Flow Pattern around Traditional Malay House using Enhanced Smoke Wire Technique in a Boundary Layer Wind Tunnel

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Abstract

Traditional Malay houses are well-known for their excellent natural ventilation. The claim was supported in a study which compared the temperature measurements in traditional Malay houses with temperature measurements in modern homes. However, few flow pattern studies have proven this fact. This paper aims to understand this phenomenon qualitatively by utilising smoke lines produced by the smoke wire technique to observe the flow pattern around a single model traditional Malay house mounted over a smooth plate in a small-scaled quasi-atmospheric boundary layer wind tunnel. Observation of the conventional model house has highlighted several common and unique flow patterns from the high-speed footage. The smoke visualisation technique will provide flow visualisation and capture using a high-speed camera at 1000 fps. In addition, the paper also focuses on developing improvements for the smoke-wire technique system by upgrading the controlled drip valve and adding a tensioner system. Limitations and the ideal conditions have been recorded for the smoke-wire technique, which improved the overall quality of the observation. The models were used did not have any opening or only a single opening has started to show good natural ventilation. However, having only inlets for the airflow has failed to show observable good natural ventilation.

1. Introduction

Traditional Malay Houses (TMH) are well known for their excellent natural ventilation. Studies have shown that they could be cooled downed passively to the comfort level (25.5-28°C) [1], [2]. This is due to the features that make them unique, which include being on stilts, tall windows and doors, feature panels designed to allow air penetration into the house, and a sloping roof with a penetrable area under the overhangs. They are commonly built in an open space [3]–[5]. However, few qualitative studies investigate the flow pattern around TMHs to support the above claim.

One of the methods of flow visualisation that have been widely used in observing flow patterns around bodies is the smoke-wire technique (SWT) [6]. This technique is known for its simplicity without lessening the quality of the flow pattern compared to the other intricate methods, namely, Particle Image Velocimetry (PIV) or Laser Doppler Anemometry (LDA). This technique produces smoke filaments by heating wires coated with a specific fluid [1] that includes safex, palm oil, diesel, gasoline, corn oil and water [2]. Although SWT is known for its ease of use, SWT comes with several limitations. A study discussed capacitor utilisation as the power source to protect wires from burning [7]. In addition, many camera techniques have been implemented to improve the visibility of the flow pattern, such as the use of Silhouette Cinematographic [8] and the use of laser sheets [9]. In a cinematic framerate (24 frames per second), the smoke's movement would be blurry, requiring high-speed recording to help reduce the motion blur. [10]. Furthermore, studies have also shown that the smoke wire would cause the airflow to become fixed vortex pair at higher air velocity [11] and the smoke wire will burn up if excess power is out into them [7]. Initially, SWT is limited to only a single wire which uses a manual dripping system [12], [13]. In our previous work, an enhancement was made by fabricating a Control Dripping Valve (CDV) system to increase the total number of wires from a single to 10 lines and run automatically instead of manual. However, the original CDV system shows problems with the smoke density and coverage, which can be attributed to the issue of the combination between power input and airspeed.

Due to the above circumstances, the present work motivates to improve the existing SWT by implementing CDV, a tensioner system and further optimisation of power input and velocity for continuous and thick smoke productions to investigate the flow pattern around a single TMH model mounted on a smooth wall in a small-scaled quasi-atmospheric boundary layer wind tunnel (BLWT). The resulting flow pattern would be recorded and observed using high-speed camera recordings at 1000 fps at a playback speed of 30 fps.

2. Methodology

2.1. Small Scaled Quasi-Atmospheric Boundary Layer Wind Tunnel (BLWT)

The studies were carried out in the Faculty of Mechanical Engineering Laboratory, University Malaysia Pahang, Malaysia, in a boundary layer wind tunnel apparatus that had been adapted to suit the study's needs.