CHAPTER

5

HEAT TRANSFER ANALYSIS OF COMPOSITE CYLINDER AS AN ALTERNATIVE TO STEEL FOR STORAGE OF LIQUEFIED PETROLEUM GASES

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5.1 INTRODUCTION

Liquefied petroleum gas (LPG) is classified as a liquid mixture of propane and butane. In addition to the main components, propylene, butylene, and butadiene are other minor components that may exist in LPG (Saleh, 2008). As compared to other liquid fuels, LPG has the advantage of being relatively cheaper, available in large amounts, zero ozone depletion, and low global warming potential (El-Morsi, 2015). It was used as early as the 1980s in Malaysia, LPG has made its way to almost every commercial and residential areas to meet public needs, especially in cooking and heating appliances (Mat et al., 2006), and its production has increased ever since.

The mode of LPG used in Malaysia is commonly through bulk storage and portable cylinder. LPG storage are designed and installed in compliance with different recognised pressure vessel codes. The most

common code used is American Society of Mechanical Engineers (ASME) Section VIII, Division 1 that is Rules for Construction of Pressure Vessels (Salman et al., 2018). However, portable cylinder is normally designed and fabricated according to Malaysian Standards MS 641 or MS 642. Several grades of material are available in fabrication and designing the storage which carries different values of the variable. Selection of material is mainly depending on the function and use of the vessel itself.

There are many factors that must be considered when sizing a container or vessel for liquefied petroleum gas (LPG). One of the most important factors considered is the vapourisation rate of LPG (Mat et al., 2006). The value of the vapourisation rate is influenced by the thermal conductivity (Lecoq et al., 2017) and heat transfer rate (Longo et al., 2015). Furthermore, by using different material, it carries different value of yield strength and maximum allowable stress which indicate the minimum thickness needed to construct the vessel. Thickness is important variable because it affects heat transfer.

The most common material used for the fabrication of LPG cylinder is carbon steel (ASTM A517 Grade 70) as this raw material is unexpensive and easy to obtain. However, there are some disadvantages of using carbon steel as this material is difficult to work with because steel is heavy and has got some safety problems (Tom et al., 2014). It can't be easily bent and molded into different shapes. This material is also more susceptible to rust and corrosion (Dwivedi et al., 2017). Thus, a new material was used to fabricate LPG cylinder known as fibre reinforced composite which specifically used aramid fibre as their main material. Aramid fibre was the first organic fibre with a high enough tensile modulus and strength to be applied as reinforcement in advanced composites. On an equal weight basis, they outperform steel and glass fibres in terms of mechanical qualities. Aramid fibres are heat and flame resistant by origin, and they retain these qualities at high temperatures (Ertekin, 2017). However, since the mechanical properties of fibre reinforced composite is slightly difference as compared to the carbon

steel especially the thermal conductivity, thus the evapouration rate of LPG stored in both materials will be different.

The rate of vapourisation is greatly influenced by a few major factors which are the composition of LPG, rate of withdrawal, atmospheric temperature (Conrado & Vesovic, 2000; Consolini et al., 2003). There are also minor factors that affect it such as wind velocity, surrounding air humidity, cylinder roughness (Thyer, 2003; Wang & Kido, 2003). Limited sources and research on the effect of LPG cylinder material on the evapouration rate were carried out.

5.2 ASSESSMENT OF HEAT TRANSFER AROUND THE LIQUEFIED PETROLEUM GAS CYLINDER

This subchapter discussed the steps and procedures in analysing the changes in vapourisation rate for 14 kg LPG cylinder which use different type of material namely fibre reinforced composite (aramid fibre) and the usual carbon steel (ASTM A516 Grade 70).

5.2.1 Tools and Platform

Microsoft Excel was chosen as the platform for the situational analysis. Microsoft Excel provides more functionality and is a better suited programme for performing simple calculations and analyses (Bourg, 2006). It was shown to be a user friendly software that was simple to run and could be used by others.

5.2.2 Condition Setting

The equation used to calculate the LPG vapourisation rate was observed. Based on the idea of natural evapouration, the vapourisation rate of the LPG in the container must be equal to or greater than the demand of the LPG in the container for any container size intended for vapour withdrawal system (Arya et al., 2016; Falkiner, 2003).