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# Flow analysis of a set of ornamental chimney caps designed by Antoni Gaudí

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**Abstract**

We analyzed theoretically and experimentally the performance of the 19 different ornamental caps of the individual chimneys located on the terrace of Palau Güell (Barcelona, Spain) designed by Antoni Gaudí. This set of chimney caps has wide range of external geometries and different number and shapes of openings. Models of the chimney caps were obtained using photogrammetry and 3D printing. Wind tunnel measurements of the pressure inside the stack pipe connected to the cap were performed for different external and stack flow velocities. Two distinct orientations of the external flow with respect to the chimneys were considered. We derived a simple theoretical model, based on the potential flow theory, to relate the non-dimensional pressure reduction in the stack (chimney draft) with the ratio between the external and stack flow velocities. It has been found that the behavior of the chimneys caps predicted by this model is in agreement with the measurements. It has been found that the performance of the chimneys depends mainly on the number of supports of the conical cover of the cap and it is essentially independent on the shape of the cap and on the number and geometry of the openings located on the cap. These conclusions obtained for this particular set of chimneys can be useful for the design of caps for ornamental or general use.

**Keywords:** Antoni Gaudí, Palau Güell, Chimney caps, Chimney draft, Ornamental chimney, Fluid mechanics, Wind tunnel

## Introduction

Chimneys have been widely used to conduct combustion and flue gases and other contaminants from animal housing and domestic and industrial sources to the atmosphere. They are also an essential part of many natural ventilation systems [1, 2]. In these systems the outlet flow rate is governed by three effects: (1) the difference in air density between the inside and the outside of the building due to temperature and/or composition (humidity) of the air, (2) the aerodynamic effects due to the wind flowing around the building and (3) the location and the geometry of the ventilation elements.

Chimney caps, fitted at the top of the chimney, usually are mainly designed to protect the stack conduit from rain and to inhibit downdraft. In some cases, their design is also oriented to improve the draft. Examples are stationary [3, 4] and mobile suction caps which are oriented by the wind to locate the exit aperture windward [5] and rooftop turbine ventilators [6, 7]. Besides the practical advantages of the chimney caps, these devices have been used for ornamental purposes since Roman times [8]. In the Middle Ages ornamental chimney caps were progressively sophisticated to indicate and show richness and power. The culmination of chimneys with visible ornamental caps has been a way to emphasize that the building was equipped with heating and consequently the inhabitants were in a good social position [9, 10]. Two well-known examples are the chimneys of the Hampton Court Palace (Molesey, UK), designed by Christopher Wren in 1514, and the chimneys of the Palau Güell (Barcelona, Spain), designed by Antoni Gaudí in 1890.

The determination and analysis of the flow characteristics of full ventilation systems or individual

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