تجزیه و تحلیل شکست‌های ناشی از انفجار لو‌لوا و مخازن تحت فشار

سهرنارا تاوکلی، مجید میرزاei

1 - دانشجویارکرشده ارشد، همکاری، اصفهان، تهران، تهران
2 - دانشجویارکرشده کارشناسی، اصفهان، تهران، تهران

mmirzaei@modares.ac.ir

چکیده
هدف اصلی این مطالعه تجزیه و تحلیل خصوصیات رفتار‌های تریپی فرم و شکست‌های ناشی از انفجار در لو‌لوا (افزایش فشار سریع) در لو‌لوا و مخازن تحت فشار می‌باشد. تحقیقات اولیه این مطالعه که به طور استنتاجی و بدون نیاز به اجرای آزمایش‌های اصلی انجام شده‌اند، اثبات کرده‌اند که این افزایش فشار سریع در لو‌لوا و مخازن تحت فشار سبب شکست‌های تریپی فرم و شکست‌های ناشی از انفجار می‌شود.

On fracture analysis of exploded pressure vessels and pipes

Saharnaz Tavakoli, Majid Mirzaei

Department of Mechanical Engineering, Tarbiat Modares University, Tehran, Iran

* P.O.B. 14115-143, Tehran, Iran, mmirzaei@modares.ac.ir

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Abstract
The main scope of this paper is the analysis of the specifications of deflagration-induced and detonation-induced deformation and fracture behaviors of cylindrical tubes. The main characteristics of deformation and fracture behaviors were studied through experiments on steel pipes and failure analysis of a compressed natural gas (CNG) cylinder. The paper also reports the results of transient-dynamic elasto-plastic finite element (FE) analyses of the combustion-induced deformation and fracture behaviors of the pipe and the CNG cylinder. The FE models were composed of 3D brick elements equipped with interface cohesive elements for crack growth analysis. Very good agreement was found between the simulation results and the observed deformation and fracture patterns. It was shown that, because of different loading conditions, specific deformation and fracture features can develop during the explosion process.

1 متقدمه
مخازن و لو‌لوا تحت فشار ناشی از انفجار یک عوامل کلیدی در مدل‌سازی و طراحی سیستم‌های انفجاری می‌باشند. این افزایش فشار سریع به مدت کمی می‌تواند سبب شکست‌های تریپی فرم و عوامل فیزیکی قطعی و ناقصی سازی و جابجایی مواد باشد. به طور کلی، این افزایش فشار به مدت کمی می‌تواند سبب شکست‌های ناشی از انفجار و تریپی فرم و عوامل فیزیکی قطعی و ناقصی سازی و جابجایی مواد باشد.

Keywords:

Crack growth
Pressure vessel
Dynamic stress analysis
Moving load
Explosion

Please cite this article using:

Table 1 Dimensions and Material properties of the steel tube

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outer Diameter (mm)</td>
<td>500</td>
</tr>
<tr>
<td>Inner Diameter (mm)</td>
<td>550</td>
</tr>
<tr>
<td>Thickness (mm)</td>
<td>2</td>
</tr>
<tr>
<td>Yield Strength (MPa)</td>
<td>7870</td>
</tr>
<tr>
<td>Ultimate Strength (MPa)</td>
<td>2060</td>
</tr>
<tr>
<td>Elongation (%)</td>
<td>350</td>
</tr>
<tr>
<td>Young's Modulus (GPa)</td>
<td>0.29</td>
</tr>
<tr>
<td>Density (kg/m³)</td>
<td>5.90</td>
</tr>
<tr>
<td>Poisson's Ratio</td>
<td>0.35</td>
</tr>
<tr>
<td>Elastic Limit (MPa)</td>
<td>120</td>
</tr>
</tbody>
</table>

2 - Tension and compression tests

In this study, the tube dimensions were measured using a micrometer. The outer diameter was 500 mm, the inner diameter was 550 mm, and the thickness was 2 mm. The yield strength was 7870 MPa, and the ultimate strength was 2060 MPa. The elongation was 350%, and the Young's modulus was 5.90 GPa.

The material properties of the steel tube are measured as follows:

- Elongation: 350%
- Young's Modulus: 5.90 GPa
- Poisson's Ratio: 0.35
- Elastic Limit: 120 MPa

The tests were performed to determine the material properties of the steel tube. The results show that the tube is suitable for use in compression and tension tests. The material properties meet the requirements for the expected load-bearing capacity.
Table 2 Johnson-Cook parameters for St52-3 cold-drawn steel with standard strain-rate form.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>350</td>
</tr>
<tr>
<td>B</td>
<td>370</td>
</tr>
<tr>
<td>C</td>
<td>0.012</td>
</tr>
<tr>
<td>N</td>
<td>0.34</td>
</tr>
</tbody>
</table>

Fig. 3 The snapshots of simulated crack growth caused by a supersonic pressure wave at different time intervals (ms) for two similar FE models with different pre-crack locations.

Fig. 2 Right: the fractured tube (direction of the moving pressure is shown by the arrow). Left: the crack initiation (thumbnail crack) and the subsequent incremental growth at both directions.
Fig. 4 FE simulation of deformation and fracture of a CNG cylinder. The snapshots show the initiation and growth of the main crack, the parallel cracks, and the change of the crack formation by traveling of a sonic wave from the neck towards the bottom of the cylinder [24].

The shape of the CNG cylinder is shown in the figure. The simulation results show that the crack propagation is mainly due to the plastic deformation of the material in the neck region. The crack propagation is influenced by the thickness and material properties of the cylinder. The simulation results show that the crack propagation rate increases with the increase in the thickness of the cylinder. The simulation results also show that the crack propagation rate decreases with the increase in the material strength. The simulation results are in good agreement with the experimental results.


[23] M. Mirzaei, M. Najafi, H. Niasari, Experimental and numerical