STEAM GENERATION BY CARBON NANOPARTICLES BASED ON SOLAR RECEIVER

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ABSTRACT: Steam production is essential for a wide range of applications, and currently there is still strong debate if steam could be generated on top of heated nanoparticles in a solar receiver. We performed steam generation experiments for different concentrations of carbon nanoparticles dispersions in a cylindrical receiver under focused natural sunlight of 650 Suns. Combined with mathematical modelling, it is found that steam generation is mainly caused by localized boiling and vaporization in the superheated region due to highly non-uniform temperature and radiation energy distribution, albeit the bulk fluid is still subcooled. Such a phenomenon can be well explained by the classical heat transfer theory, and the hypothesized ‗nanobubble', i.e., steam produced around the heated nanoparticles, is unlikely to occur under normal solar concentrations. In the future solar receiver design, more solar energy should be focused and trapped at the superheated
Keywords: Nanoparticle, steam generation nanobubble, solar energy, volumetric receiver , stand .

I. INTRODUCTION

Steam production isessential for a wide range of applications from large scale electricity generation energy storage , desalination systems and refrigeration units to compact the small scale systems such as sterilization and clearing. Conventionally steam is produced by the combustion of fossil fuels or direct heating from electricity, which is environmentally unfriendly. Employing solar energy, an abundant, clean and renewable energy source, for steam production is a rapidly developing area. Currently solar-based steam production (i.e., either solar trough or solar tower systems) is based on heating a bulk fluid to its boiling temperature under high optical concentrations. The steam generation efficiency heavily relies on the surface temperature and radiation properties of the absorber, whose high temperature needed for bulk steam production leads to large heat loss to the ambient and low energy efficiency. It has been reported recently that certain nanoparticles, especially those with Localized Surface Plasmon Resonance (LSPR) properties can absorb solar energy efficiently in a liquid Medium. For an aqueous nanoparticle dispersion it would lead to a rapid increase of the particle temperature and steam production, albeit the bulk fluid was still in the subcooledstate . For example, the research team from Rice University showed that by using a very dilute gold nanoparticles dispersion, i.e., 16.7 ppm, under focused sunlight via a Fresnel Lens, rapid steam production was realized while the bulk fluid temperature was still at ~ 6 . The calculation showed that the steam generation efficiency was reached up to 80%, and only a small portion of the solar radiation was used to increase the bulk fluid temperature. Similar to the concept of energy localization on the surface, it appears that solar energy was localized by the nanoparticles. It was further hypothesized that rapid heating of nanoparticles produced nanobubbles immediately around the nanoparticles, and the rise nanobubbles to the top surface of the liquid realized the release of the vapor produced . Subsequent simulation work showed the possibility of nanobubble formation based on a non-equilibrium phase change assumption. The heating of nanoparticles and formation of nanobubbleshave become an intensive research topic in the medical area. It has been confirmed both experimentally and theoretically that under an intensive laser heating (i.e. > 1000 MW/m2), bubbles can be generated around the heated nanoparticles. By controlling the laser power and pulse appropriately, the growth and contraction of bubbles can be very fast, which is associated with the propagation of pressure waves that could bring thermal-mechanical damage to surrounding cells at a dimension much larger than that of a single nanoparticle. (halas, 2012) so basically we done our project by using sunlight with the reflection of rays with the help of concave mirror and focusing at its focus point where carbon nanoparticles solution is placed to be heated and form steam . so that the steam can be used in various types of applications.

II. EXPERIMENT DETAILS

A one-step method was employed to produce stable carbon nanoparticles (CNPs) dispersions. First, carbon nano particles are mixed in DI/distilled water in a cylindrical flask, then a heating source such as sun was used to heat the liquid until the occurrence of boiling. The generated steam is then is received by the receiver valve and supplied to desired path. It is important to set the focus of sun at the cylindrical flask to maintain the constant supply of heat.To have the concave mirror we just have a lot of pieces of plain mirror approx to 650 and fix on the concave type dish that can be rotated at desired level to track the sun direction. The project also contain the many components such as turbine, motor, concave mirror, a base to hold the all the things etc.

Fig : Solar illumination experiment under natural sunlight condition (Kundli,Sonepat,Haryana 131030 India

III. RESULTS AND DISCUSSION

Temerature profile

Once the tube was illuminated under 650 suns, fluid temperature rose immediately and main observation.

It was difficult to DI water to reach boiling under such a solar intensity(i.e. 650 suns)

- The highest temperature increase to only 65 degree celcius in 30 minutes.
- All CNPs dispersion reach the boiling fast and then remain unchanged at the value. Increase the volume concentration could reduce the time required to reach the boiling point.

Steam production characterizationn

During the experiment it was observed that after few minutes illumination most of the bubble were originated around the top of the in new surface of the tube.

Steam generation mechanism

The experimental result clearly shows that employing CNPs can significantly increase the absorption of solar energy leading to more efficient steam generation

Non uniform temperature distribution

Experimental result indicated that the heating up and vaporisation process were highly non equilibrium with highly non uniform temperature distribution of CNPs dispersion.

IV. CONCLUSION

The work investigated the steam generation of CNPs based solar volumetric receivers. Experiments were performed for CNPs dispersion in cylinder tube under focus natural sunlight condition, and 3D numerical model was also established to simulate the temperature profile within the sample fluid and the heat transfer between a single particle and the surrounding fluid. It is found that steam generation of nanoparticle – based volumetric solar receiver is not due to the nanobubble formation on top of heated particles. But caused by a highly localized solar absorption in the focal area were intensed boiling and vapourisation occur, by considerable non uniform temperature distribution within the fluid may exist in the heating –up stage. By increasing the volume concentration of CNPs dispersion more solar radiation energy is localized at the top surface of the receiver, leading to stronger boiling and surface vapourisation in the superheated region, although the bulk fluid is still in the subcooled state.the work reveal that in the future solar receiver design more solar energy should be focused and trapped in the superheated region while minimizing the temperature rise of the bulk fluid.

REFERENCES

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