# Finite element analysis of crack growth in pipelines

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**The paper presents a short crack theory together with the finite element method (FEM), which is used to model crack initiation during the operational phase of a pipeline. To simulate the crack, the virtual crack extension (VCE) method, implemented in the FE code, is used. This paper describes the modelling and simulation of a welded pipeline with initiated crack in the beginning. A FEM modelling procedure for analysing the stress intensity factors (SIF's) and J- integral for two practical problems is presented. For the first problem the commercial software ANSYS was used to calculate the crack parameters in a straight pipe with a radial crack. The second problem deals with an axial crack tip in the main pipe of a welded tubular Y-joint. For this problem numerical results for calculated crack parameters and contour integrals are presented. The parameters were calculated by commercial software ABAQUS. For J-integral evaluation, the region on the surface of the blunted notch should be used to define the crack front.**

**Keywords:** FEM, XFEM, stress intensity factor, J-integral, pipelines

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## References

[1] CHIEW, S.P., LIE, S.T., LEE, C.K., HUANG, Z.W. (2001): *Stress intensity factors for a surface crack in a tubular T-joint.* In: Int. J. of pressure Vessels and Piping, 78, pp. 677-685.

[2] NOVAK, P., MESKO, J., ZMINDAK, M., (2013), *Finite element implementation of Multi-Pass Fillet Weld with Phase Changes*. In: Manufacturing Technology Vol. 13, No.1.

[3] G. VENKATACHALAM & R. HARICHANDRAN & S. RAJAKUMAR &C. DHARMARAJA & C. PANDIVELAN. *Determination of J-integral and stress intensity factor using the commercial FE software ABAQUS in austenitic stainless steel (AISI 304) plates*. In: Int. J. Adv. Manuf. Technol.

[4] MESKO, J., FABIAN, P., HOPKO, A., KONAR, R. (2011). *Shape of heat source in simulation program SYSWELD using different types of gases and welding methods*. In: Manufacturing Technology, Vol. XVI, No. 5.

[5] GAO, L., LIU, K.; LIU, Y. (2006): *Applications of MLPG Method in Dynamic Fracture Problems.* In: CMES: Computer Modeling in Engineering & Sciences, vol.12, No.3, pp. 181-195.

[6] MOHAMMADI, S., (2008). *Extended Finite Element Method*. Singapúr : Utopia Press PteLtd, 2008. 277 pp.

[7] SLADEK, J.; SLADEK, V.; KRIVACEK, J.; ZHANG, CH. (2005). *Meshless Local Petrov-Galerkin Method for Stress and Crack Analysis in 3-D Axisymmetric FGM Bodies.* In: CMES: Computer Modeling in Engineering & Sciences, vol. 8, No. 3, pp.259-270.

[8] APEL, T., STEINBACH, O. (2013) *Advanced Finite Element Methods and Application*, Springer –Verlag Berlin Heidelberg

[9] AKIN, J.S. (1976)., The generation of elements with singularities. In:*Int. J. Numer. Meth. in Engng.*, 10, pp. 1249-1259.

[10] KUNA, M. (2013). *Finite Elements in Fracture Mechanics: Theory-Numerics_Applications*, Springer Science +Bussines Media.

[11] SLADEK, J, SLADEK, V., JAKUBOVICOVA, L. (2002). *Application of Boundary Element Methods in Fracture Mechanics*, University of Zilina, Faculty of Mechanical Engineering, Zilina , 2002.

[12] ZMINDAK, M., NOVAK, P., MESKO, J. (2010). *Numerical simulation of arc welding processes with metallurgical transformations*. Metallurgy, Vol. 49, No.2, pp. 595-599.

[13] SATTARI-FAR. I., FARAHI, M.R. (2009). *Effect of the weld groove shape and pass number on residual stress in butt-welded pipes.* In: International journal of Pressure vessels and Piping Vol. 86, pp. 723-731.

[14] KOVANDA, K., HOLUB, L., KOLARIK, L., KOLARIKOVA, M., VONDROUS, P., (2012). Experimental *verification of FEM Simulation of GMAW bead on plate welding.* Manufacturing Technology Vol.12, No. 12, pp. 30-33.

[15] NOVAK, P., MESKO, J., ZMINDAK, M., (2013). *Finite element implementation of Multi-Pass Fillet Weld with Phase Changes.* Manufacturing Technology Vol. 13, No.1.

[16] GDOUTS, E.E., RODOPOULOS, C.A., YATES, J.R., (2003*). Problems of Fracture Mechanics and Fatigue : A solution Guide.* Kluwer Academic Publishers.

[17] KONAR, R., MICIAN, M., (2012). *Numerical simulation of residual stresses and distortions in butt weld in simulation program Sysweld.* In: Comunications: scientific letters of the University of Žilina. Vol. 14, No. 3. pp. 49-54. ISSN 1335-4205. Žilina.

[18] KONAR, R., MICIAN, M., HOPKO, A., (2011). *Analysis of boundary for the simulation of welding at the repair of gas pipelines with steel sleeve*. In: Comunications: scientific letters of the University of Žilina. Vol. 13, No. 4. pp. 36-39. ISSN 1335-4205. Žilina.

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