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Plasma-end mill hybrid cutting method for decommissioning of nuclear facilities

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In Korea, the decommissioning process of Kori 1, the oldest nuclear power plant, is planned to start in 2026 after the spent fuel is removed [1]. For a successful decommissioning of Kori 1, it is essential to secure a safe and fast cutting process for radioactively contaminated metal structures. Compared with conventional cutting tools, such as arc plasma torches and other mechanical tools, an end mill can be preferred since it can produce no aerosols except chips that can be retrieved easily. In addition, an end mill splits the inner surface of a workpiece in the last cutting pass, making this cutting tool to be attractive, in particular, in safe cutting of metal structures with radioactively contaminated inner layers such as pipes and tanks. Despite these unique features as a cutting tool, however, end mills have been hardly used for dismantling of nuclear power plants due to their high expenditure of time and tools, particularly when using tools without cutting fluids [2]. Normally, mechanical strengths of metals are reducing when temperature is increased [3]. In other words, the cutting force of an end mill can be lowered if target metal structures are preheated by an external heat source such as arc plasmas, improving the cutting performance of an end mill such as life time of cutting tool or cutting volume per unit time even though no cutting fluid is used.

In this work, based on this thermally heating effect on the cutting performance of an end mill, a plasma-end mill hybrid cutting method was proposed to apply to the quick and safe decommissioning of nuclear facilities. In this method, an end mill removes the thermally soften parts of the metal structures that is heated by a moving plasma torch. For this purpose, we combined a transferred type plasma torch (Hypertherm, 180° Duramax robotic torch) with an NC (Numerical Control) milling machine and carried out cutting tests of 316 L type stainless-steel plates for the cases with and without arc plasma. Figure 1 illustrates a test result for splitting a 316 L type stainless-steel plate with 25 mm thickness by the sequential application of hybrid and conventional cutting processes. In this figure, the outer layer of 21 mm thickness was removed quickly by the suggested hybrid cutting method. Then, the inner layer of 4 mm was splitted slowly but safely using only an end mill, assuming an inner layer of 4 mm was assumed to be radioactively contaminated. With this test example, we estimate the applicability of hybrid cutting method to the dismantling process of nuclear facility. This research was supported by the Korea Hydro & Nuclear Power (KHNP) Co.(G18IO16).

References

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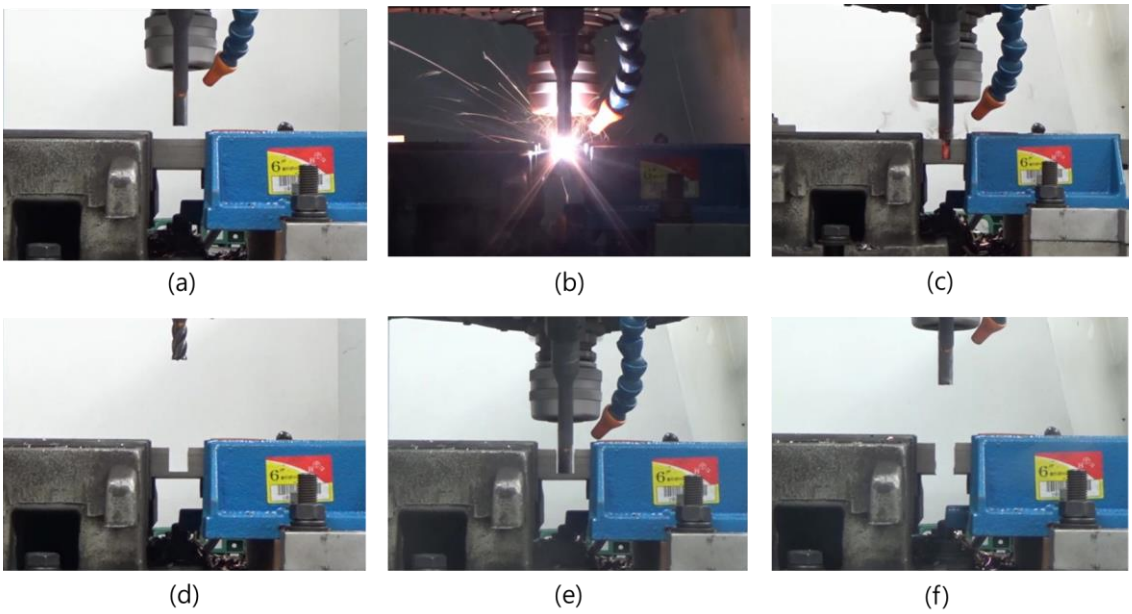

Figure 1. Sequential application of hybrid and conventional cutting processes for splitting a 316 L type stainless-steel plate of 25 mm in thickness and an inner layer of 4 mm in thickness assumed to be radioactively contaminated. (a) Before cutting, (b) Hybrid cutting of a 21 mm thick outer layer at feeding speed of 200 mm/min, (c) End mill cutting after arc plasma off (d) Resultant slot with the depth of 21 mm, (e) Conventional cutting of 4 mm thick inner layer at feeding speed of 50 mm/min (f) Completely splitted stainless steel plate