The bombardier beetle, power venom, and spray technologies

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The bombardier beetle is inspiring designers of engines, drug-delivery devices and fire extinguishers to improve spray technologies, writes Andy McIntosh, from Leeds University, and Novid Beheshti, of Swedish Biomimetics 3000 Ltd, in April's *Physics World*.

The bombardier beetle, found mainly in Africa and Asia, is remarkable in that it can fire a powerful jet of hot, toxic fluid to fight off predators such as birds and frogs. While the chemical reaction that makes the venom has been understood for some time, the actual power behind the venomous squirt, which can travel as far as 20cm, has been cause for speculation.

Quantities of hydroquinone and hydrogen peroxide gases build up in the beetle's abdomen but, when necessary for defence, get mixed together in a connected 'combustion chamber' to produce toxic benzoquinone. This hot fluid is then fired off at force in the face of enemy predators.

The key to the beetle's powerful defensive trick is in its combustion chamber's inlet (or entry) and exit valves. The inlet valve opens to receive the chemicals, which begin to boil as soon as they meet, and closes when a sufficient amount of gas has been received.

As the gases react together, they generate heat and increase the pressure in the closed chamber. When the pressure reaches a critical point, the end of the exit valve is forced open and the hot fluid is ejected as a powerful burst of toxic steam in a process known as "flash evaporation".

Once the gas is released, the exit valve closes, the inlet valve opens and the chamber fills again, preparing for the next venomous ejection.

The research team at the School of Process, Environmental and Materials Engineering at LeedsUniversity has now managed to replicate how the bombardier beetle fires hot venom. In a series of experiments using just water (rather than venomous liquids), McIntosh and his team have been able to fire pulses of hot spray distances of up to 4 m and have been able to control the size of the droplets in the spray. The technique has now been licensed by Biomimetics 3000 Ltd for industrial applications.

This new technology is likely to be of interest to firms making drug-delivery systems as it could prove far more reliable than the mechanically-driven spring technology used in, for example, inhalers. It could also provide a much more energy-resourceful mechanism for fuel-injection in car engines and even lead to a new generation of fire extinguishers that can both produce either a fine mist or large droplets depending on what type of fire needs to be put out.

Source: Institute of Physics