Optimization of Bursting Strength of AA6061 Alloy Pipelines

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ABSTRACT

Metal tubing is used to transfer liquids, air, or solids. Metal tubing is used in heating, ventilation, and air conditioning (HVAC) and plumbing systems and for applications in the aerospace, automotive, chemical processing, food and beverage, manufacturing, and medical industries. AA6061 is used for heavy duty structures requiring good strength-to-weight ratio with good corrosion resistance. The most important parameters in designing pipelines are the pressure and temperature of the conveying media. The major concern of pipes is to maintain its geometric integrity to ensure they are safe and effective during operation to avoid unforeseen disaster. One of the major geometric integrity of the pipe is cracks on its surface. The wall thinning on a pipe due to corrosion, results in localized pit with different depths and lengths on its internal and external surfaces. The codes such as BS 7910 and DNV RP-F101 are the semi-empirical methods used for the assessment of the integrity of pipes.

Table 1: Control factors and their levels

Factor	Symbol	Level–1	Level–2	Level–3
Thickness, mm	A	0.89	1.24	1.47
Length of crack, mm	B	28.2	47.3	60.0
Depth of crack	C	0.56	0.64	0.71
Pressure	D	3.5	4.0	4.5

Table 2: Orthogonal Array (L9) and control factors

Treat No.	A	B	C	D
1	1	1	1	1
2	1	2	2	2
3	1	3	3	3
4	2	1	2	3
5	2	2	3	1
6	2	3	1	2
7	3	1	3	2
8	3	2	1	3
9	3	3	2	1

The present work is aimed at to study the finite element analysis of crack propagation and pipe bursting with predefined flaws of varying length and depth. The pipes are analyzed for various bursting pressures. As illustrated in 1igure 1, the longitudinal crack length is shown at 2a and the pipe is under an internal pressure loading of p, with the pipe thickness depicted as t.

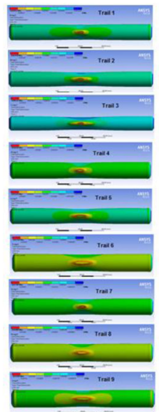


Figure 1: Total deformation of test coupons.

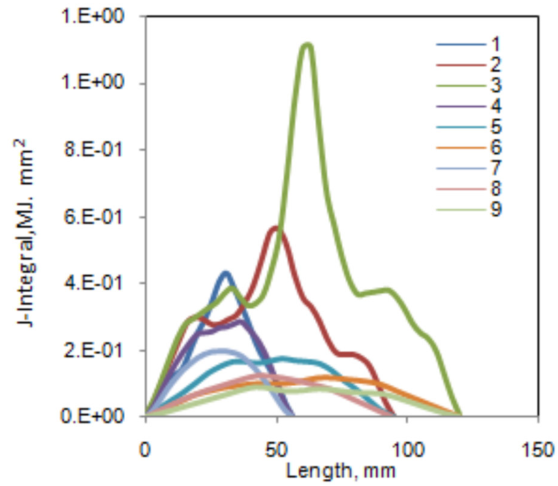


Figure 2: J-Integral values of all trials.

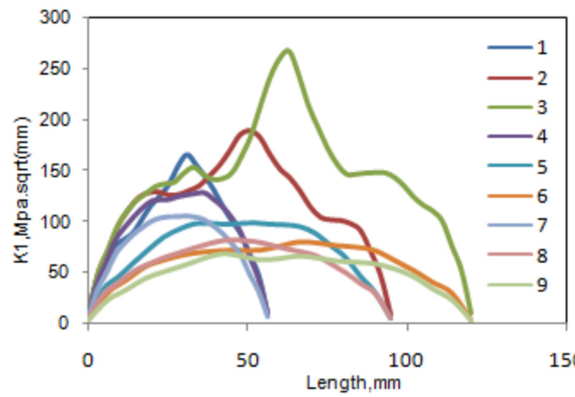
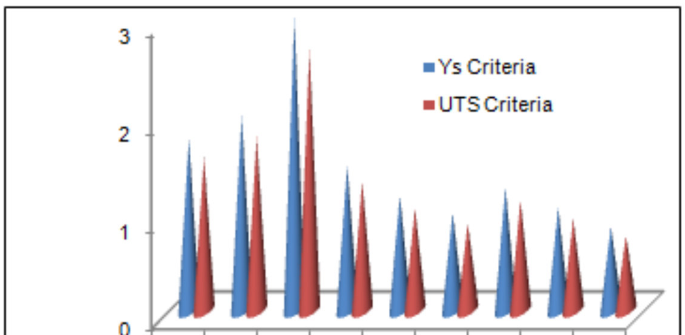


Figure 3: KI values of all trials.



	1	2	3	4	5	6	7	8	9
Ys Criteria	1.7	2	2.9	1.4	1.1	1	1.2	1.0	0.8
UTS Criteria	1.5	1.7	2.6	1.3	1.0	0.8	1.1	0.9	0.7

Figure 4: Failure criteria based on yield and tensile.

During crack propagation analysis it was observed that the path dependence of the J-integral was significant during the large deformation of pipes subjected to internal bursting pressure. The predominant control factors of pipe failure were the pipe thickness, depth of crack and bursting pressure. The allowable depth of crack and the bursting pressure were 0.56 mm and 3.5 MPa for the pipe having thickness of 1.24 mm and 0.64 mm and 4.0 MPa for the pipe having thickness of 1.47 mm respectively. The fracture of the pipes was of opening mode (KI).

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