博士論文　（要約）

High speed machining of nickel-base superalloy using specially designed tools for enhancing cooling ability of high pressure coolant

（高圧クーラントの冷却能力を向上させる工具を使用したニッケル基超合金の高速切削）

方　正隆

Rapidly developing world economies compel the industry to deploy high value manufacturing and substantial environmental manufacturing approaches to meet the demands of global transportation. Advanced superalloys have been developed for retaining excellent mechanical properties and chemical stability at elevated temperature environment of turbine engines. Their manufacturing processes, however, equally encounter a severe cutting tool wear and the inferior machined surface owning to the high thermo-mechanical loadings on the cutting edge. Developing high performance cutting tool is an alternative to shoot the thermally-induced problems in addition to advanced cooling method.

In this work, cooling of cutting tool was investigated by applying high pressure jet coolant assistance in combination with specially-designed high performance cutting tools: Internally cooled tool and micro-textured tool, during the high speed turning process of nickel-based superalloy Inconel 718. By utilizing the hydraulic wedge at flank clearance, the cooling channels and micro-textures fabricated at the tool flank face by EDM and laser irradiation were proposed to escalate the heat transfer from tool to the coolant owning to the enhanced flow. In particular, the computational fluid dynamics was introduced and successfully applied to the turning process with high-pressure jet for the first time. Flank wear patterns were investigated by a field emission scanning electron microscope with scanning electron microscope and energy dispersive X-ray spectroscopy analysis. As a result, the coolant flow patterns and pressure distribution of hydraulic wedge at flank clearance was illustrated and found they were primarily influenced by the depth-of-cut. Further, the specially designed tools were proved effective in enhancing cooling process which showed the advanced cutting performances in terms of tool wear, tool life, cutting temperature, adhesion and coolant depositions. Good conformances between the experimental and computational results proved that the computational fluid dynamics is an appropriate tool for simulating the high pressure coolant turning process and instructing the design of cooling channel and micro-texture.