Numerical Simulation Analysis of Polished Elbow in Solid-Liquid Two Phase Abrasive Flow Machining

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Abstract: As a precision machining technology, abrasive flow polishing technology plays an important role in many precision machining fields. In order to study the effect of abrasive flow polishing on elbow parts, the 90° elbow pipe is taken as the research object to study the numerical simulation of elbow pipe parts polished by solid-liquid two-phase flow. The dynamic pressure and turbulent kinetic energy distribution of the abrasive flow in the elbow channel under different inlet velocities were analyzed. Through the comparative analysis, the effectiveness of the abrasive flow polished elbow parts was explored. The effects of different inlet velocities on the abrasive elbow processing parts were analyzed, which provided theoretical support for the improvement and development of the abrasive flow polishing technology.

1. Introduction
With the development of science and technology, people have higher and higher requirements on the surface quality of parts. Abrasive flow machining technology as a non-traditional polishing technology takes an important part in polishing processing technology. Abrasive flow polishing processing technology used the abrasive particles as a processing tool to cut the surface to be machined, and achieved the deburring and polishing purposes. The abrasive particle flow machining technology can realize the surface finishing of the micro-holes or the complicated surface channels, improve the surface precision of the surface to be machined, and solve the problem of the surface polishing of the complicated surface channels which is difficult to be achieved by the traditional polishing technology [1-4].

Elbow parts has a very wide range of applications in the food, pharmaceutical, automotive, military and other industrial production and daily life, and has become an integral part of industrial manufacturing [5]. As the special nature of the work environment and the use requirements, these elbow fittings are often required to have a high inner surface finish. In order to improve the quality of the inner surface of elbow parts, it is necessary to polish the inner surface. Due to the different bending angle and radius of curvature of the elbow pipe, the inner surface structure is complicated, and the traditional surface polish technique is difficult to finish the inner surface of the elbow pipe. The abrasive flow processing technology can process complex surfaces, free from surface shape and structure constraints, and the processing of some complex inner surface or channel is more consistent.
In this paper, 90° elbow pipe numerical simulation is analyzed.

2. The Numerical Simulation Analysis of Abrasive flow polishing elbow

2.1 Model Meshing
Meshing is the most critical part of the numerical simulation and has a great impact on the simulation results. Therefore, it is necessary to pay enough attention to the quality of meshing. In this paper, 90° elbow pipe is selected as the simulation model. The grid is a hexahedral grid, and the grid of the runner is shown in Fig. 1.

![Fig. 1 elbow mesh model](image)

2.2 Boundary Conditions Setting
(1) entrance boundary conditions setting
Liquid phase selected material for the hydraulic oil, solid phase selected silicon carbide particles, and set the initial volume fraction of silicon carbide 0.2, the initial temperature of 300K. Entrance conditions choose speed inlet conditions, the inlet flow velocity is perpendicular to the inlet boundary, and choose different inlet flow velocity to simulate.

(2) export boundary conditions setting
Since the pressures and velocities at the outlet are not known before the simulation of the fluid, the outlet is directly connected to the outside world, and the flow state is assumed to be fully developed turbulence. Therefore, the boundary condition at the outlet end is set as the free outlet.

(3) Wall boundary conditions setting
As the abrasive flow processing is the processing of the workpiece wall, the workpiece is stationary during processing, the cutting force on the wall mainly comes from the pressure driven by the fluid under the flow of particles flowing through the workpiece to be processed. For a fixed workpiece to be machined surface, the relative slip between the abrasive grain and the wall surface is the movement of the particle itself, so the boundary conditions of the wall surface should be selected for the non-slip wall boundary conditions.

2.3 analysis of the numerical simulation results of abrasive flow polished elbow pipe
In order to investigate the effects of different initial velocity on the effect of abrasive flow polishing, the fluid behavior of abrasive flow at different inlet velocities needs to be analyzed. The inlet velocities of 25m/s, 30m/s, 35m/s and 40m/s were selected for numerical simulation. Dynamic pressure cloud chart under different initial velocity conditions is shown in Fig. 2 by numerical simulation.
As can be seen from Figure 2, the trend of dynamic pressure cloud after abrasive flow processing is basically the same under different inlet velocity conditions. The pressure of dynamic pressure at the entrance is smaller. As the abrasive flow continues to move, the dynamic pressure gradually increases. When entering the bend section, the pressure difference between the inner side and the outer side of the bend section gradually becomes noticeable. When the bend section just enters the exit section pressure difference between the inside and outside reached a peak, then tended to be stable and the pressure difference tended to decrease. When the velocity is 25m / s and 30m / s, the pressure difference at the exit section is smaller and the distribution is more uniform. When the velocity is 35m/s and 40m/s, the pressure difference at the exit section is larger and the difference in pressure difference is also worse big. Therefore, through the analysis shows that the appropriate inlet velocity will increase the dynamic pressure of the abrasive, so that the impact of abrasive more intense, making the abrasive flow better polished. Although the excessive increase of inlet speed can enhance the polishing effect, but the polishing uniformity is weakened. It can be adjusted as needed when the actual abrasive flow polish elbow parts. In order to better study the effect of abrasive flow polish elbow, the same initializing settings of the above inlet velocities are obtained, and the turbulence kinetic energy cloud images under different inlet velocities are obtained as shown in Fig. 3.
As can be seen from Figure 3, the turbulent kinetic energy of the abrasive flow in the inlet section is small. The turbulent kinetic energy increases when passing through the bend section, and the turbulent kinetic energy remains unchanged at the outlet section. This shows that when abrasive flow polishing polished elbow parts, abrasive flow in the bending part is the most messy, and this messy movement will remain to the exit, this messy movement makes the opportunities of the abrasive collided to the inner surface of the wall increase, so as to achieve the purpose of polishing the workpiece. At the entrance, the turbulent kinetic energy of the near-wall region is greater than that of the middle region, which is beneficial to the polishing effect of abrasive flow on the wall. When the speed increases, the turbulent kinetic energy also increases, indicating that the increase of speed is conducive to the grinding of the inner wall of the elbow, resulting in a better polishing effect.

3. Conclusion
Through the numerical simulation analysis of the polished elbow of solid-liquid two-phase abrasive flow, the effects of different inlet velocities on abrasive flow polishing are analyzed and compared, and the conclusions are as follow.

(1) When the abrasive flow into the channel, at the same inlet velocity conditions, the dynamic pressure increases gradually, the dynamic pressure in the curved part reaches the maximum, and in the exit section tends to be flat. It shows that abrasive flow can polish the bending part best when polishing the elbow parts, and the polishing effect of the exit section is slightly higher than the entrance section. As the inlet velocity increases, the dynamic pressure in the same region gradually...
increases, indicating that the speed increase can effectively improve the polishing effect. However, when the speed is high, the pressure difference at the outlet will be increased, which will affect the uniformity of abrasive flow processing. Therefore, appropriately increasing the inlet velocity results in a more uniform and better surface quality.

(2) Under the same inlet velocity, the turbulent kinetic energy of the abrasive flow after entering the flow channel is small, and the turbulent kinetic energy will increase in the curved part and will be steady in the outlet section. It shows that abrasive flow on the bend part have the best polishing effect. As the inlet velocity increases, the turbulent kinetic energy in the same region becomes larger, indicating that the turbulent kinetic energy increases with the increase of inlet velocity and the effect of abrasive flow is more remarkable.

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