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Corner error simulation of rough cutting in wire EDM

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Abstract

This paper describes a novel simulation method for wire electrical discharge machining (EDM) in corner cut of rough cutting. In the simulation system, we analyzed the wire electrode vibration due to the reaction force acting on the wire electrode during the wire EDM, set up a geometrical model between the wire electrode path and NC path, and investigated the relationship between the wire electrode movement and the NC movement. From the simulation system, the wire electrode path could be obtained when the machining parameters such as the discharge current, the tension of the wire and the thickness of the workpiece were known. Simulations of the corner cut in right-angle machining, sharp-angle machining, obtuse-angle machining were carried out. By comparing the simulation results with experimental results, the feasibility of the simulation method was proved.

Keywords: Wire EDM; Simulation; Corner machining; Wire vibration; Geometrical model

1. Introduction

Wire EDM is thought to be suitable for processing high accuracy molds and parts, because it is a non-contact machining technique, unlike other cutting machining methods, it can provide higher machining accuracy and good roughness of surface. However, with the high-speed development of the mold industry, the need for precision instruments is steadily increasing, resulting in greater demand for the machining accuracy of the wire EDM technique. Since wire EDM uses a thin and flexible wire as a tool electrode, which is subject to deformation due to reaction forces such as explosive force and the electrostatic force between the wire electrode and workpiece, an unfavorable geometrical error of the machined surface easily occurs (as shown in Fig. 1). This is especially true in corner cut machining, in which the workpiece is subject not only to geometric errors along the direction of the electrode wire, but also to corner errors because the electrode wire lags behind the numerical control path (as shown in Fig. 2). Therefore, improving the corner cut accuracy is a significant area of study for all researchers interested in wire EDM. However, if only traditional technology is used to study wire EDM, research in this field will fall behind modern technology, so it is important to actively update research methods according to modern advances. Also, the development of computer technology creates new opportunities for the development and theoretical research of wire EDM. Simulation technology is a new method to research wire EDM, allowing researchers to model wire EDM processes, predict the surface roughness and machining accuracy, optimize the process parameters, and research machining mechanisms, so as to improve the machining characteristics.

Because the simulation of wire EDM is so important, there has been much research in this area. The majority of the new methods use simulations of machining technology in which the machining parameters are generated automatically by optimizing known parameters [1,2]. Obara et al. [3] and Han et al. [4–6] simulate the processing phenomenon of wire EDM on the computer by analyzing the vibration of the wire electrode and searching for the discharge locations. However, most of them are the simulation for cutting a straight line, the simulation for corner cut, especially for the corner in rough cutting, is rarely reported in these papers. Magara et al. [7] describes a research investigation on improvement of machining accuracy of corner parts in finish-cutting of wire EDM, in which the shapes of corner and machining feed at the corner can be simulated by considering changes of removal thickness, however, the

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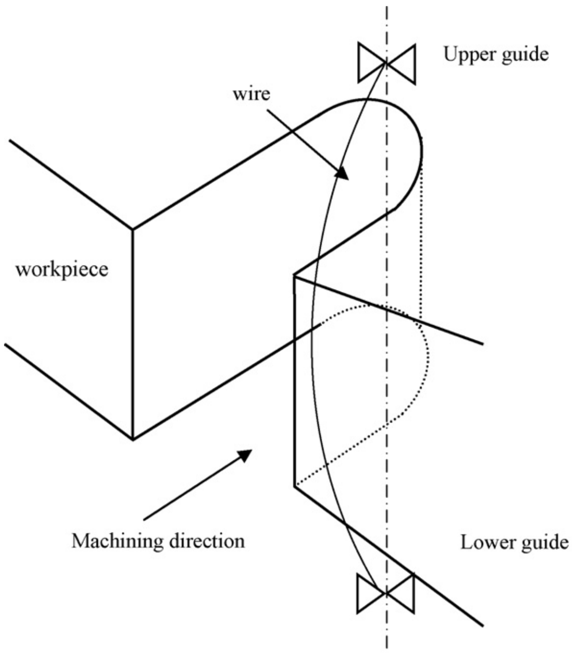

Fig. 1. Sketch map of linear machining.

vibration of wire electrode is not considered and the simulation only limited in the finish cutting. Although there has been much research about the corner machining for improving the corner accuracy of rough cutting [8–11], the research mainly focuses on the strategy of controlling corner accuracy due to the bends of wire electrode, the corner accuracy is not simulated in these papers.

The present study aims to simulate the relative motion between the wire electrode path and NC path of the rough cutting in wire EDM, and reproduce the corner machining process on the computer based on the wire vibration analysis and geometry model newly established between the wire electrode path and the NC path. This study also can address the control method to improve the corner cut accuracy of wire EDM in the future.

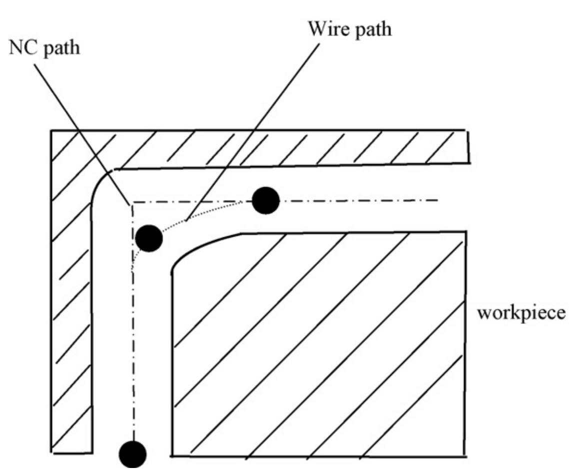

Fig. 2. Sketch map of corner machining.

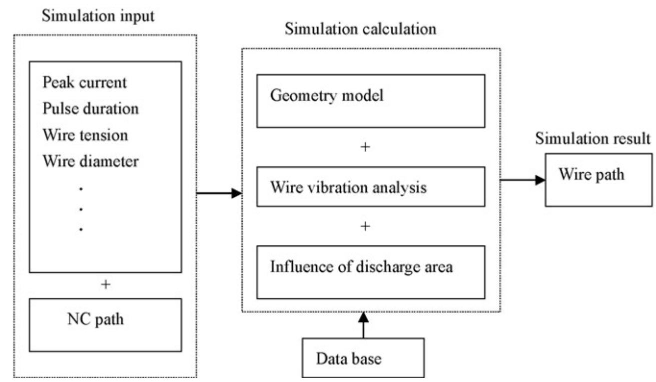

Fig. 3. Diagram of simulation system.

2. Simulation method

2.1. Overview of simulation system

Fig. 3 shows a diagram of the proposed simulation system. It is composed of simulation input, simulation calculation, a database and simulation results. After the NC path and machining parameters such as peak current, pulse duration, wire tension, etc. are inputted, the simulation system can simulate the actual wire path based on the geometry model, wire vibration analysis and influence of discharge area in corner processing. The database provides the relationship between the reaction force and pulse energy per pulse used for analyzing the wire vibration.

2.2. Wire vibration model

Although the wire tension is appended on the wire, since the wire is thin and flexible, it is subject to deformation and vibration due to reaction forces such as explosive force, electromagnetic force, the electrostatic force, etc. Therefore, to simulate the corner accuracy, the wire vibration must be analyzed first. Fig. 4 shows the wire vibration model. Since the wire electrode is sufficiently slender compared with its length, we can assume that

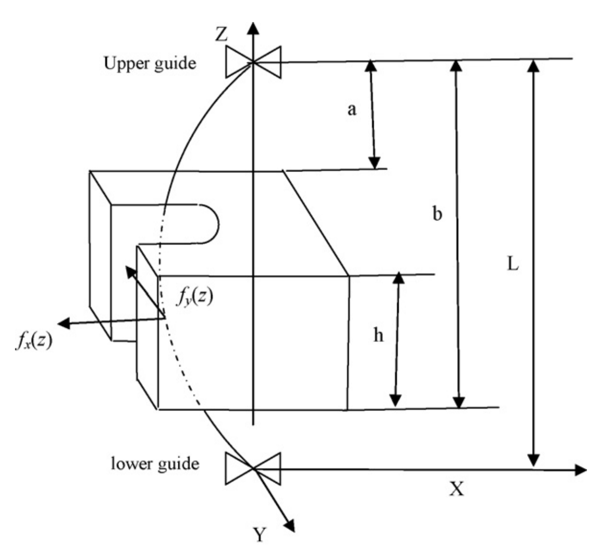

Fig. 4. Wire vibration model in the steady state.