# Environmentally Friendly Near-dry Machining of Titanium Alloy

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Near-dry machining attracts increasing attentions for environmental and economical benefits, and minimal quantity lubrication (MQL) machining has been the most representative near-dry method. In order to achieve successful MQL machining, cutting lubricants would play a significant role because they should be supplied to the cutting zone in a very small amount.

Then recent concern for environmentally friendly manufacturing encourages the attempts at applying near-dry operations to machining of such difficult-to-cut materials as titanium alloys. In this case, a hybrid mist (HM) generation system is proposed as a novel near-dry technique. The HM system can supply not only the mixture of MQL mist and coolant mist (CM) but also either the regular MQL mist or the single CM separately. For comparison, the evaluation should be carried out by using dry machining (DRY) with no lubricant and ordinary wet machining (WET) with flood cutting fluid supply.

A commercial oil, CO-1, is chosen as a MQL cutting lubricant because it is a synthetic biodegradable polyol ester and has the satisfactory performance in practical use. CM was an atomized water-soluble cutting fluid after diluting as 10% emulsion. This fluid is environmentally acceptable because it is derived from vegetable-based oil. In addition, 10% emulsion of water-soluble cutting fluid (JIS A1-No.2) was used in the ordinary WET operation. In turning of a titanium alloy, the performance of these lubrication methods was evaluated by the cutting distance at the tool life criterion which is the flank wear exceeding 0.2mm.

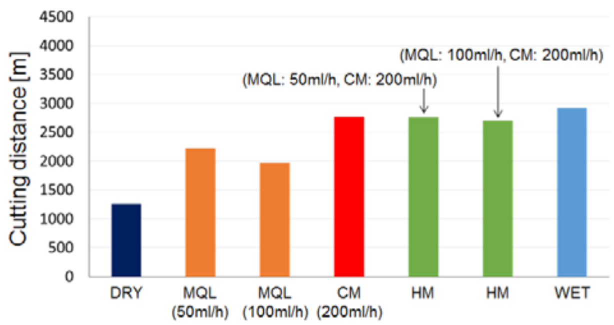


Fig.1 Cutting distance at tool life under various lubricating conditions

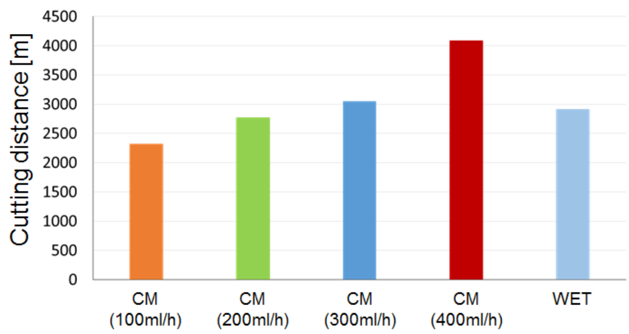


Fig.2 Cutting distance at tool life for CM and WET operations

Figure 1 illustrates the results of cutting distance after tool life judgment under various lubricating conditions. Each of these results is given as an average value of three turning test data. As seen here, all the MQL, CM and HM supply methods can make flank wear much smaller than that of dry cutting, so that both lubricating and cooling abilities of supplied mists are important in order to achieve preferable cutting situations. However, all these near-dry methods are inferior to WET. In the case of MQL machining, the CO-1 supply of 50ml/h, rather than 100ml/h, is unexpectedly better. This could probably be due to the reason that the amount of 100ml/h would be too much as a MQL supply to produce fine oil mist particles, but the further examination should be necessary to understand more details.

Figure 2 compares the results of cutting distance after tool life judgment for CM and WET operations. This figure demonstrates that the cutting performance improves with the increase in the CM supply amount. The CM operation with the amount of 200ml/h has provided the slightly inferior cutting performance to that of WET, whereas the CM supply of 300ml/h is almost equivalent to WET and the CM supply of 400ml/h can surprisingly elongate the tool life: 1000m longer than that of WET. This is undoubtedly due to the improvement of the cooling efficiency with the increase in the amount of CM. However, regarding merely the cooling ability, WET with flood cutting fluid supply should be better than CM with a small amount of cutting fluid. This may possibly be because the thermal softening of the workpiece is another important factor to facilitate cutting. The CM supply of 400ml/h is therefore considered to be able to give the balancing effect of the cooling and workpiece softening capabilities.