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Parameter Setting for Dynamic Milling of Aluminum Alloy

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Abstract. This paper introduces the application of dynamic milling technology in the mastercam software, and makes a further study on the processing technology of aluminum alloy workpiece. With the development of the industry, Aluminum alloy is in widely application in various fields, but due to its rigidity of the workpiece during the machining process, which is easy to make deformation, the processing quality is difficult to meet the specified requirements. Using the dynamic trajectory optimization of tool machining technology in high speed machining can make optimization in many ways, such as the tool cut-in and cut-out, tool moving, the corner solving etc. Dynamic trajectory optimization can formulate appropriate tool path processing aluminum alloy workpiece, and can also reduce tool wear and improve cutting efficiency.

The Processing Characters of Aluminum Alloy

The aluminum alloy has the lower specific gravity, higher specific strength, wear-resisting, corrosion-resisting, thermally conductive, and shock-absorbing abilities, which would not spark during impacting. And the aluminum is also easy to recycle, widely used in the national defense, aerospace and the automobile fields. [1,2]

The followings are such processing characters:

(1)The aluminum alloy has a poor performance in plastic deformation-resisting and scratch resisting. The aluminum workpiece would be easy to scratch and deform. If the chip removal is not smooth enough, the chips will adhere to the processed surfaces.

(2)The aluminum alloy has higher thermal conductivity, so that the chips can bring massive heat during cutting, but for its less modulus of elasticity can cause large elastic deforming and hard to get high processing precision. Besides, the chips can cause severe friction between the processed surface and the major flank face, which would accelerate the tooling wear and cause vibration, especially in the thin-wall parts processing.

(3)The aluminum alloy is large expanding ratio, 2~3 times larger than the steel. So the expand when heated and contract when cooled phenomenon is severe, which is bad for the high precision processing. Besides, the lower fusing point of the aluminum would cause large plastic deformation during temperature increasing. And the chips flows out would easy cause the built-up edge during processing, which would cause the lower processing precision and the surface roughness and reduce the tooling life.

(4)In the small margin processing, indexable insert tip edge is usually too dull to cause the cutting force increasing inexpertly, which will cause the large cutter relieving and higher power demands. All above would cause the quality problems, which are the main defeats of the thin-wall Aluminum alloy parts. [1]

To get higher strength and reliability, many parts is using the aluminum alloy for the whole structure design. For the structure design is complicated, and the higher shape precision, usually using the NC milling machine or the CNC milling machine for processing. The whole structure parts have higher chip removal ratio, usually to 70% of the total machining allowance, some even to 95%. Efficiency has become an important factor affecting the cost of processing

Dynamic Milling

HSM(high speed milling) is a widely used technology from 1990s, usually in end milling of high spindle velocity and feeding speed, which is widely used in the aerospace manufacturing, molding field, automobile parts manufacturing, and precise accessory processing. HSM can handle various materials, such as the aluminum alloy, copper, high temperature alloy etc. In the aluminum alloy parts processing, the surface and structure are complicated, the chip removal ratio, usually to 70%～95% of the total machining allowance, using HSM can greatly improve the production efficiency and processing precision. [3,4]

Mastercam is outstanding CAD/CAM software. For its vexatious design and processing faction, Mastercam is widely used in aerospace, automobile, vessel, medical apparatus and instruments and molding fields. Mastercan adds dynamic milling faction from X4 version, which is enhancing in the newest version. The Dynamic Motion technology is a bran-new milling method, which is not only calculating the tool moving path, but also analysis the tool cutting-in and chip removing procedure by series algorithms, according to the tool movement adjusting cutting parameters. Using Dynamic Motion, the processing time, the tooling and machine wear and tear can be reduced greatly. [3]

The specific algorithms of Dynamic Motion can reduce spare cutting and can shorten the cutting time to 25% of former. The Dynamic Motion uses the full tooling blade in cutting which can reduce the stratification and proceeding time.

The traditional motion usually uses the end of the mill that would cause inhomogeneous wearing. Full tooling blade in cutting can make full use of the blade, and make the heat and wear homogeneous, reduce the change tool times, improve the processing speed, reduce the cost. Besides, the dynamic motion can keep the tool loading stable, reduce vibration, bring most heat through the chips, and protect the workpiece, tool and the machine. Smoothing tooling path can avoided the sudden change, protect the machine.

The Parameters of the Dynamic Motion

The CNC milling usually divide into rough finish, semi finishing and finishing. The aim of rough finish is to move as much as chips from the workpiece. the workpiece removes most of allowance after the rough finish, but still leave some allowance in the complex structure(such as Conner, hollow, fillets), in which the allowance is not equal, directly to the semi finish or finishing will cause the loading fluctuates which will cause the tool or spindle damage. So before the semi finish and the finishing process, it is necessary to remove the remaining to make sure the allowance homogeneous.

Parameters Setting for the Rough Finish

For the 2D parts, Mastercam supplies kinds of process methods, such as dynamic mill, area mill, dynamic contour, peel mill, blend mill etc. Master cam's 2D High Speed toolpaths are specially designed to produce the smoothest, most efficient tool motions, optimized for high speed and hard milling.

High Speed Dynamic milling toolpaths utilize the entire blade length of their cutting tools to achieve efficiency in milling. They maximize material removal while minimizing tool wear. The benefits provided by high speed dynamic milling toolpaths also include Tool burial voidance, Minimum heat buildup, and Better chip evacuation.

2D dynamic milling can create reasonable tool path for the closed or opening outline. It is necessary to use a closed series connection to create the tool path for the closed area, including a maximal 2D boundary; the rest series connection will be distinguished to avoid geometry. It is better to choose stay inside option of the Machining region strategy for the closed area, and from outside option for the opening area.

Dynamic milling toolpaths support many powerful entry methods, including a custom entry method, all designed to simplify the programming of complex pocket and standing core shapes etc. from the above figures, we can see the tool path of dynamic milling is smoother, so it is no need to layering in the depth direction, which can greatly reduce the cutting time and improve the process

efficiency. Besides. The NC code which is generated by dynamic milling is better than the traditional milling.

For the 3D parts, the Mastercam supplies Dynamic optiRough to rough finish. Choose dynamic optiRough for the cutting parameter setting, the milling method is down milling, set the gap to the percentage of tool diameter, suggest to 8%~40%, the best is 20%~30%, and adjust the parameter to different material, for the aluminum alloy the maximum is 40%, otherwise will damage the tool. The depth layering setting suggest to 150%~350% of the tool diameter, the softer of the alloy hardness, the higher of the percentage. Make sure the depth no less than 150%, too little depth will get lower efficiency and cause the vibration. Set the minimum tool route radius to the 30-50% of the tool diameter, the larger, the smoother, but too large will increase the processing time. [3]

Figure1 is the tool path of rough finish for the dynamic milling and traditional milling

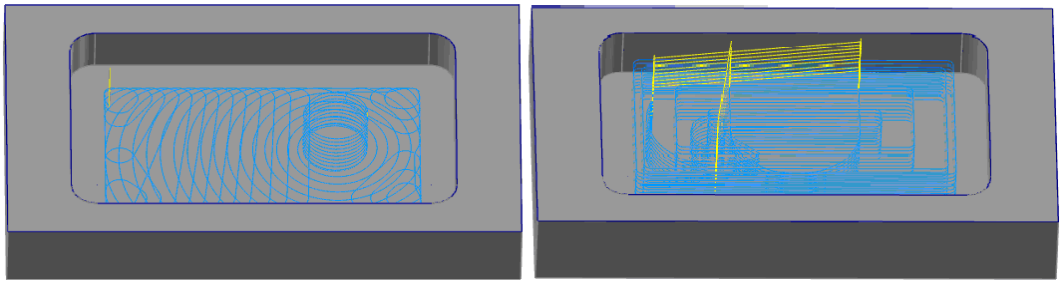

Figure1 The tool path of rough finish for the dynamic milling and traditional milling

Figure 2 is the tool path generated by the Dynamic optiRough programming

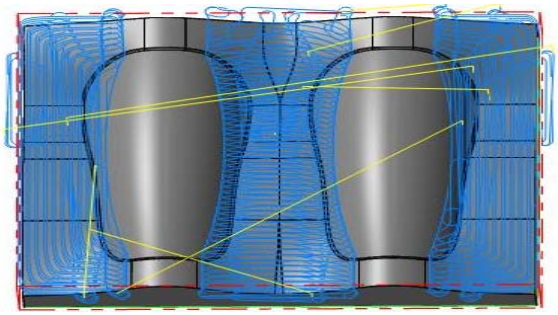

Figure 2 The tool path generated by the Dynamic optiRough programming

Remachining

In 3D curved surface, as the less layers of rough finish or the limited cutting area, which will cause a large remainder during the coner or fillets. Directly to the semi finish or finishing will cause the loading fluctuates which will cause the tool or spindle damage. So before the semi finish and the finishing process, it is necessary to remove the remaining to make sure the allowance homogeneous. Under these circumstances, it is better to choose the remainder material method to processing. Use this strategy to calculate the cutting passes on only the stock left over from one or more previous roughing operations, instead of the entire drive surfaces.

Figure 3 is the tool path generated by the remainder material method programming

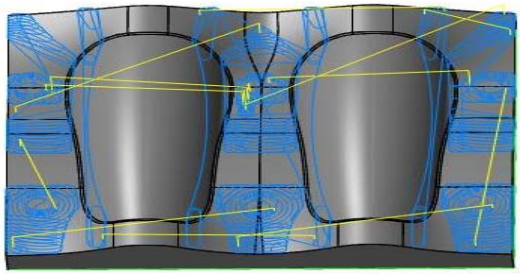

Figure 3 The tool path generated by the remainder material method programming

Finishing in Dynamic Motion

Mastercam supplies kinds of finishing methods, including Waterline, scallop, Horizontal Area, Raster, Pencil, Spiral, Radial, Hybrid, Project etc.

The waterline toolpaths are created from a set of profile curves along the cut surfaces. The profiles are separated by a constant Z amount. They are similar to finish contour toolpaths, but use Mastercam's high speed toolpath techniques for a smoother, more efficient tool motion.

Waterline toolpaths are suited for surfaces whose angles are between 30 and 90 degrees.

Mastercam's Hybrid finishing toolpath addresses steep and shallow areas utilizing both scallop and constant Z approaches in a single toolpath. The toolpath switches seamlessly between both methods and cuts in a logical optimized order. [5]

Figure 4 is the tool path programmed by the finishing hybrid method of the dynamic milling

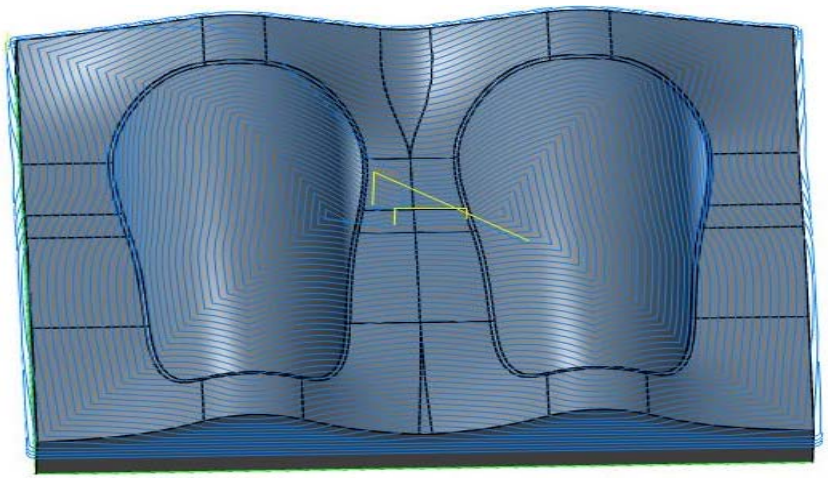

Figure 4 The tool path programmed by the finishing hybrid method of the dynamic milling

Conclusion

Through the examples above, we can get a conclusion, that is, the dynamic milling motion of Mastercam is a safe, reliable programming. It can supply many kind of processing methods, suit large remove allowance of the high milling efficiency programming. The dynamic milling programming is a more stable and reliable method compared to the traditional milling methods, especially suit the aluminum alloy NC milling.

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References

[1] LD. Kang, FZ.Yang,CM.Tong, Research status and analysis of key technologies for high speed machining of aluminum alloy, Modern Manufacturing Engineering. 1(2014)83-86.

[2] Q.Guo, Research on the methods and technologies for high performance peripheral machining of complex surface, Dalian University of Technology 2013, pp. 1–5.

[3] YB.Wang,A side edge milling method based on Mastercam programming,Die manufacturing technology vol. 7, pp. 74–76,2015.

[4] JX.Pan,Application of Mastercam software in high speed milling,NC Technology,vol. 1, pp. 43–46,2006.

[5] Mastercam help documentation.