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Hydraulic Optimization of an Adjustable Spiral-Shaped Evaporator

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Abstract : To ensure reliability in miniaturized devices or processes with increased heat fluxes, very efficient cooling methods have to be employed in order to cope with small available cooling surfaces. To address this problem, a certain type of evaporator/heat exchanger was developed: It is called a swirl evaporator due to its flow characteristic. The swirl evaporator consists of a concentrically eroded screw geometry in which a capillary tube is guided, which is inserted into a pocket hole in components with high heat load. The liquid refrigerant R32 is sprayed through the capillary tube to the end face of the blind hole and is sucked off against the injection direction in the screw geometry. Its inner diameter is between one and three millimeters. The refrigerant is sprayed into the pocket hole via a small tube aligned in the center of the bore hole and is sucked off on the front side of the hole against the direction of injection. The refrigerant is sucked off in a helical geometry (twisted flow) so that it is accelerated against the hot wall (centrifugal acceleration). This results in an increase in the critical heat flux of up to 40%. In this way, more heat can be dissipated on the same surface/available installation space. This enables a wide range of technical applications. To optimize the design for the needs in various fields of industry, like the internal tool cooling when machining nickel base alloys like Inconel 718, a correlation-based model of the swirl-evaporator was developed. The model is separated into 3 subgroups with overall 5 regimes. The pressure drop and heat transfer are calculated separately. An approach to determine the locality of phase change in the capillary and the swirl was implemented. A test stand has been developed to verify the simulation.

Keywords : helically-shaped, oil-free, R-32, swirl-evaporator, twist-flow
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