

[Local Stress Prediction] User Manual

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1. Introduction

The process of calculating the local stress at the nozzle junction of a pressure vessel using the finite element method is highly complex. To alleviate the difficulty of analysis, a predictive software based on ABAQUS and ML has been developed. This software can quickly predict the local stress at the nozzle junction of a pressure vessel, with an accuracy level exceeding 0.999 and a mean square error of only 1.639. This method contrasts with traditional finite element analysis design methods as it bypasses many complex analysis steps. Furthermore, we provide the methods and tools needed for software development, which will assist users in developing predictive software for specific operating conditions and material parameters. It provides a reliable and convenient platform for rapid evaluation and optimization of pressure vessel design, while also serving as a reference for stress prediction under different operating conditions and materials.

2. Product Overview

The Local Stress Prediction package comprises an ABAQUS script and a corresponding plugin (Generate Dataset) for generating datasets, Python code for machine learning and model generation, and a comprehensive stress prediction software (Stress Prediction-ML). This means that users can refer to these publicly available files to create stress prediction software tailored to specific working conditions and materials.

One ABAQUS script and one plugin are publicly available and serve the purpose of generating datasets. This script or plugin can create nozzle models in batches based on user-provided parameters and subsequently calculating the stress within them. All the calculated data is saved in a .txt file, which can be transformed into datasets in various formats as per requirements. Modifying the script or plugin allows users to obtain datasets for different materials and working conditions, although it is recommended to limit modifications to material parameters and avoid altering other parameters. An example of the dataset is also provided here, which has 2860 samples (date-1.scv).

The complete stress prediction software is an illustrative example that can be directly utilized. It employs Q345 as the material and assumes normal temperature as the working condition. On top of this, it uses parameters such as pressure and geometry as features for machine learning to derive the software's predictions.

1. Copy the "GenerateDataset" folder to 'C:\Users\Username\abaqus_plugins'.
2. Open ABAQUS, and you will find "GenerateDataset" under the "Plug-ins" menu.
3. Open "GenerateDataset" and enter the parameters. Click "OK" to complete the batch analysis.
4. In the folder "C:\temp\Local_pipe_analysis", you will find the "MaxMises.txt" file.
5. Copy or convert the data into the desired format for your dataset.

Stress analysis at nozzle-GenerateDataset


Geometric parameter(mm)	material parameter	Load parameter
Barrel length L: 3000	Mass density(kg/m ³): 7.85E-09	Radial force along the Z-axis(N): 1E-05
Nozzle length h: 1000	Young modulus(MPa): 206000	Horizontal force force along the X-axis(N): 1E-05
Thickness of barrel T1: 20	Poisson s ratio: 0.3	Horizontal force force along the Y-axis(N): 1E-05
Thickness of barrel T2: 21	Yield stress(MPa): 300	Torque about the Z-axis(N*mm): 1E-05
differences 1	Plastic strain(mm): 0	Bending moment about X-axis(N*mm): 1E-05
Thickness of nozzle t1: 20	Cpu Number: 2	Bending moment about Y-axis(N*mm): 1E-05
Thickness of nozzle t2: 21	Gpu Number: 0	
differences 1		
Inside radius of barrel R1 600		
Inside radius of barrel R2 601		
differences 10		
Inside radius of nozzle r1: 200		
Inside radius of nozzle r2: 201		
differences 10		
Nozzle tilt Angle a1(°): 0		
Nozzle tilt Angle a2(°): 1		
differences 6		
Inside radius of nozzle P1: 1		
Inside radius of nozzle P2: 3		
differences 1		

The diagram illustrates a mechanical model of a gun barrel and its nozzle. The main barrel has a total length L , an outer radius R , and a wall thickness T . Attached to the front of the barrel is a nozzle of length h . The nozzle has an inner radius r and a wall thickness t . A 3D coordinate system is defined with the Z -axis pointing along the longitudinal axis of the barrel, the X -axis pointing horizontally to the left, and the Y -axis pointing vertically upwards.

Please make sure that each parameter is entered.

Stress_Prediction-ML

1. Press Win+R to open the Run dialog box, then type "cmd" and press Enter. This will open the Command Prompt window.
2. In the Command Prompt window, enter the following commands (install one after another once the previous one is installed): pip install PyQt5 pip install pandas pip install scikit-learn pip install matplotlib pip install seaborn
3. Double-click on "Stress_Prediction-ML.exe" to run the program. Enter the corresponding geometric parameters and click OK to obtain the predicted values.
4. You can copy and save the results for each set of input parameters for further analysis.

 Stress Prediction-ML

T:

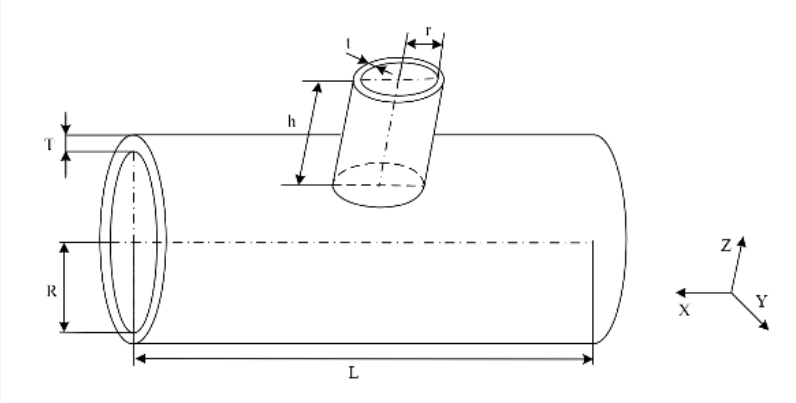
t:

R:

r:

a:

P:



Parameter: T: 12.0; t: 12.0; R: 300.0; r: 120.0; a: 10.0; P: 0.5;
Predicted stress: 104.32

4. Operating Instructions

GenerateDataset

Stress analysis at nozzle-GenerateDataset

Geometric parameter(mm)	material parameter	Load parameter
Barrel length L: 3000	Mass density(kg/m3): 7.85E-09	Radial force along the Z-axis(N): 1E-05
Nozzle length h: 1000	Young modulus(MPa): 206000	Horizontal force force along the X-axis(N): 1E-05
Thickness of barrel T1: 20	Poisson s ratio: 0.3	Horizontal force force along the Y-axis(N): 1E-05
Thickness of barrel T2: 21	Yield stress(MPa): 300	Torque about the Z-axis(N*mm): 1E-05
differences 1	Plastic strain(mm): 0	Bending moment about X-axis(N*mm): 1E-05
Thickness of nozzle t1: 20	Cpu Number: 2	Bending moment about Y-axis(N*mm): 1E-05
Thickness of nozzle t2: 21	Gpu Number: 0	
differences 1		
Inside radius of barrel R1: 600		
Inside radius of barrel R2: 601		
differences 10		
Inside radius of nozzle r1: 200		
Inside radius of nozzle r2: 201		
differences 10		
Nozzle tilt Angle a1(°): 0		
Nozzle tilt Angle a2(°): 1		
differences 6		
Inside radius of nozzle P1: 1		
Inside radius of nozzle P2: 3		
differences 1		

How much each cycle increases

geometric parameters

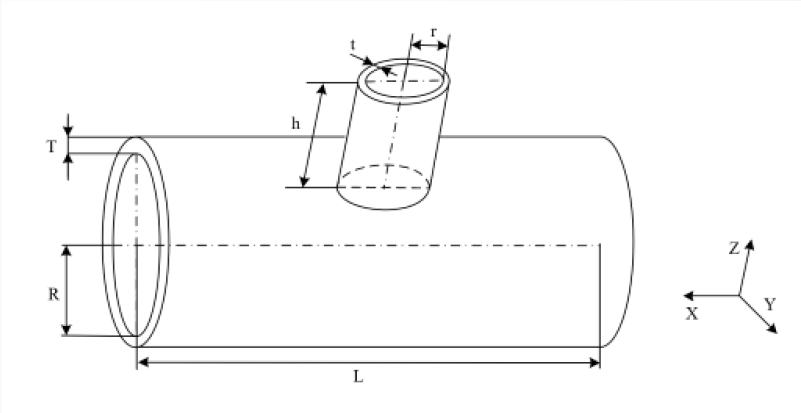
A very small value should be entered even if the parameter is 0

Make sure you enter each parameter before clicking


!Please make sure that each parameter is entered.

Make sure you enter each parameter before clicking "OK".

OK cancel



Stress_Prediction-ML

 Stress Prediction-ML

T:

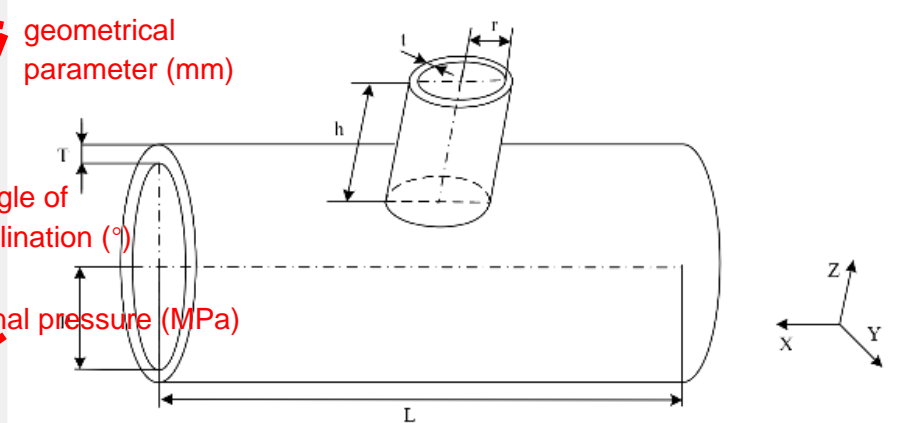
t:

R:

r:

a:

P:



geometrical
parameter (mm)

Angle of
Inclination (°)

internal pressure (MPa)

Make sure you enter each
parameter before clicking

Parameter: T: 12.0; t: 12.0; R: 300.0; r: 120.0; a: 10.0; P:
0.5;

Predicted stress: 104.32

5. Troubleshooting

If you have any questions, please leave a message, or email Fanhangchao@163.com.

6. Disclosures

Refer to license.txt for details.