Paragraph Ran in the Queries

Paper Title: Research on the influence of ultra-low temperature extreme environments on the surface quality and fatigue life of FeCoCrNiAl0.6 high entropy alloy

Content :

Mechanical properties analysis

Fig. 9 shows the tensile stress–strain curves of samples processed at different cutting speeds based on the finite element simulation model at room temperature and low temperature. As can be seen from Fig. 9(a-d), at all four environmental temperatures, the yield strength and tensile strength of the specimens both increased with the increase in cutting speed. In Fig. 9(a) at the room temperature environment of 20 °C, the yield strength of the specimen was 835 MPa, and the tensile strength was 1084 MPa at a cutting speed of 2000 mm/min. When the cutting speed was increased to 2800 mm/min, the yield strength reached 878 MPa, and the tensile strength reached 1129 MPa, with improvement rates of 5 % and 4.2 % respectively. Fig. 9(d) shows the tensile fracture stress–strain variation of the specimen after machining under a low-temperature environment of −120 °C. At the same cutting speed of 2000 mm/min, the yield and tensile strengths were respectively 887 MPa and 1197 MPa, both higher than those under room temperature conditions. When the speed increased to 2800 mm/min, the yield and tensile strengths reached 945 MPa and 1271 MPa, with growth rates of 7.6 % and 12.5 % compared to the same cutting speed at 20 °C room temperature. According to the tensile fracture stress diagram 10–11, the fatigue failure position and stress concentration can be judged.Changing the cutting environment temperature can enhance the material strength to a certain extent. It is believed that during low-temperature cutting, the environmental temperature is low, which can be considered as cryogenic treatment of the material. In the cutting process, the low-temperature environment effectively reduces the temperature in the cutting zone, making the material locally brittle, decreasing its plasticity and toughness, thereby facilitating chip breaking and parting, enhancing chip breaking, and simultaneously reducing tool wear, thereby improving the damage to the already machined surface [31], [32]. Under the effect of low temperature, the increase in cutting speed further reduces the extrusion friction of the tool on the machined surface, thereby enhancing the surface quality and increasing its strength.

As can be seen from Fig. 12(a-d), within the cutting depth range of 0.6–1.4 mm, as the cooling temperature decreases, the yield and tensile strengths of the material after cutting both show some improvement, reaching a peak at −120 °C, with material yield and tensile strengths reaching up to 973 MPa and 1356 MPa. Under both room temperature and low-temperature conditions, the yield and tensile strengths of the specimens decrease progressively with increasing cutting depth. In Fig. 12(a) at room temperature of 20 °C, the yield strength of the specimen was 836 MPa, and the tensile strength was 964 MPa at a cutting depth of 0.6 mm. When the cutting depth increased to 1.4 mm, the yield strength decreased to 810 MPa, and the tensile strength also dropped to 923 MPa, with a reduction rate of 3.1 % and 4.2 % respectively. Fig. 12(d) shows the tensile fracture stress–strain curve of the specimen after machining under a low-temperature cooling environment of −120 °C. Similarly, at a cutting depth of 0.6 mm, the yield and tensile strengths were respectively 973 MPa and 1356 MPa. When the cutting depth increased to 1.4 mm, the yield strength decreased to 936 MPa, 95 % of the value at 0.6 mm cutting depth, while the tensile strength dropped to 1175 MPa, only 86.6 % of the value at 0.6 mm cutting depth, indicating that under low-temperature conditions, the increase in cutting depth has a greater impact on the material's tensile strength than at room temperature. By combining a smaller cutting depth with low-temperature cooling during machining, the tensile properties of the material can be somewhat enhanced. It is considered that during low-temperature cutting, the low ambient temperature can be seen as cryogenic treatment of the material, and the low-temperature environment effectively reduces the temperature in the cutting zone during the cutting process, making the workpiece material locally brittle, which decreases its plasticity and toughness [33], [34], facilitating the separation of chips from the workpiece, enhancing chip breaking, and simultaneously reducing tool wear, thereby improving the damage to the already machined surface. Under the effect of low temperature, the increase in cutting speed further decreases the extrusion friction of the tool on the machined surface, thus enhancing surface quality and increasing its strength. From Fig. 13, Fig. 14, it is evident that under various low-temperature cooling conditions and after different cutting depths, the fatigue fracture locations of the specimens subjected to fixed loads are consistently positioned at the central tensile weak points. This where stress concentration is most prominent, and fatigue cracks originate from this point and propagate outward.