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Experimental study on the minimum design metal temperature of Q345R steel

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Key words:

Q345R steel; Exemption curve; Master curve (MC);

Charpy V-notched impact test; Fracture toughness

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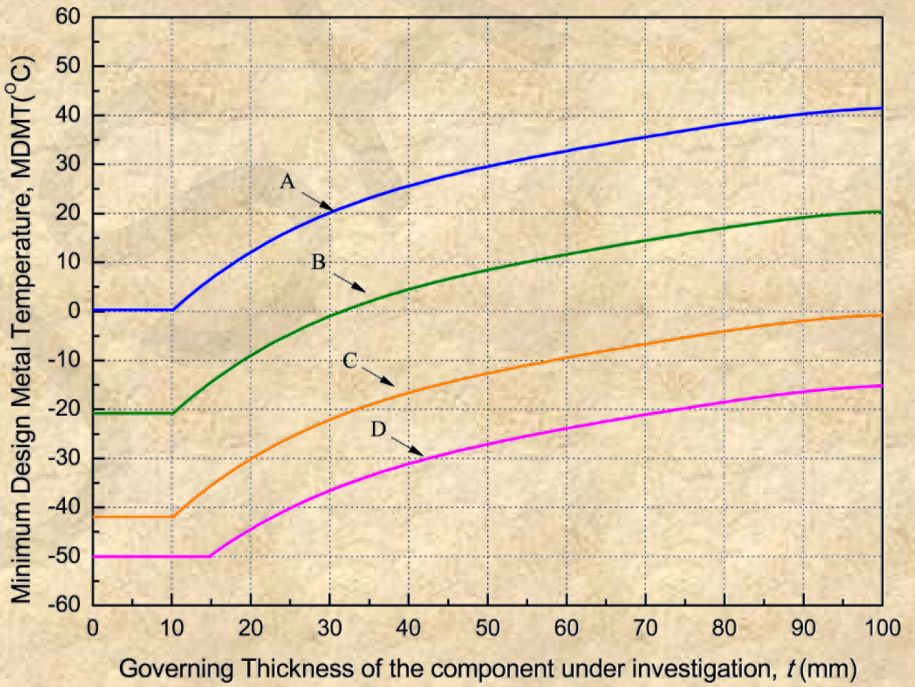
Research Background

- As the material most widely used in manufacturing pressure vessels in China, Q345R steel has been permitted in ASME Code Case 2642 to be used for fabricating pressure vessels since 2010.

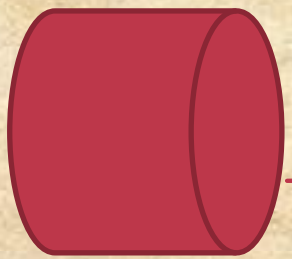
- It is listed in the material group corresponding to the exemption curve A for Charpy V-notched (CVN) impact test requirements.



Recent studies indicate that the mechanical property of Q345R has been underestimated and the curve A classification is over-conservative.

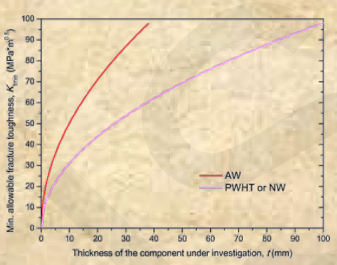
Method

Component Safety



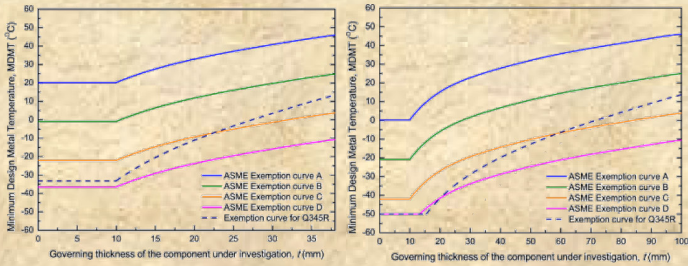
Component Assumption

Failure Assessment Diagram



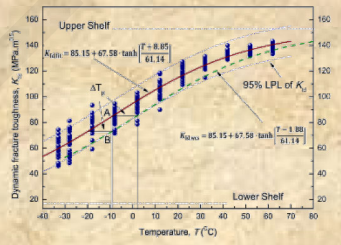
$K_{(1min)}$-t relationship

Exemption Curves



Material CVN tests

Two-step Converting Method

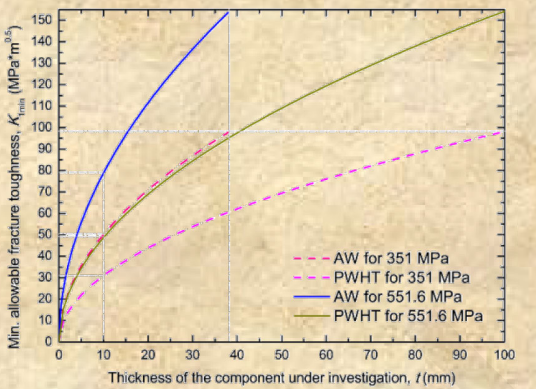


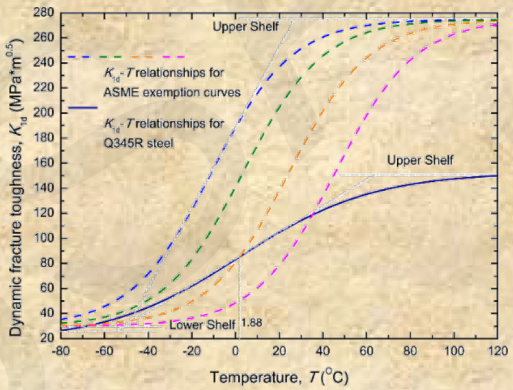
K_{1d}-T relationship

Material Properties

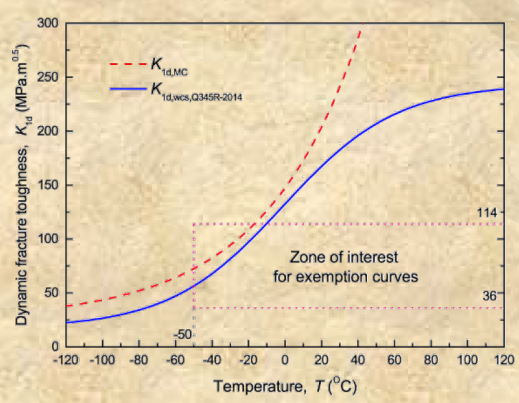
Discussion

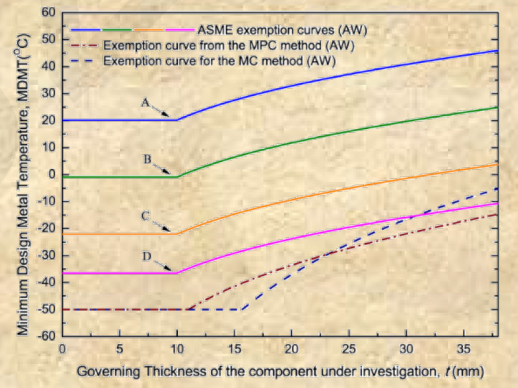
Comparison with the ASME exemption curves

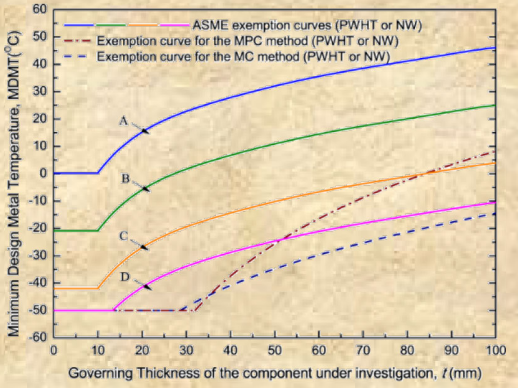




Comparison with the Master Curve method







Conclusions

- The specific exemption curve for Q345R-2009 and Q345R-2014 were obtained. Such a specific curve expands the impact test exemption area, especially for small components with a thickness of less than 20 mm, and greatly simplifies the design process.

- It is safe to classify Q345R into ASME Group B instead of Group A by reference to the mechanical properties of the worst batch of Q345R steel, Q345R-2009.

- The method firstly presented in this paper (MPC method) was compared to the Master Curve (MC) method. both the two methods are reliable for determining the exemption curve for certain materials, and the MC method expands a further area for the impact test exemption and results in a lower MDMT than the MPC method.