In shoe manufacture, soles are made by injection moulding or foam moulding. When making the moulds for soles, it is necessary to make master models for all soles of every size. The master model of a sole is manufactured by numerically controlled (NC) machining. The present method for making 3D NC part programs for the sole master models is to use a computer-aided design and a computer-aided manufacturing (CAD/CAM) system. This is tedious and manpower intensive.

This paper proposes a method for reducing the time and cost for producing the 3D NC part programs of the sole master models. In this method, the NC part programs of the master model for the sample size sole are generated by the CAD/CAM system. Then, depending on the difference in dimensions between the sample size sole and another size sole, the scaling (grading) dimensions (values) in each of 3 axes are used to generate 3D NC part programs for the master model for another size of sole.

Keywords: CAD/CAM; NC part program; Shoemaking

1. Introduction

Shoes are necessities. Recently, new technology has been applied to shoemaking, for example the use of air bags, active air systems, etc. In addition, people participate in sports and leisure activities so that sportswear is very popular, and fashion and style are always changing. There is a wide range of types and shapes of sports shoes. This makes the shape of the soles increasingly complex and difficult to manufacture. So, computer-aided design (CAD) and computer-aided manufacture (CAM), and numerically controlled (NC) machining are increasingly used for the design and manufacture of shoes.

The soles of sports shoes are usually made of plastic or rubber by the injection moulding or foam moulding process.

The mould for a sole is a necessary and important requirement for sole production. Before making the sole mould, the master models (which are enlarged to allow for moulding and casting shrinkage) of soles for all sizes must be prepared. Then the master model of the sole is used as the pattern for investment casting (lost wax casting) to make the mould of the sole. After polishing, bench working and assembly, the sole mould is ready for production. Thus, the quality of soles depends on the precision and accuracy of the master models. The design and manufacture of master models for soles is one of the most important processes in shoe and sole mould making. It is equivalent to the design and manufacture of a master model for a stamping die for the steel panel of car body.

2. CAD/CAM and NC in Sole Master Model Design and Manufacture

Because of the complex shape and accuracy requirement, in the design and manufacture of the master model of the sole for high-quality sports shoes, a CAD system has been used to create a 3D model. Then a CAM system is used to compute and generate the NC part programs for machining. The procedure for the design and manufacture of the master model of a sole using CAD/CAM and NC is as follows:

1. Create 2D geometry from a drawing or template of sole.
2. Modify and smooth the 2D geometry (curves) (Fig. 1).
3. Create 3D profiles (curves) of the sole (Fig. 2).
4. Create 3D surfaces of the sole (Fig. 3).
5. Check 3D surfaces by shading, etc. (Fig. 4).
6. Create a machining process plan.
7. Select tool and cutting conditions.
8. Compute and generate NC part programs.
9. Simulate and check NC part programs.
10. NC machining master model of sole.
Using a CAD/CAM system and an NC machine tool, the required high accuracy and precision of the master model for the sole can be obtained. Once one master model has been made, it is very simple to design and manufacture the corresponding master model of the lefthand or righthand sole by using the mirror function of the NC and CAD/CAM systems. Therefore, the asymmetric problem in handmade master models of the lefthand and righthand soles can be eliminated by using CAD/CAM and NC systems.

There are many sizes for identical style shoes. For each size, there are dimension grade (like scale) increments in length, width and height (length, width and height grades) i.e. there are different scales in the X-, Y- and Z-axes. In addition, it is usual that the dimension grade increments of the front and rear zones in length are not the same (Fig. 5, Table 1). Some soles in a range of sizes have the same heel and/or height (Fig. 6). From know-how and ergonomics, the different dimensional grades are applied in different zones of a sole by the shoe makers [1,2] (Fig. 7).

Because of the complex dimension grading and the 3D shapes, the scaling function of a CAD/CAM system or an NC controller cannot be applied. CAD/CAM and NC systems provide only one scale for all 3 axes or one scale for each of the 3 axes [3–7] and do not support a scaling function requiring multiscaling in multizones for each of the 3 axes. Thus, the CAD geometric models for the master models for soles of all sizes must be produced by the CAD/CAM engineer and then the NC part programs are computed and generated for machin-