Atmospheric Research 151 (2015) 236–249

Contents lists available at ScienceDirect

Atmospheric Research

journal homepage: www.elsevier.com/locate/atmos

Large fog collectors: New strategies for collection efficiency and structural response to wind pressure

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ARTICLE INFO

Article history:
Received 28 October 2013
Received in revised form 6 June 2014
Accepted 15 June 2014
Available online 21 June 2014

Keywords:
Large fog collector
Fog
Water
Fog water
Fog collector screen
Fog collector structure

ABSTRACT

Most studies of large fog collectors (LFC) have focused on the collection efficiency, the amount of water collected, or economic and social aspects, but have not addressed the effects of strong winds on the system. Wind pressure is directly related to fog water collection efficiency but on the other hand may cause serious damage on the structure of LFCs. This study focuses in the effects of wind pressure on the components of the LFC as an integral system, and the ways to face strong winds with no significant damage. For this purpose we analysed cases of mechanical failure of LFCs both in our experimental station at Peña Blanca in Chile and elsewhere.

The effects of wind pressure can be described as a sequence of physical processes, starting with the mesh deformation as a way of adapting to the induced stresses. For a big enough pressure, local stress concentrations generate a progressive rupture of the mesh. In cases where the mesh is sufficiently strong the wind force causes the partial or total collapse of the structure. Usually the weakest part is the mesh, especially close to where it is attached to the structure. The way the mesh is attached to the frame or cable of the structure is particularly important since it can induce significant stress concentrations.

Mesh failure before the structure failure may be considered as a mechanical fuse, since it is cheaper to repair. However, more practical mechanical fuses can be conceived.

In relation to structural performance and water collection efficiency, we propose a new design strategy that considers a three-dimensional spatial display of the collection screen, oblique incidence angle of wind on mesh and small mesh area between the supporting frame. The proposed design strategies consider both the wind pressure on mesh and structure and the collection efficiency as an integral solution for the LFC. These new design strategies are the final output of this research. Applying these strategies a multi-funnel LFC is proposed, which is far more efficient than the conventional one, and even though it is more expensive, the final cost of the collected water should be notoriously reduced.

1. Introduction

The availability of fresh water is one of the most crucial problems for social and economic development around the world (United Nations, 2008) and fog water collection projects could contribute to solve this problem. Fog water collection has been studied and proved for decades as a feasible alternative source of fresh water in semi-arid areas with the presence of suitable persistent fog. This is common in arid and semi-arid areas close to the ocean, where clouds are formed over the sea and then pushed by predominant winds towards the continent, where they turn into fog when

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http://dx.doi.org/10.1016/j.atmosres.2014.06.005
0169-8095/

intercepted by high lands. This kind of fog is addressed as 'advection fog', although sometimes orographic fog also contributes to fog water collection (Cereceda et al., 2002, 2008b). Several studies have recognised the potential of fog water collection for human consumption around the world, in places such as: Pacific coast of northern South America (Cereceda et al., 2008a,b, 2002; Larrain et al., 2002), the Canary Islands (Marzol, 2002, 2008), Morocco (Marzol and Sánchez, 2008), South Africa (Olivier, 2002; Olivier and de Rautenbach, 2002; Louw et al., 1998), Oman (Abdul-Wahab and Lea, 2008; Abdul-Wahab et al., 2010), Saudi Arabia (Al-hassan, 2009; Gandhidasan and Abualhamayel, 2006), western Mediterranean basin (Estrela et al., 2008), and Namibia (Shanyengana et al., 2002).

Since the first studies made by Carlos Espinosa in Chile, 1957 (Gischler, 1991), fog water collection projects had relied on different designs of fog collection devices, where the flat screen large fog collector (LFC, see Fig. 1) is the most common type of design used in the last decades (Schemenauer et al., 1988; Schemenauer and Cereceda, 1994b; Gischler, 1991). The materials used for the LFC are usually simple components, locally available, because the main focus of fog water collection projects has been to provide fresh water to small, poor communities around the world. These projects have been mainly supported by non-governmental organizations (NGO), which are responsible to install the system (Klemm et al., 2012; Schemenauer et al., 2005).

One of the main problems that affects the sustainability of fog water collection projects is maintenance of the LFC that are frequently damaged by strong winds events, the sun (UV radiation) and other environmental factors which affect the structure, mesh and other components (Schemenauer et al., 2005). Since the collection systems are usually installed in poor communities in developing countries, personnel in charge of maintenance have neither the technical nor the economic resources to repair them and, eventually, this implies the abandonment of the project (de la Lastra, 2002).

Recently, Klemm et al. (2012) made a thorough review of existing LFC installations around the world. However, they did not analyse in detail the effects of wind pressure on the

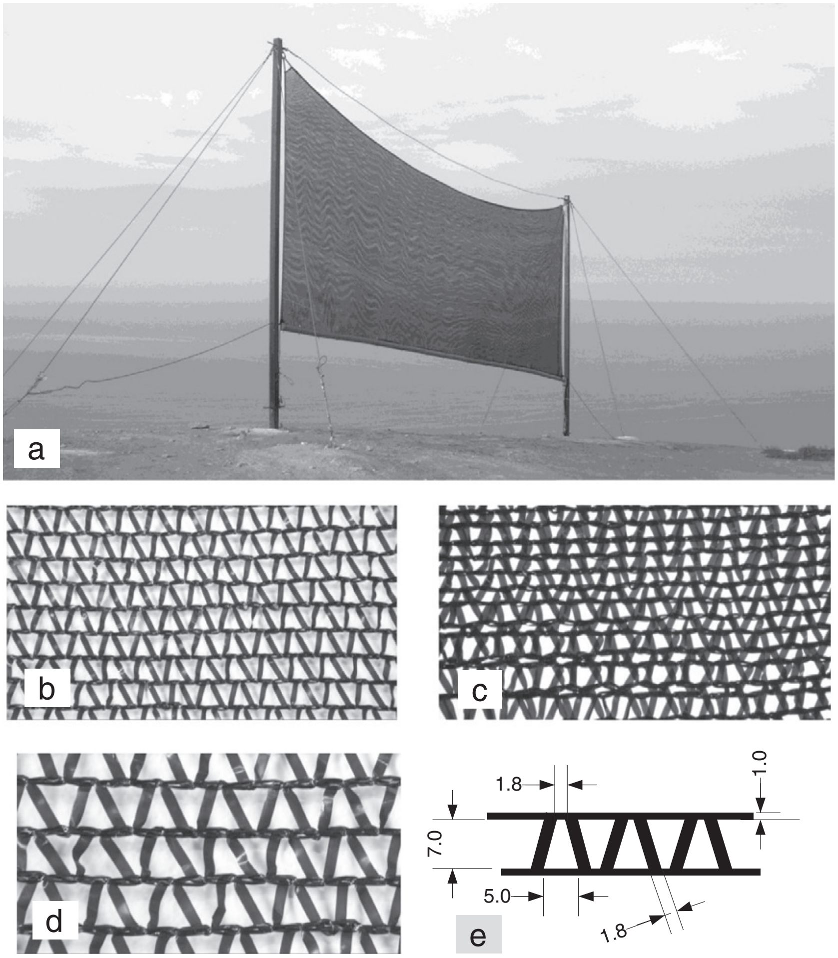

Fig. 1. a: The most common type of design for a large fog collector (LFC), based on a flat screen, has been used for decades. Example of a flat screen LFC at Alto Patache, Chile. b: Single layer Raschel mesh, 35% shade coefficient. c: Double layer Raschel mesh, 35% shade coefficient each layer, notice the uneven local shade coefficient resulting from the overlapped meshes. d and e: Details and dimensions in millimetres of the structure and the filaments of a typical Raschel mesh (www.marienberg.cl).