Developing a New Expander

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A New Thermodynamic Cycle

Based on the idea for a novel power cycle, Technical University of Denmark and IPU investigate a concept proposed by Viking Heat Engines. In contrast to other systems, expansion can take place in the two-phase domain within a heated reciprocating machine.

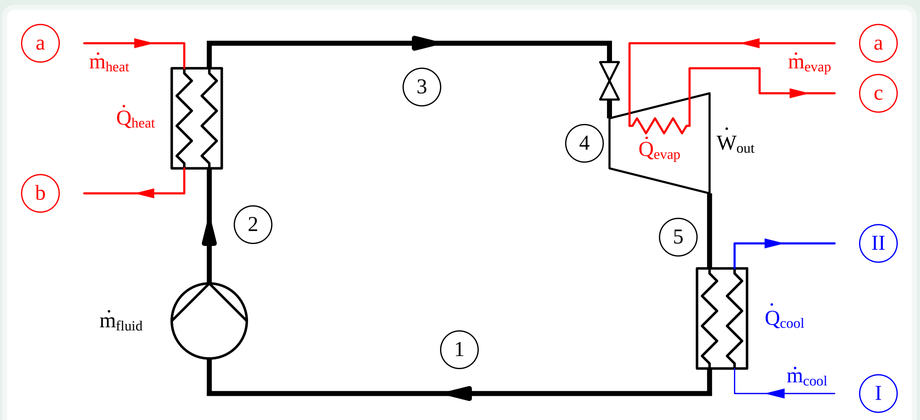

Figure 1: A sketch of the proposed cycle. Condensed working fluid (1) is pumped at $\dot{m}_{fluid}$ to a high pressure (2) and heated to state (3) with $\dot{m}_{heat}$ releasing $\dot{Q}_{heat}$ between (a) and (b). Before it reaches the expander, an initial pressure loss occurs in the injection system. Afterwards expansion takes place from state (4) to (5) while $\dot{Q}_{evap}$ is supplied by a second oil loop of $\dot{m}_{evap}$ coming from the same reservoir and hence changing state from (a) to (c). Working fluid at low pressure enters the condenser where it approaches the initial conditions of state (1). The necessary heat removal $\dot{Q}_{cool}$ is carried out by a cooling water loop of $\dot{m}_{cool}$ that is warmed from (I) to (II).

Modelling and Experiments

Heat is supplied only to the first stage of a uniflow compound expansion in two connected chambers.

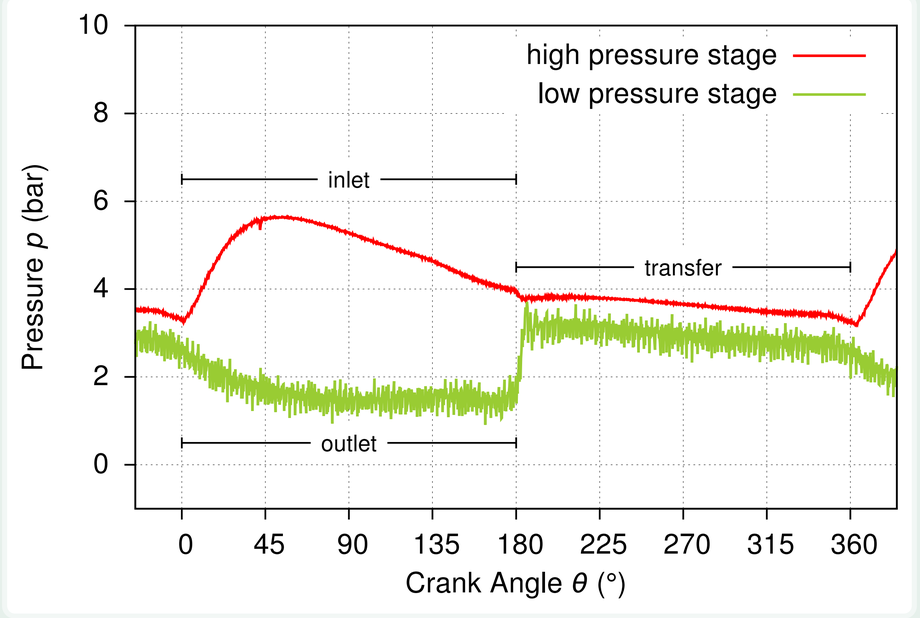

Figure 2: Liquid pentane is injected on the hot inner surfaces followed by expansion with simultaneous evaporation. The high pressure expansion ends at 180° with the transfer of the fluid to the pressure chamber. The second expansion step takes place in both chambers as connected volume. Closing the transfer lines at 360° initiates exhaust from low pressure chamber and injection to the first stage.

Figure 3: A decreased injection period of approximately 90° promises higher efficiencies. The results were obtained from a test with a 130 °C heat source and 450 rpm. The feed stream was slightly superheated gaseous pentane and the machine delivered 800 W with an estimated thermal efficiency of 6 %.

Current objectives are improving the injection system, trying new working fluids and testing a second design based on standard automotive components.

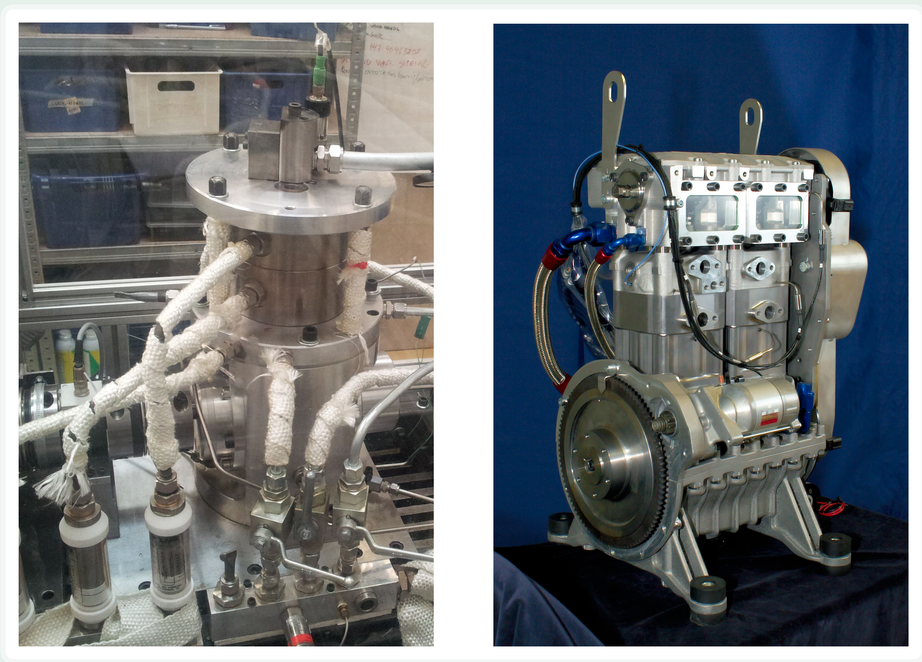

Figure 4: Proof of concept design (left) and second generation machine (right) for further testing. Both test machines are still operated and components get improved constantly according to results from measurements and modelling. The second generation employs more standard parts and the double-acting single cylinder design has been replaced by a two-cylinder two-stroke layout.

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