Performance of an effervescent atomizer for geo-engineering purposes

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Abstract

One candidate spray nozzle for geo-engineering systems that fight global warming is the effervescent atomizer. Performance of a device is provided in terms of characteristic drop diameter (D_{30}) and mean velocity. Performance scaling with injection pressure is also reported.

Introduction

Due to an ever increasing population and increasing *per capita* energy use from traditional sources to support an elevated standard of living, the production of greenhouse gases continues to remain high. In order to prepare for the most dire predictions of global climate change, many scientists are now calling for research into alternative schemes intended to alter the earth's temperature.

One promising method is outlined by Salter *et al.* [1]. A fleet of remote controlled ocean vessels (Figure 1) are to inject a fine mist (drop diameter < 2.5 μm) of sea water into carefully selected marine stratocumulus clouds thereby increasing the average drop concentration. This will enhance the cloud reflectivity via a mechanism known as the Twomey effect [2]. As a result, more solar radiation will be reflected back into space, thereby reducing global temperatures.

Currently very little data exists to confirm the feasibility of the design. Unanswered questions include: (1) What is the most effective size drop? (2) Can such drops be produced on a large scale with the limited amount of power available? (3) Will natural circulation be effective to transport the drops to the clouds as intended? and (4) Can the effects be easily reversed if needed? Due to uncertainty in available models, an experimental proof of concept is needed. Unfortunately, commercially available atomizers are not capable of producing the desired drops sizes and flow rates. Therefore, additional research and development is required.

Effervescent atomization, a technique developed by Arthur Lefebvre while at Purdue University, appears promising for this purpose. Figure 2 shows such an atomizer designed for diesel injection, which Sovani *et al.* [3] demonstrated is capable of producing mean drop sizes (D_{32}) on the order of 2.5 μm. With additional design improvements it is believed that drop sizes on the order of 0.5 μm are possible. Salter *et al.* [1] predict that the optimum drop size is somewhere within this range.

Materials and Methods

The goal of Phase I of this study is to demonstrate the feasibility of effervescent atomizers via laboratory measurements at pressures up to 70 MPa. The goal of Phase II is design of a high mass flow rate (~10 kg/s) injector for testing on an ocean vessel.

Drop sizes, velocities, and concentration were measured using a Dantec PDA. While the laboratory is equipped for liquid injection pressures up to 200 MPa, gas injection pressures in this study were limited to 10 MPa.

Results and Discussion

Initial testing was conducted at injection pressures of ~7 MPa and a variety of air-liquid ratios (ALR) resulting in a D30 of around 15 μm that is independent of ALR. From previous investigations [4] it is known that drop sizes for this type of device scale as the inverse of the supply pressure. Therefore an increase in the gas injection pressure to 70 MPa is expected to yield mean drop sizes on the order of 1.5 μm.

References

[1] References

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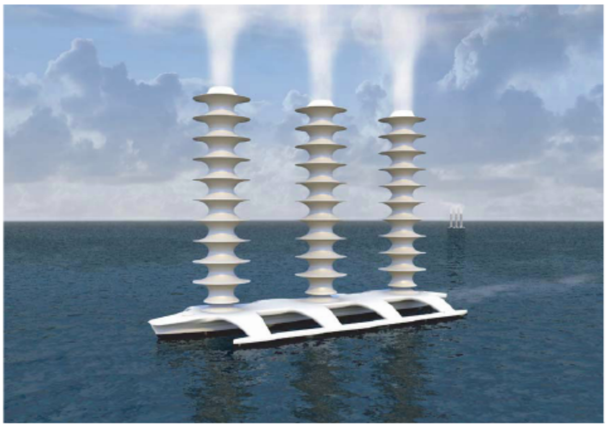

Figure 1. Artist rendition of spray vessel [1]

Figure 2. Effervescent diesel injector [2]