiate sudden pipe damage and subsequently, create cracks in the pipeline, especially at the junctions. When the maximum induced stress exceed the allowable stress of pipe material, cracks and fluid leakage can occur at the pipeline junctions.

Also, when applied weight exceeds the bearing capacity of the pipe materials, failure occurs. In such cases, the weight of the fluid and pressure waves is transmitted along the pipeline. This high-pressure build-up can damage the pipeline by creating sudden pipe displacements and excessive stresses in the pipe wall.

Zachwieja (2017) claimed that the vibrations, stress and displacement in the pipelines can be excited both by the external factors, such as pumps, as well as the internal factors like pulsating motion of the fluid and fluid weight. The vibrations may result in immediate fatigue damage as a long-term effect.

Linear regression modeling here is a linear approach for modeling the relationship between a scalar response (fluid weight) and one explanatory variable (induced stress or displacement).

There are no doubts that there is induced stress and displacement along pipelines due to fluid weight. Hence, the paper aimed at studying linear regression modeling of induced stress and displacement along a pipeline due to fluid weight through MATLAB approach.

Statement of Problem

In order to minimize, sudden pipe failure and excessive displacement of pipelines, due to fluid weight, there is a need to establish the relationship between fluid weight and induced stress or displacement along a pipeline.

According to Moses et al (2019), when induced stress due to fluid weight exceeds the bearing capacity of the pipe materials, failure occurs. In such cases, the weight of the fluid and pressure waves is transmitted along the pipeline. This high-pressure build-up can damage the pipeline by creating sudden pipe displacements and excessive stresses in the pipe wall. It is on this note that the researchers aimed at determining the linear regression model of induced stress and displacement due to fluid weight along a pipeline through MATLAB approach.

Purpose of the Study

The general purpose f the study is to determine the linear regression models of induced stress and displacement along a pipeline due to fluid weight.

Significance of the Study

The result of this study will be beneficial to industrial pipe designers/production engineers in the following ways:

1) Production engineers can improve fluid flow safety; reduce flow noise and avoid sudden pipe failure by choosing pipe material whose allowable stress is greater than induced stress due to fluid weight.
2) The knowledge of displacement along pipeline can be used to improve the design life of pipelines by making appropriate provisions for expansion along pipe length.

Scope of the Study

This research will focus on establishing the linear regression models between the induced stress and displacement along a pipeline due to fluid weight. So, all efforts will be directed towards the general objectives. Stress and displacement evaluations followed Finite Element Analysis approach and is beyond the scope of this paper. The researchers are members of Federal Polytechnic Nekede, within South East of Nigeria. Results may be subject to variations within other parts of the World.

Review of Related Literature

Zachwieja (2017) investigated on stress analysis of vibrating pipelines. He generalized that vibration can result to fatigue damage to pipes and pipeline supports.

Rajput (2012) evaluated flow through pipes and concluded that there are losses due to fluid weight, friction and valve fittings.

Moses et al. (2019) studied flow-induced stresses and displacements in jointed concrete pipes installed by pipe jacking method. They concluded that displacements and stresses are significant under transient flow conditions.

II. METHODOLOGY

The study considered fluid, Diesel flowing through a pipe element at different rates and variable specific gravity of 0.96, 0.74 and 0.62, which yielded different weights. Finite Element Analysis was used to evaluate stresses and displacements induced due to variable fluid weight.

III. RESULTS AND PRESENTATIONS

Table 1.0: shows maximum principal stress and maximum displacements on pipe material for different fluid weight.

S/N	Fluid	Weight Within Pipe Length of 100 mm (N)	Maximum Principal Stress (MPa)	Maximum Displacement (mm)	Maximum induced Stress(MPa)
1	**Diesel**	7.9968	1.090	1.399×10^{-4}	1.679
2	**Diesel**	6.1642	0.840	1.078×10^{-4}	1.294
3	**Diesel**	5.1646	0.704	9.035×10^{-5}	1.084

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 7 July 2022, pp: 684-689 www.ijaem.net ISSN: 2395-5252

```
%MATLAB PROGRAMME FOR FLUID WEIGHT AND INDUCED STRESS IN PIPELINE.
>> % X = FLUID WEIGHT in N.
>> % Y = INDUCED STRESS  in MPa.
>> X = [7.997 6.164 5.165];
>> Y = [1.679 1.294 1.084];
>> mdl = fitlm(X,Y)

mdl =


Linear regression model:
y ~ 1 + x1

Estimated Coefficients:
Estimate        SE        tStat       pValue
__________      __________      _______
__________

(Intercept)    -0.0010753    0.00028861    -3.7258
0.16693
x1             0.21009     4.4077e-05     4766.4
0.00013356


Number of observations: 3, Error degrees of freedom: 1
Root Mean Squared Error: 8.95e-05
R-squared: 1,  Adjusted R-Squared 1
F-statistic vs. constant model: 2.27e+07, p-value = 0.000134

>> tbl = anova(mdl)

tbl =

SumSq      DF     MeanSq       F        pValue
__________    __   __________    __________
__________

x1         0.18212    1       0.18212    2.2719e+07
0.00013356
Error    8.0162e-09    1    8.0162e-09
[R,P] = corrcoef(X,Y)

R =

1.0000    1.0000
1.0000    1.0000


P =

1.0000    0.0001
0.0001    1.0000

>>end
```

The computed linear regression model between fluid weight and induced stress is shown below;

$$\mathbf{Y = 0.21009X - 0.00108}$$

Where Y = Induced stress in MPa and X = Fluid Weight in Newton.

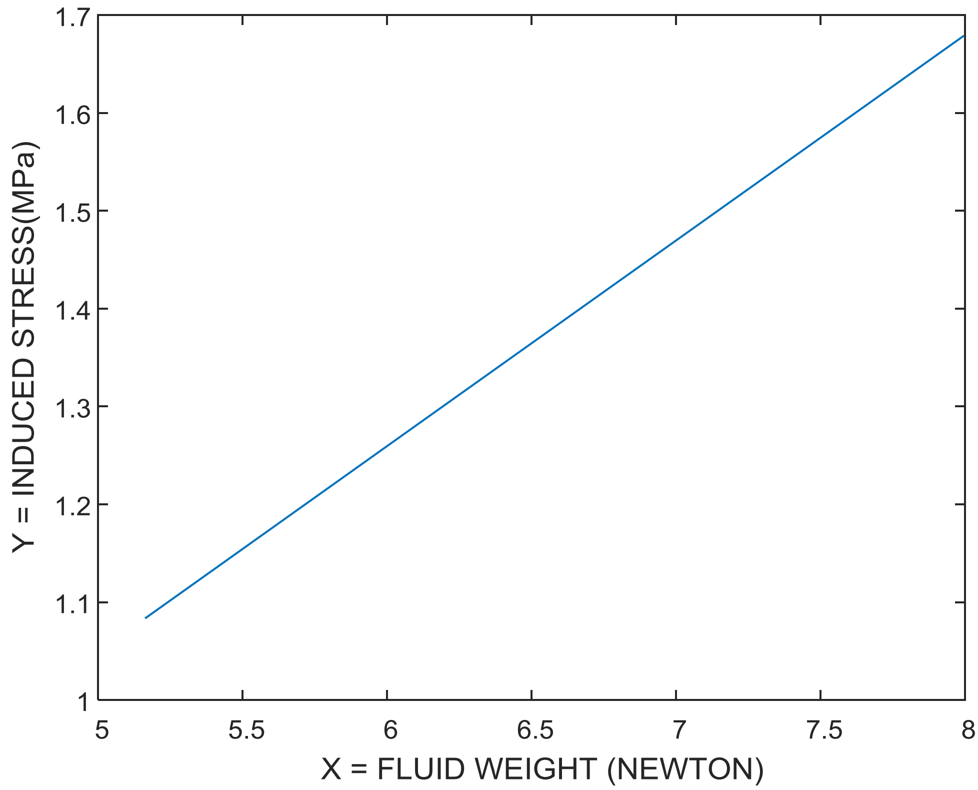

Fig 1.1: Graph Of Induced Stress Against Fluid Weight.

MATLAB CODES/SCRIPTS OF THE GRAPH ABOVE

```
function createfigure1(X1, Y1)
%CREATEFIGURE1(X1, Y1)
%  X1:  vector of x data
%  Y1:  vector of y data

% Create figure
figure1 = figure;

% Create axes
axes1 = axes('Parent',figure1);
box(axes1,'on');
hold(axes1,'on');

% Create plot
plot(X1,Y1);

% Create xlabel
xlabel({'X = FLUID WEIGHT (NEWTON)'});

% Create ylabel
ylabel({'Y = INDUCED STRESS(MPa)'});
```

```
>> %MATLAB PROGRAMME FOR DISPLACEMENT AND FLUID WEIGHT IN A PIPELINE.
>> % A = FLUID WEIGHT IN NEWTON
>> % B = PIPE DISPLACEMENT IN mm
>> A = [7.99690 6.16420 5.16460];
>> B = [0.00014 0.00011 0.00001];
>> mdl = fitlm(A,B)

mdl =


Linear regression model:
    y ~ 1 + x1

Estimated Coefficients:
                   Estimate          SE          tStat      pValue
                ____________    ___________    ________    ________

    (Intercept)     -0.00018555    0.00014042    -1.3214    0.41242
    x1              4.2257e-05     2.1445e-05     1.9705    0.29897
```

```
Number of observations: 3, Error degrees of freedom: 1
Root Mean Squared Error: 4.36e-05
R-squared: 0.795,  Adjusted R-Squared 0.59
F-statistic vs. constant model: 3.88, p-value = 0.299
>> tbl = anova(mdl)

tbl =

             SumSq        DF      MeanSq         F        pValue
          ___________    __    ___________    ______    ________

    x1     7.3688e-09    1     7.3688e-09     3.8827    0.29897
    Error  1.8979e-09    1     1.8979e-09

>> [R,P] = corrcoef(A,B)

R =

    1.0000    0.8917
    0.8917    1.0000


P =

    1.0000    0.2990
    0.2990    1.0000

>>END
```

The computed linear regression model between fluid weight and pipe displacement is shown below;

$$\mathbf{B = 0.000042257A - 0.00018555}$$

Where B = Pipe Displacement in mm and A = Fluid Weight in Newton.

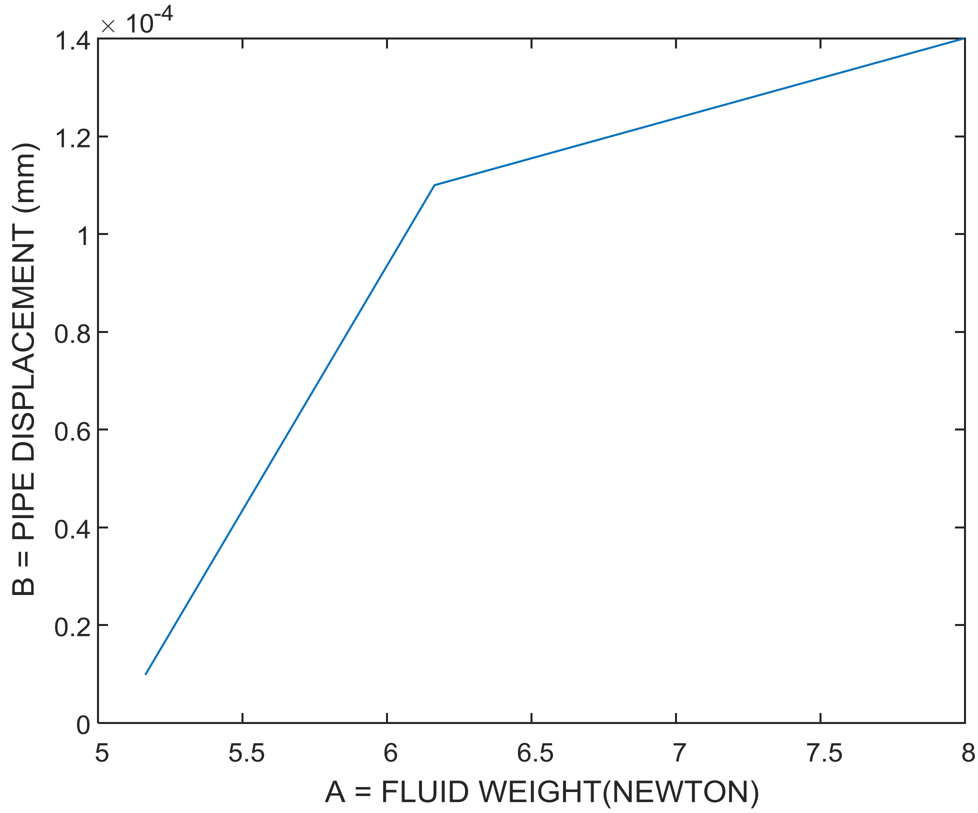

Fig 1.2: Graph of Pipe Displacemnt Against Fluid Weight.

MATLAB CODES/SCRIPTS OF THE GRAPH ABOVE

```
function createfigure1(X1, Y1)
%CREATEFIGURE1(X1, Y1)
%  X1:  vector of x data
%  Y1:  vector of y data

% Create figure
figure1 = figure;

% Create axes
axes1 = axes('Parent',figure1);
box(axes1,'on');
```

```
hold(axes1,'on');

% Create plot
plot(X1,Y1);

% Create xlabel
xlabel({'A = FLUID WEIGHT(NEWTON)'});

% Create ylabel
ylabel({'B = PIPE DISPLACEMENT (mm)'});
```

IV. DISCUSSION

The results of the study, linear regression modeling of induced stress and displacement along a pipeline due to fluid weight were discussed here. The linear regression modeling of induced stress and fluid weight was achieved using variable weight of fluid, diesel 7.997N, 6.164N, and 5.165N with the corresponding induced stress 1.679MPa, 1.294MPa, and 1.084MPa. The correlation coefficient of 1.000 and p-value coefficient of 0.0001 from data analysis indicated that there is positive and significant relationship between induced stress and fluid weight in a pipeline.

The MATLAB analysis also computed the linear regression model between induced stress and fluid weight;

$$\textbf{Induced Stress}(\textbf{MPa}) = \textbf{0.21009} \times \textbf{Fluid Weight} - \textbf{0.00108}$$

The standard error was observed to be 8.0162e-09. The P-value 0.00013356 and degrees of freedom 1 of the linear regression model are consistent with the P-value and degrees of freedom of ANOVA model, that proves correctness of the model.

The linear regression modeling of pipe displacement and fluid weight was achieved using variable weight of fluid, diesel 7.997N, 6.164N, and 5.165N with the corresponding pipe displacement 0.00014mm, 0.00011mm, and 0.00001mm. The correlation coefficient of 0.8917 and p-value coefficient of 0.2990 from data analysis indicated that there is positive and insignificant relationship between pipe displacement and fluid weight in a pipeline.

The MATLAB analysis also computed the linear regression model between pipe displacement and fluid weight;

$$\textbf{Pipe Displacement}(\textbf{mm}) = \textbf{0.000042257} \times \textbf{Fluid Weight} - \textbf{0.00018555}$$

The standard error was observed to be 2.1445e-05. The P-value 0.29897 and degrees of freedom 1 of the linear regression model are consistent with the P-value and degrees of freedom of ANOVA model, that proves correctness of the model.

V. CONCLUSION

The linear regression modeling induced stress and displacement along a pipeline due to fluid weight was obviously achieved. Undoubtedly, results revealed that at any given value of fluid weight, induced stress and displacement of pipe can be easily computed.

VI. RECOMMENDATIONS

The following recommendations are suggested based on the study:

1) To avoid failure and fluid leakage in pipelines, induced stress due to fluid weight must be computed to make appropriate choice of pipe material.
2) Pipeline displacement must be computed before pipe joining is done to ensure appropriate displacement accommodation.
3) This research can also be done using other advanced software for generalization.

REFERENCES

[1]. Moses, K., Mehrdad, K. & Mohammad, N.S. (2019). Flow-Induced Stresses and Displacement in Jointed Concrete Pipes Installed by Pipe Jacking Method. International Journal of Fluids-MDPI 4(34).

[2]. Rajput, R.K. (2012). Fluid Mechanics and Hydraulic Machines. New Dehi: Khanna Publishers.

[3]. Zachwieja, J.(2017). Stress Analysis of Vibrating Pipelines. American Institute of Petroleum Conference Proceedings 1822,020017.