# Investigation on the Impact on Thermal Performances of New Pin and Fin Geometries Applied to Liquid Cooling of Power Electronics

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## Abstract

Liquid cooling of cold plates and base plates appears to be the near-term solution for the current cooling demand of the power electronics market. A numerical and experimental investigation has been carried out in order to evaluate the impact on the thermal performances of new pin and fin geometries applied to liquid cooling of power electronics. It is concluded that new geometries can provide a significant improvement on the thermal performances.

## Introduction

Most of today's hybrid electric vehicles (HEV) and electric vehicles (EV) have a liquid cooling system to keep the power electronics at a safe operating temperature. The most common form of power electronics is an IGBT module. The heat fluxes, flow rates and other variables for hybrid and electric vehicle inverter cooling lend to the use of specific coldplate geometries.

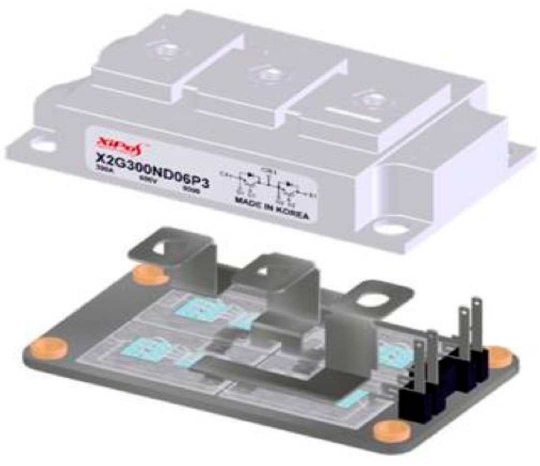


Fig 1. Typical IGBT

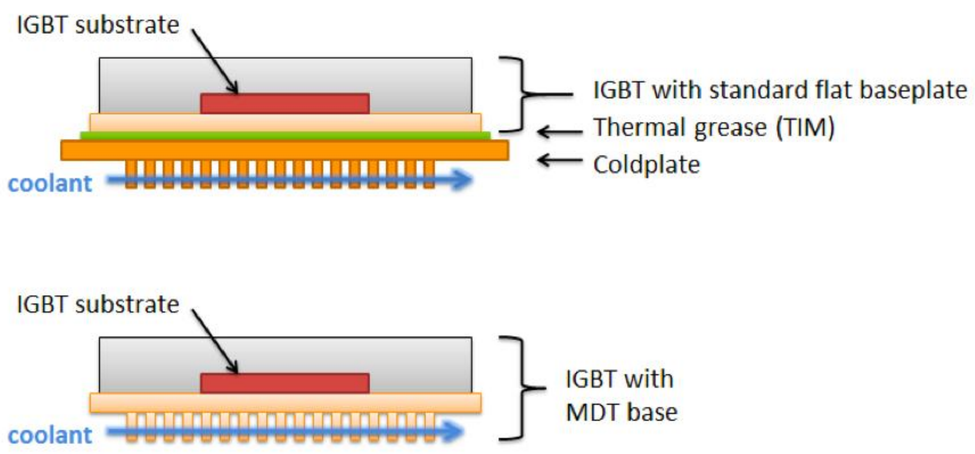



Fig 2. Typical and Integrated Baseplates Cooling Methods

## Coldplates Geometries and Manufacturing Methods

Three different coldplate geometries will be characterized in this paper: straight fins, round staggered pin fins, and MDT in-line pin fins. All these geometries meet the 1mm gap requirement.

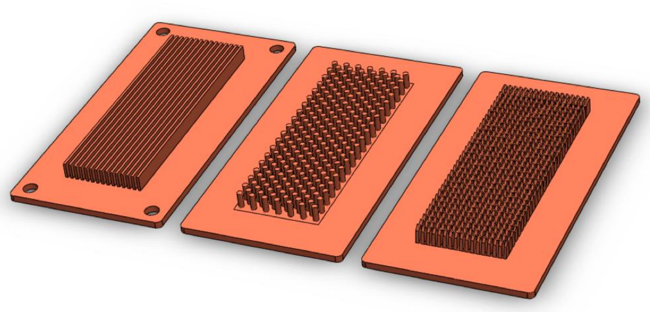


Fig 3. Geometries Tested: Straight Fin, Round Staggered Pin Fin and MDT In-Line Pin Fin

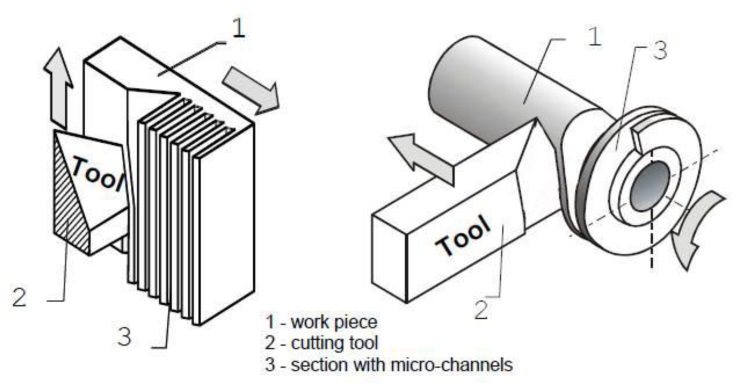



Fig 4. Micro Deformation Technology (MDT)

MDT is a low cost, manufacturing method for creating fin and pin surfaces for use in heat transfer applications. This patented process employs a fixed tool, which mechanically and plastically deforms the work piece to form finite and repeatable fin and pin patterns.

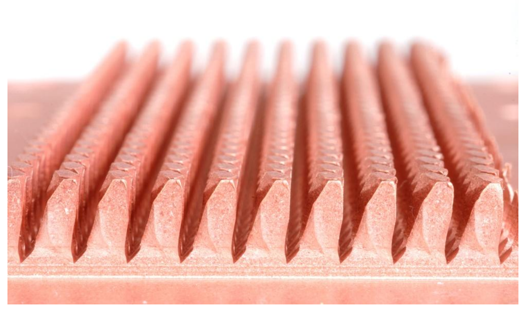


Fig 6. MDT In-Line Pin Fin

## Numerical (CFD) Method Description

The CFD model was based on the experimental test platform so that a correlation could be made between the two. Heat was added in the same area, and the inlet and outlet were modelled to match the exact specifications of the test platform. Temperature and pressure measurements were recorded at the same locations as the experimental test platform. The Cooling fluid in both experimental and numerical is water at 20deg C. The power is 350 watts in a 90x32mm area in both the experimental and numerical tests.

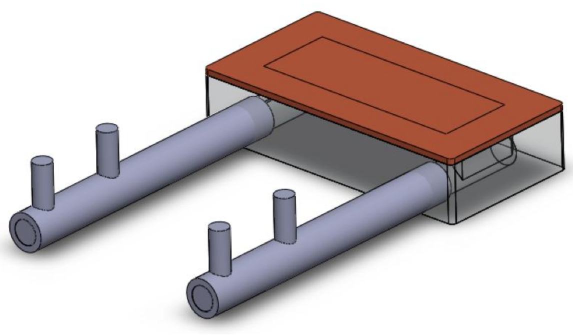


Fig 7. CFD Model

## Experimental Method Description

An experimental test platform was built to test the different geometries with the same conditions as the CFD study. The setup consists of a test tub in which a test sample can be inserted. This test tub is connected to a temperature and flow controlled chiller. A custom heater which resembles the heat flux of a standard IGBT Module is applied to the test sample. This heater measures temperature, power and heat flux. Pressure drop is measured across the test sample using a differential pressure transducer. Temperature measurements are also taken at the fluid inlet, fluid outlet, and multiple locations on the test sample surface.

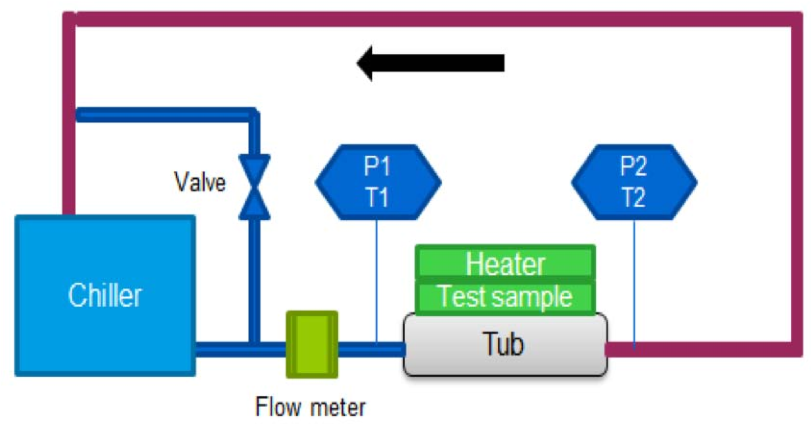
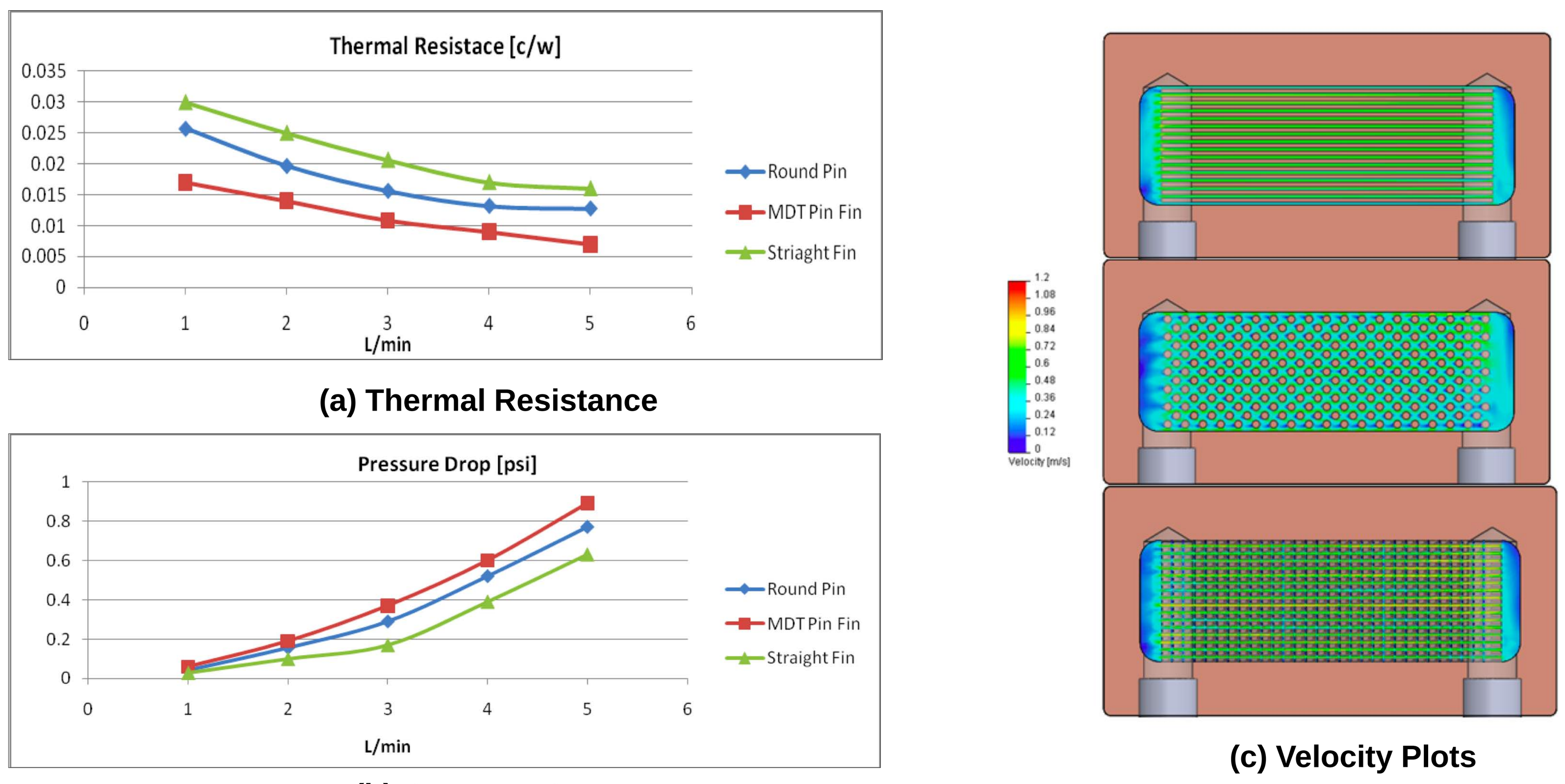



Fig 8. Experimental Test Platform Schematic

Fig 9. Picture of the Test Platform

## Numerical (CFD) Characterization of Geometries

Numerical (CFD) data were collected on all three geometries.




(a) Thermal Resistance

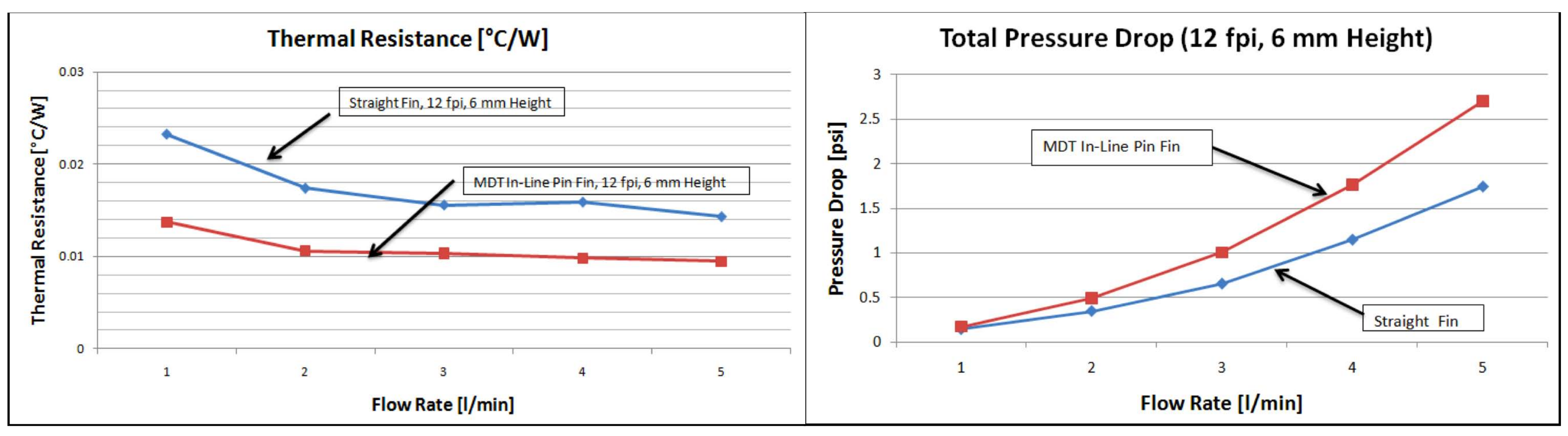
(b) Pressure Drop

(c) Velocity Plots

Fig 10. CFD Results

## Experimental Characterization of Geometries

Experimental data were collected on straight fin and MDT in-line pin fin.




(a) Thermal Resistance (b) Pressure Drop

Fig 11. Experimental Results

## Findings and Conclusions

MDT in-line pin fin has the best thermal performance per pressure drop when a 1mm flow gap is required at flow rates from 1-5 l/min. The twisted pin shape adds turbulence and breaks up of boundary layer increasing the heat transfer coefficient with only a minimal impact on pressure drop when compared to a straight fin or round pin fin.

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