

Catastrophic impact loading resilience of welded joints of high strength steel of refineries' piping systems

Prof. Andrzej Klimpel, Silesian University of Technology, Gliwice, Poland

Abstract

Statement of the Problem:

Refineries piping installation systems are designed, fabricated, and operated to assure very high levels of quality and structural integrity, to provide very high resilience to catastrophic events like earthquakes, explosions, or fires, which could induce catastrophic damage to piping systems due to collapse of nearby structures as towers, bridges, poles, walkways, vessels, etc. To evaluate the catastrophic impact loading resilience to failure of MMA (Manual Metal Arc Welding), GMA (Gas Metal Arc Welding), SSA (Self-shielded Arc Welding) and LASER+GMA of modern API 5L X80 pipes butt welded joints used for piping installation systems of refineries, the new, original technique of the quantitative and qualitative evaluation of impact loading resilience of butt welded joints of pipes was developed. The high-quality butt welded joints were impact loaded by the freely dropping 3000 kg mass hammer of the die forging hammer apparatus. The developed impact loading technique of butt welded joints of pipes to simulate the catastrophic events in refinery piping systems and to evaluate the resilience of the butt welded joints of pipes to catastrophic failure proved to be very efficient and accurate. Experiments of impact loading indicated that all specimens of butt welded joints API 5L X80 steel pipes are resilience to failure (cracks) in the extreme stressed/strained areas, above yield and tensile strength of the weld metals, and no cracks or tears appeared in the extreme stressed/strained areas of the edges of the pipes, proving the very high quality of API 5L X80 steel pipes.

The research results presented in the lecture paper are done in the scope of two EU projects:

1. XP-RESILIENCE: Extreme Loading Analysis Of Petrochemical Plants And Design Of Metamaterial based Shields For Enhanced Resilience. H2020-MSCA-ITN-2016, ID 721816
2. SMARTWELD - Development of a SMART system integrating

automatic/robotic hybrid WELDing technologies, digital-twin-assisted quality monitoring, and WPS predictive tool. RFCS-02-2022-RPJ. ID 101112414.

Conclusion & Significance: The developed impact loading technique to evaluate the resilience to catastrophic failure of the MMA, GMA, SSA, and LASER+GMA butt welded joints of API 5L X80 steel pipes under simulated catastrophic impact loading events in refineries piping systems and proved to be very efficient and accurate. All impact-loaded specimens of the MMA, GMA, SSA, and LASER+GMA butt welded joints of API 5L X80 steel pipes at impact energy forced by the hammer mass 3000 kg and at the hammer height $H=1,0$ m, forcing at the extreme areas of butt welded joints the Huber Mises stresses and effective plastic strains beyond the yield strength ($R_e = 0,618$ GPa) or even tensile strength ($R_m = 0,700$ GPa) of the weld metal and API 5L X80 steel pipes, proved high resilience to catastrophic impact loads, as no cracks or tears were detected

Recent Publications

1. Andrzej Klimpel, et al.: Experimental investigations of the influence of laser beam and plasma arc cutting parameters on edge quality of HSLA strips and plates. Journal of Materials Processing Technology. 2016.
2. A. Klimpel, et al. Catastrophic impact loading resilience of welded joints of high strength steel piping systems of refineries - Materials 2022, 15, 1323. <https://doi.org/10.3390/ma15041323>
3. Klimpel A.: Jakość procesu cięcia laserowego blach stalowych – wpływ zawartości krzemu i innych pierwiastków stopowych. STAL, METALE, NOWE TECHNOLOGIE. 11-12. 2020, s. 10-19.
4. A. Klimpel et al.: Quasi-Static Loading Of Piping Welded Joints International Journal of Modern Manufacturing Technologies ISSN 2067–3604, Vol. XII, No. 2 / 2020,
5. A. Klimpel; Nowoczesne lasery i technologie laserowe w inżynierii spawalnictwa. Wyd. Pol. Śląskiej. Gliwice 2023.

Photograph



Biography

Prof. Andrzej Klimpel - The welding engineer by education and next year's research, scientific and didactical and activities, Andrzej Klimpel has developed into an expert in the area of large-scale welding technological R&D - programs, on the national and the international levels being TGS8/TGA4 member since 2003 up to 2023 and RFCS, FP7, HORIZON 2020 and HORIZON EUROPE expert. He specializes in development of modern welding engineering technologies and welding processes quality assurance systems. In specific he is working on modern technologies of HSS and UHSS structures welding and repair welding, resistance and solid-state welding, hardfacing, thermal spraying and on the applications of laser technologies in welding processes. He has extensive, hands-on experience with the management of R&D projects and AI implementation in the welding engineering.

Email: andrzej.klimpel@polsl.pl