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Short Communication

Making fire by drilling different wood materials: a revisit to an old story

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ABSTRACT

The fire is closely related to people's life. The essence of making fire by drilling wood is the process which can transform mechanical energy into heat. When the speed of heat generation by kinetic energy is faster than the external heat dissipation during friction process, the temperature of sliding contacts will be rising all the way to the ignition point of wood. The aim of this paper is to investigate the old story quantitatively by drilling three different wood materials and by correlating the change of the temperature gradient with friction coefficient. The underlying mechanism is tentatively discussed. As a result, a kind of material can be suggested that is most suitable for making fire.

1. Introduction

Friction is one of the most basic phenomena in everyday life; tribology is an interdiscipline that investigates the mechanism of friction, lubrication and wear between the surfaces in relative motion. Although many efforts have been devoted to tribology area [1–6], there are still many things are interesting to be known, such as the origin of friction. However, the history of the utilization of friction to make fire by drilling wood by our ancestors can date back to the paleolithic era. The invention of the Stone Tools also benefits from the stone wear-resistance for more effecient hunting activities [7].

Fire is produced during burning, characteristic of illuminating phenomenon. A strong oxidation reaction can be occurred in a flame of fire, concurrent with plasma generation on the top of flame. The elements indispensable for making a fire are fuel ignition, temperature increase and the presence of oxidant. According to the law of conservation of mass, the combustion transform materials to different existing patterns by chemical reaction. The application of the fire is an important event in the history of human civilization, allowing possible cooking food, sending distress signals, fighting against infection and processing metal tools, etc. Several methods of making fire have been developed. At the beginning, people made fire by keeping the fire seeds in ancient times. Thunder and lightning are considered as fire seeds, but this is not very often happened. Then, people invented the flint fire method. Making fire by drilling the wood was invented by Suiren of an ancient Chinese wise man, which can be easily understood, but a hard-working thing. People developed an easy way to make fire by using a convex mirror to focuse sun light. Many others were also invented in the long history of human evolution, such as bow drill fire, waterproof matches, the flash light and small stone sticks etc.

Many fire-making approaches are based on the science of friction with the essence of transforming mechanical energy into internal energy (heat). The physical principle of making fire by drilling wood is the generation of heat by friction: at fast relative motion between sliding wooden pairs, the speed of heat generated by kinetic energy is faster than the external heat dissipation, the temperature of wood will be rising. Then the fire can be initiated when the temperature reaches the ignition point of wood. The main aim of paper is to revisit the old story of making fire by drilling different wood materials with different textured structures, to investigate the change of the temperature gradients and to correlate the fire initiation with coefficient of friction. Eventually, a kind of material which is most suitable for making fire is proposed.

2. Experiment

2.1. Material

Pine, platane and fir original wood were derived from Hubei province of China. These kinds of original wood have been further

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processed in a local store. First, the basal wood was punched with a hole of 0.015 m in diameter. The hole has an inverted trapezoidal structure for a guarantee of a good contact of wood with oxygen. Before test, the woods were dried in the oven at 45° for 2 h to remove the existed water inside.

2.2. Friction and wear test

The tribological tests were implemented on a high-speed reciprocating HSR-2MT tribometer. The stroke was 5 mm in length. The wear tests were carried out at room temperature under a load of 5 N. The sliding speed was fixed at 300 revolutions per minute (rpm), respectively. The samples were pine–pine wood, platane–platane wood and fir–fir wood. Each test was repeated three times. The friction time is 60 s, and the consequential friction coefficient were recorded automatically.

2.3. Making fire by drilling different wood materials

The tests were carried out at room temperature under a constant load force. The sliding contact of wood pairs was carried out by an electric wood drill. Drill head and basal material sample were pine–pine wood, platan–platane wood and fir–fir wood. The speed of electric drill is 20 rad/s. The temperature of sliding contacts will be rising as the sliding time increases. The temperature of the drill head and basal wood can be recored by infrared thermometer. Additionally, it is good to put some wood chips into the basal sample to help combustion.

2.4. Instrumentation and characterizations

Scanning electronmicroscopy images comes from JEOL JSM-5600LV scanning electron microscopes with Au-sputtered specimens. The X-ray Photoelectron Spectrometer were obtained by Thermo ESCALAB 250, Physical Electronics USA. The temperature of the drill head and the basal wood can be recored by the infrared thermometer (BM-300, Shenzhen Binjiang Electronic Science and Technology Company, China). The hardness of different wood material were measured by Shao'hardometer (SLX-D, Wenzhou Sundoo Instruments Co., Ltd., China)

3. Results and discussion

The sliding contact of wood pairs was driven by an electric drill as is shown in Fig. 1. Two factors will determine the energy accumulation at the interface: heat transfer and work, that eventually express to the rise of temperature. The selection of wood materials was turned out to be a key parameter for rapid ignition. Drill head material should choose relatively hard wood, and the basal material should be relatively soft, so that wood particles (wear debris) from the basal wood can be easily produced and piled up locally. The hardness value of different wood are listed in the Table 1. When the temperature is high enough, the small size crumbs of wood will turn to the dark color carbides for further firing.

The surface microstructures of the different kind of wood were observed by a field emission scanning electron microscope. Fig. 2 shows the SEM images of the original pine (a), platane (b) and fir (c) wood. It is clear that original wood is very rough with the anisotropic texture. It is noted that the anisotropic texture is related to the friction coefficient at different sliding direction.The SEM image of the surface on wear tracks of pine (d), platane (e) and fir (f) are relatively smooth, with the platane wood being much smoother, that will potentially reflected from the coefficient of friction **(COF)** data. Additionally, the chips of woods are also shown in Fig. 2 pine (g), platane (h) and fir (i), indicating that the chips of fir wood are relatively small. The diameter and length of

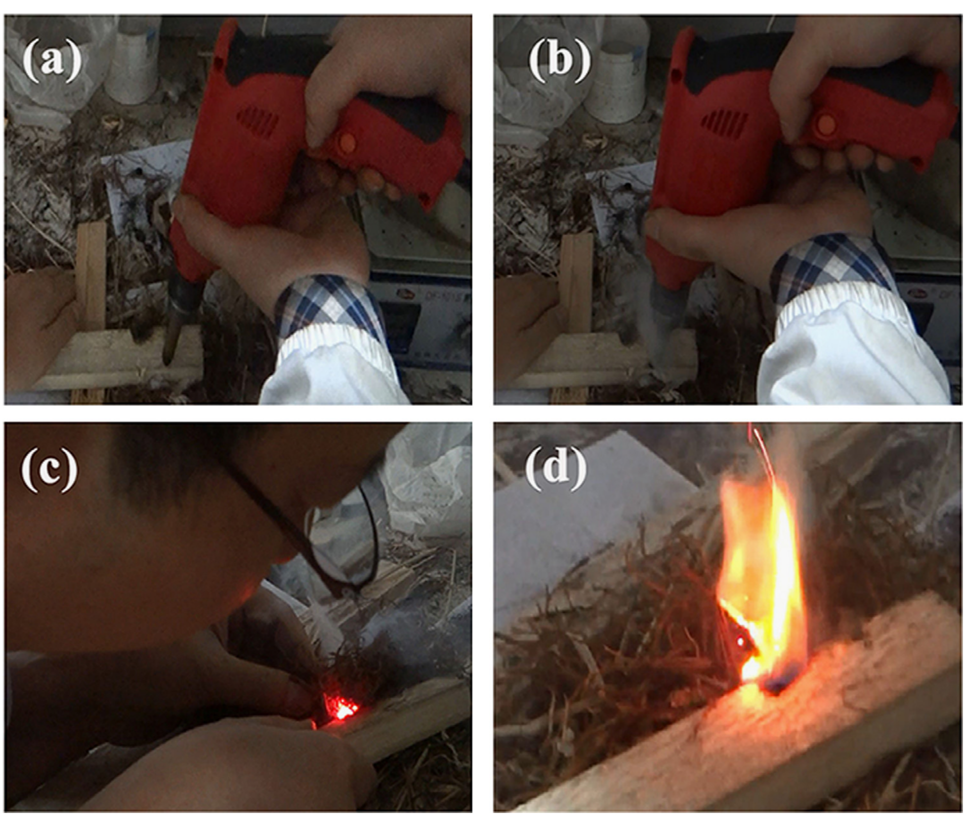

Fig. 1. The process of using electric pine drill to rotate against pine wood for making fire.