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Design and manufacturing technology of high speed milling cutter for aluminum alloy

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Abstract

Base on the development practice of carbide milling cutter used for high speed machining of aluminum alloy, through the empirical analysis of the failure mechanism of milling cutter, and combined with the cutting performance of high strength aluminum alloy and the stress strain characteristics of cutter on high speed condition, the design principle, manufacture and using technology of carbide milling cutter for high speed machining of aluminum alloy are discussed in detail.

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Keywords: Aluminum; High-speed Cutting; Failure; Design Method

1. Introduction

In the manufacture of aviation products, the amount of machining of aluminum alloy is very large. First, large proportion of aluminum alloy component, in a high performance fighter, high strength aluminum alloy components accounted for 70-80% of the whole weight of the aircraft. Secondly, high material removal rate, in order to improve the reliability and reduce the weight of the parts, the traditional riveting structure has gradually been replaced by the overall thin-walled machined components. Most of these parts are made of solid aluminum alloy material, 70-95% of the material has been removed during processing. Such as the fuselage frame blank is up to 0.5 tons of aluminum alloy forgings, when processed into an overall thin-walled component, it weighs only about 40 kg. . Finally, thin-walled structure cannot withstand a larger cutting force.

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China has become an important subcontract producer of aircraft parts, Boeing, McDonnell Douglas, Airbus and other world famous manufacturing companies subcontract production of aircraft parts in our country. High speed cutting is not only high efficiency, but small cutting force, small deformation, high processing quality, and has been widely used in the manufacture of foreign aviation products. In recent years, domestic aircraft manufacturing companies have conducted a large-scale technological transformation, a large number of introduced from abroad for high speed and high precision processing of numerical control equipment. High speed cutting technology of aluminum alloy is an urgent need to apply advanced technology in domestic aircraft manufacturing enterprises, high speed cutting tool technology is one of the key technologies to realize high speed machining. At present, the main tool companies have begun to develop high speed milling cutter of aluminum alloy, but cannot provide a mature product series, heavily dependent on imports.

2. Cutting characteristics of aluminum alloy

Aluminum is generally considered a low strength and hardness, good thermal conductivity, easy processing materials, high speed cutting. It has proved in the production that certain elements has added to the aluminum, after solution strengthening and precipitation strengthening, its strength close to steel No.45, and specific strength is more than doubling to steel No.45, known as high-strength aluminum. At the same time, the cutter has a great wear by aluminum alloy which is not easy to get better surface roughness and high precision, not easy to process materials.

Table 1. Tensile strength and specific strength of high-strength aluminum alloy, high-strength steel and steel No.45.

Material	Tensile strength (σ_b, Mpa)	Density(g/cm^3)	Specific strength
High-strength aluminum alloy	490-588	2.7	175-210
High-strength steel	1000-1400	7.8	154
Steel No.45	610	7.8	78

2.1. Characteristics of general aluminum alloy cutting

A small modulus of elasticity (only about 1/3 of steel No.45), the workpiece surface machined has a large of elastic recovery, there is a serious friction to tool flank, and affecting the tool durability.

A low melting point, in the cutting the chip is easy to adhere to the cutting edge to form a built-up edge, which is the main factor that affects the surface quality of processed surface.

A large coefficient of thermal expansion, cutting temperature increases quickly, the size of parts swell as the temperature increases and contract when cooled, which bring some difficulties in control of dimensional accuracy.

The machined surface is quickly oxidized in the air to from Al2O3 hard film (surface hardness at room temperature is up to HV2500 ~ 3000), and its wear on the flank surface affects the tool durability.

2.2. Characteristics of High-speed cutting

In a high-speed processing, with the increase of cutting speed, the chip is too late to deformation and flow from the rake face. Not only reduced deformation resistance and deformation work shift, and most of the high-speed heat are taken away by flow chips. Therefore the deformation resistance decreases and the heat deformation work shift, the machining precision is easy to guarantee. In the research project of "High Speed and Low Cutting Force Milling Technology for Thin-Wall Structural Parts of Aircraft Aluminum Alloy" jointly by Northwestern Polytechnical University, Chengdu Aircraft Manufacturing Company and Shanxi Aviation Carbide Tools Co., Ltd., a force cutting test was carried out with a diameter Φ32mm of milling cutter, when the spindle speed was 20000RPM, the main cutting force was between 30-60Kg, only about 1/2-1/3 of general cutting.

The aluminum alloy chip is generally unfolder shape, with the cutting speed increases, the chip deformation reduced (deformation coefficient close to 1), the shear angle will become larger as shown in Fig. 1, the chip on the rake face pressure increases. At the same time, due to the high relative movement speed between cutting tool and workpiece, the friction speed between rake face, rear face and machined surface becomes faster, and frictional heat