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A STUDY ON THE SHEDDING OF DROPS ON A HYDROPHILIC SURFACE

Shanti Priya Vatsh[1], Arvind Kumar Yadav[2], Deepak Mandal[3]
Sandeep Sharma[4], Abhimanyu Sharma[5]

Department of Mechanical Engineering, Indian Institute of Technology (ISM) Dhanbad (India)

ABSTRACT

The present work deals with the shedding of liquid drops with the flow of air. Which is still not adequately addressed .The effect of surface wettability , physical properties of water drops and the process of surface detachment was studied .A sessile water drop exposed to an air flow will shed if the adhesion is overcomed by external aerodynamic forces on the liquid drop.In shedding of water droplets is investigated in different conditions on hydrophilic surfaces. A wind tunnel is used considering the temperature as constant.The main focus was on the behavior of the drop with type of surface and with the treatment given to it.A hydrophilic surface are those on which drop makes an acute angle with the surface i.e angle less than 90 degree. Hydrophilic surface has more affinity towards liquid. A relation is developed between the different volume of water droplet (in µl) on the x-axis and the critical velocity in m/s on the y-axis. Graph trend shows that as the volume increase the critical velocity decreases.The drop movement was captured by two cameras.The position of upstream and downstream contact points, baselength height was measured using image processing .The deformation and sliding of the drop was also observed.

KEY-WORD- Adhesion, Base length,Contact angle hysteresis, Drop shedding,Surface wettability.

I. INTRODUCTION

Drop motion of a surface is the subject of research for its practicle and fundamental importance with regard to many application processing industry (e.g distillation,water management in fuel cell [12,13] ,spray coating and condensation,enhanced oil recovery[12,13] ,cleaning [13,14,15,16] ,biological application(soiling of vehicle and avoidance of airframe icing[1,2,5,9,].A sessile drop to initiallydeform under the action of aerodynamic stresses. I f the aerodynamic forces applied to the drop is high enough,the drop start to move along the substrete,various condition may influence like surface wettability,surface roughness, surface affinity [2].Practically when the sessile drop is placed on the surface, inside the test section of the wind tunnel, the air flow induces a drag on the drop and when the drag force just exceeds the adhesion force then the drop start moving [3,4,5,6] .The velocity of incipient motion is called the critical air velocity [3,4,5] , it depends upon the shape of the drop and the surface adhesion . The higher the adhesion , higher the critical velocity required to drag the drop [3,4] . Adhesion is higher for hydrophilic surface [3] . The adhesion depends upon the surface tension [17,18] , contact angle hysteresis and size of the drop . [3,4,5,6,19].Study has been done on the hydrophilic surface by comparing the normal surface behavior with the treated surfaces (surface is treated with sun and water) . Surface was

treated with sun for (6,12,18)hrs and same was done with water. So as the amount of hour of treatment with sun or water increases the hydrophilic property increases and comes close to the normal behaviour . As the surface treatment hour with sun or water increases the critical velocity increases. For 6hr it is lower for 18 hr it is highest. Contact angle, contact angle hysteresis (CAH) and base length determines the wetting characteristics. As the treatment hours of the surface increases the characteristics like the, contact angle hysteresis, base length increases, but contact angle decreases.

In the present paper the influence of treatment (i . e sun and water treatment) on the shedding of the sessile water drops with volume ranging from 10µl to 100µl is studied .The result of normal hydrophilic surface is compared with the sun treated surface (6hr,12hr,18hr) and the same process is followed for the water treatment on the same plot of critical velocity(y-axis) vs volume(x-axis) .

Our previous papers are conceptually different from this work in the manner as follow. The experimental evidences and justification of flattening of a given drop on various substrates under differential treatment condition. The details affecting the adhesion of the surface. The loss of the hydrophilic characteristics with the different treatment and the variation of the critical velocity with respect to volume under different treatment condition.

II. EXPERIMENTAL SETUP

The velocity and the temperature is measured using an electronic sensor.set up is having the dimension of 4.8” each side (inside area).the test section has a square tunnel part with length of 19” and two convergent part on both ends which is which is having the area in decreasing order of 4.8”x4.8” to 2”x2” .A phantom camera v4.3 high speed camera operating at 500 frames/s to capture the side image of the drop. It consists of navitar lenses having the magnification of 0.56 and the resolution of 38µm/pixel.Camera is connected with a 12v dc supply.A diffused light source was used behind the test section as per the requirement.One end of the setup is added with the test section having the outer dimrnsion of 2”x2” and the other end of the test section consist of a blower which provides the

necessary velocity.As per the requirement we set the blower on the minimum velocity as per the size of the test section.Test section should be prepared keeping in mind that their should not be any leakage.On the blower side also the leakage should be prevented as much as possible as it can create extra turbulence Before starting the experiment calibration is performed i.e velocity w.r.t to time graph is plotted by taking the reading of the blower (with the help of velocity meter) with time.Experiment procedure began with placing a drop on the glass surface using a micropipette .

2.1The experimental setup is shown schematically in figure.

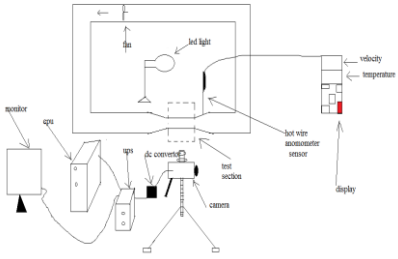

FIGURE 1 :- Set up diagram with all its equipment intact.

The surrounding temperature is stabilized prior to performing the experiment, then both camera and fan was triggered at the same time,the delay between placements of drops and triggering the camera and fan was typically 3-5 s. The airflow was increased gradually and the drop shedding procedure is recorded after the drop shedding procedure was recorded then the upstream and downstream contact point was recorded using MATLAB software.Incipient motion was defined as the instant at which the difference between the instantaneuous and the initial upstream of the drop was 5 pixel or 190µm and the corresponding velocity is called the critical air velocity at that time.The drop volume was taken as 10,20,60,100 (µm).The surface choosen for the experiment is hydrophilic (PMMA coated glass slide).Hydrophilic surface is prepared with PMMA material which is prepared by dissolving 1% by weight of pmma powder with 99% by weight of tolune . Experiment was performed on the hydrophilic surface on the three aspects i.e the surface was treated with water for 6hr, 12hr, 18hr, then with sunlight for the same time period and at the end for the normal hydrophilic surface it wasalso performed, then a particular volume of drop was taken thrice to minimize the chances of error , for example if we took 10µm drop then it was taken three times.

III.GRAPHS AND RESULT

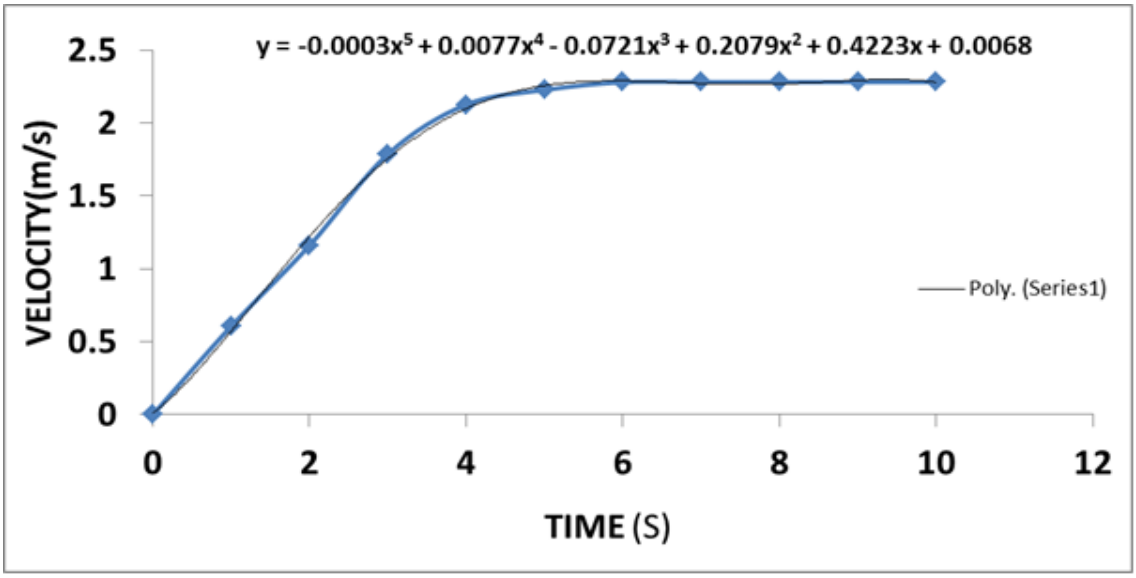

FIGURE 2.1:- Graph between critical air velocity (m/s) for the incipient motion as a function of time(s). Graph shows that as the time increases critical velocity first increases linearly then it became constant.

Critical air velocity is calculated by the method of calibration with the help of a device called as anemometer. Velocity of the blower is measured with respect to time. The values obtained there are plotted, plot gives a linearly Increasing graph in terms of y (critical air velocity) and x (time) initially then after some time it changes to constant. This graph gives an equation which results into the calculation of critical velocity (y) for a particular time (t) interval.

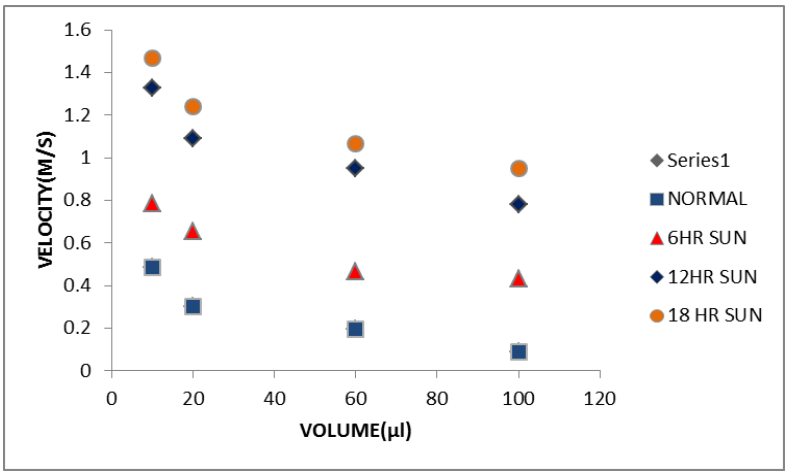

FIGURE 2.2:-Graph between critical air velocity (m/s) for the incipient motion as a function of volume (µl). Graph shows the relation between the normal hydrophilic surface and the surfaces being treated with sun for 6hrs, 12 hrs and 18hrs.

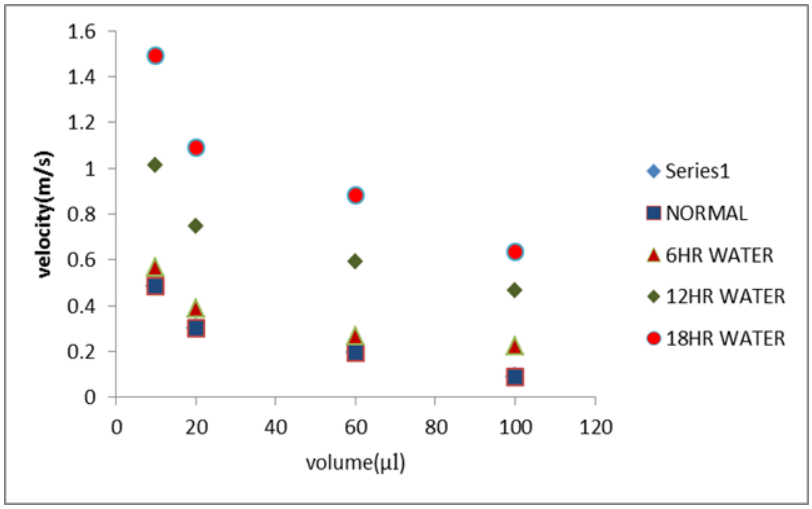

FIGURE 2.3:- Graph between critical air velocity (m/s) for the incipient motion as a function of volume (µl). Graph shows the relation between the normal hydrophilic surface and the surface treated with water for 6hrs, 12 hrs, 18hrs

Figure 2.2 and 2.3 shows the critical air velocity with respect to different volume of the drops. For the small drops on the hydrophilic surface critical velocity decreases as the volume of the drop increases. Here normal surface is compared with sun treated surface (6hr, 12hr, and 18 hr) and water treated surface separately. Graph shows same trend for all surfaces treated in different condition. Critical velocity graph increases as the hour of treatment with sun or waterincreases. Critical velocity shows decreasing value from 18 hr to 6hr for any treatment for sun or water. To explain the increase in the critical air velocity, one should question whether the drag coefficient is reduced under treatment condition or whether any other parameters like CAH, base length etc is changed. To examine if the drop is flattened then it symbolizes that the hydrophilic characteristics prevailing and affinity towards the drop increases. As the hours of treatment increased the drops acquire more area i.e drop gets flattened, so the base length of the drop increases. Same trend is shown by the contact angle hysteresis

(CAH) but contact angle decreases. A lower drag coefficient and higher adhesion for a given drop volume together provides an explanation for the reason to shed a drop under treatment condition.

IV. CONCLUSION

The drop base length and the contact angle increases as the treatment hours of sun and water increases compared to the normal hydrophilic surface. The increase in the base length, decrease in the contact angle and increase in the contact angle hysteresis shows that adhesion increases as the drop volume increases. The drop base length increases on the other hand the base gets flattened. Higher adhesion results into higher air critical velocity, however it may differ for different volume of drops under different treatment.

As the hydrophilic behaviour start prevailing or the surface starts losing its coating due to more hours of treatment with sun or water the critical velocity increases.

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