2017 International Bionic Innovation Competition

Bio-inspired elastic thermal conductive wall for drag-reduction

Abstract

Inspired by the fluid control mechanism of the elastic and boundary heating abilities of dolphin skin, we prepared a new kind of elastic thermal conductive composite using graphene as the filler and silicone rubber as the matrix. The drag reduction mechanisms of thermal conductive elastic wall (TEW) depend on the elastic deformation and the thermal conductivity. TEW have a better drag reduction performance than that of Elastic wall (EW). TEW could delayed the aging process and increase the service life of the fluid machinery.

Methods

Types of TEWs with different thicknesses were prepared to study the drag reduction performance among elastic and rigid walls. Fig.2 was the results of mechanical and thermal properties of the walls. To study the performance of the walls, internal flow equipment with a testing system (fig.3) was designed based on differential pressure measurement.

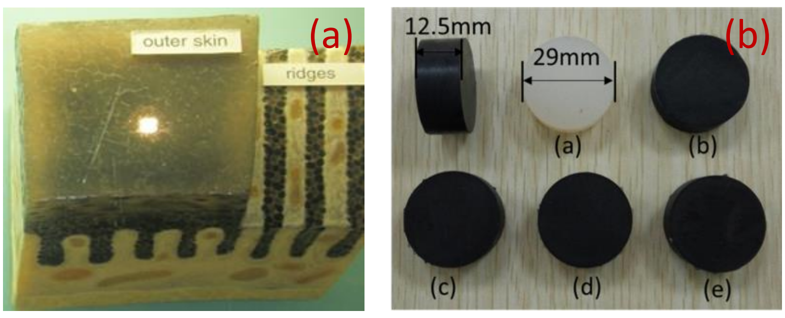

Fig.1. (a) Dolphin skin texture. (b) Samples of TEWs and EW.

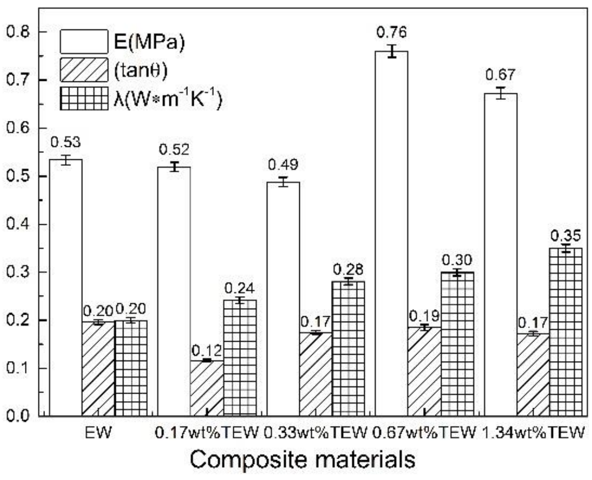

Fig. 2. Mechanical and thermal properties of the TEWs.

Results and conclusions

1. The thermally conductive elastic wall exhibited the most optimal drag reduction effect, the maximum drag reduction rate of the elastic wall reached 8.54%.

2. The elasticity deformation increased the boundary layer thickness and decreased the velocity gradient, reducing the shear force.

3. The heat produced by the elastic deformation of the TEW was conducted at the boundary layer and decreased the viscosity, resulting in drag reduction.

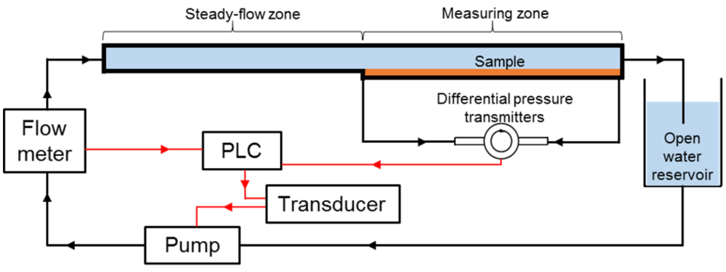

Fig. 3. Schematic of the experimental setup.

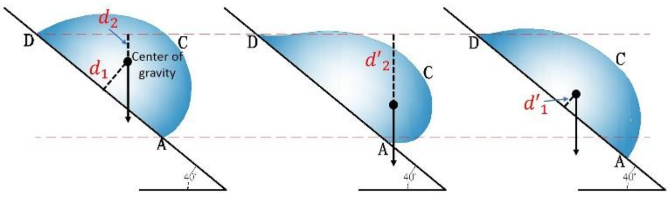

Fig.5. Water droplet shapes on TEW at different temperatures.

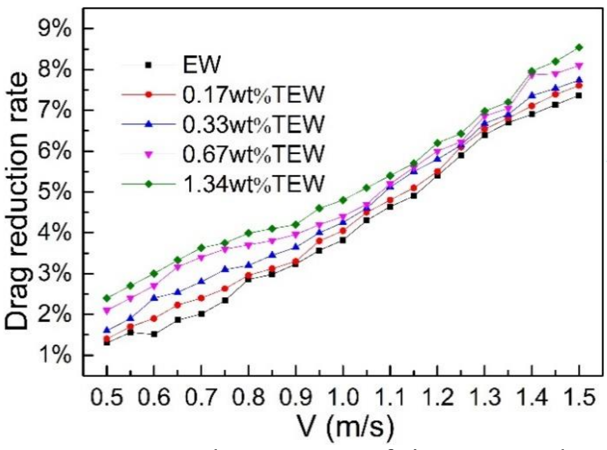

Fig. 4. Drag reduction rate of the TEW and EW.

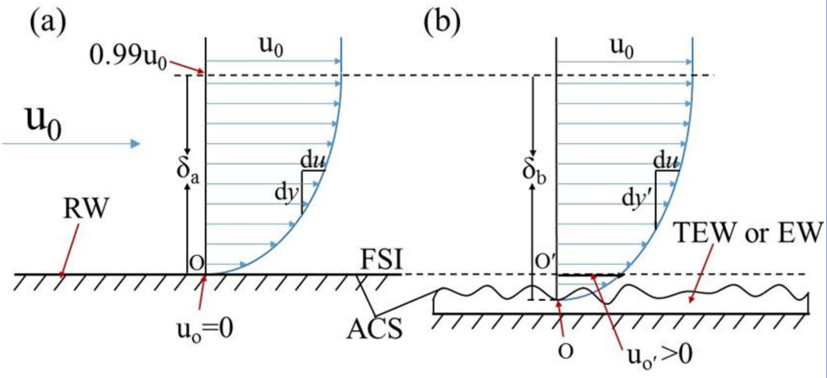

Fig. 6. Schematic diagram of the dynamic deformation and the velocity gradient: (a) RW and (b) TEW or EW.

Engineering application

Based on above results, we apply the thermal conductive elastic composites to the impeller surface of pump. After running the same time and observing impeller wear condition, we found that the impeller of the bionic pump has less wear and better flow characteristics, compared to the prototype pump.

Fig. 7. A bionic coupling impeller.

Publications and Patents:

- Drag reduction performance and mechanism of a thermally conductive elastic wall in internal flow[J]. *Applied Thermal Engineering*,2017, 123:1152-1157.
- The thermal conductivity-dependant drag reduction mechanism of water droplets controlled by graphene/silicone rubber composites[J]. *Experimental Thermal and Fluid Science*, 2017, 85:363-369.
- Development of drag-reduction test System of Bionic Function Surface with internal flow[J]. Journal of Jilin University (Engineering of Technology Edition), 2017,47(4),1180-1184.
- A device for measuring the flow field parameters of thermally conductive elastic surface,CN105547929A.
- A thermostatic switch with a delay [P], CN106531551A.