

Machining processes are the techniques using various kinds of tool to remove excess material to shape the workpiece into the desired geometries, dimensions, and surface conditions. It is common that some stresses will be preserved within the finished parts after the machining processes, which is called residual stress. The machining-induced residual stresses have attracted wide attention for the last decades because they were closely related to the quality and performance of the machined components. Residual stresses can be induced with various magnitudes and distributions by any machining operation. The final residual stress depends on the material of the components, and the employed cutting conditions: cutting speed, cutting feed, depth of cut, tool geometries, tool wear, lubrication, etc., and pre-existing stresses in the parts. Therefore, the investigation of the effect of different cutting parameters on residual stress and the underlying mechanism of residual stress formation is very important to optimize the machining process and improve the work performance of the machined products.

There are three commonly used methods for residual stresses investigation: experimental measurement, analytical modeling, and finite element simulation. Generally, cutting processes operate at severe deformation conditions, involving very high strain, strain rate, stress, and temperature. These extreme conditions increase the difficulty in the measurement of the cutting temperatures, stress, plastic strains, shear angle, etc., which are critical parameters to understand the mechanism of residual stresses. The analytical method has been developed is a good alternative to achieve a better understanding about the phenomena occurring during the cutting processes. The drawback of the analytical models is the lack of accuracy of the results due to the significant simplification of the process. Moreover, some essential aspects, such as the multiple cuts and the pre-stress conditions due to prior manufacturing processes, are difficult to investigate with analytical models. With the continuous development of finite element techniques, the model of machining processes has attracted plenty of attention by many researchers over the last decades. This method not only realize the visualization of the cutting process, but also incorporate the complexity of the actual cutting process.

In this dissertation, orthogonal cutting and fillet surface turning models are established to predict the residual stress induced by metal cutting process under different cutting parameters. With the validated models, this dissertation is further aimed to visualize the cutting process and formation of residual stresses. Therefore, some process variables (i.e., stresses, strains, forces, and temperatures) which are not measurable or difficult to measure experimentally can be obtained to explore the underlying mechanisms of residual stress formation. With a deeper understanding of the influence from each process parameter in detail, an optimization of the machining conditions is possible in the practical machining process.