method is used to design a test of input variables and output indicators. Then, the BP neural network model is established to predict the carbon emission and precision of gear hobbing based on the data. Finally, a process parameter optimization model with the lowest carbon emission and optimal precision is built,and the particle swarm algorithm (Particle Swarm Optimization algorithm (PSO)) is used to solve the model. As a result, three sets of optimal process parameters including lowest carbon emission, optimal precision and comprehensive optimization are obtained.

II. Analysis Of Influencing Factors Of NC Gear Hobbing Process

A. Analysis of influencing factors of carbon emission

Materials, auxiliary materials, energy consumption and waste disposal will affect the carbon emissions of the machining system [12]. This section analyzes the influencing factors of carbon emission of gear hobbing process from the above perspective.

1) Impact of machine tool equipment

In the process of gear hobbing, various operating parameters of NC gear hobbing machine tools will change in different stages. Specifically, the gear hobbing machine tool has a complex structure, including a processing system and auxiliary system. In different stages of gear hobbing, changes in motor parameters will cause changes in hobbing speed and hobbing feed. During this process, the carbon emissions produced by the processing system change continuously over time, which can be calculated by integrating the power curve. The power of the auxiliary system varies little with the processing stage, so it can be regarded as unchanged in the time series, and its carbon emissions can be calculated by multiplying the power by the time.

2) Impact of materials and auxiliary materials

In the hobbing process, materials and auxiliary materials (such as coolant, lubricating oil, etc.)would be consumed, and they produced carbon emissions during their own preparation process, so the calculation of rolling Tooth carbon emissions should also be taken into consideration. The exact carbon emission of materials and auxiliary materials in the preparation process can not be known in advance, so it can be evaluated by the following methods: firstly, the materials and auxiliary materials consumed can be calculated through the comparison before and after the process; secondly, the carbon emission factor table of common materials can be consulted to determine the carbon emission factor; finally, the specific materials can be converted into standard coal for conversion.

3) Impact of waste disposal

After the waste generated by the gear hobbing processing system is collected, removed from impurities, briquetting, etc., it needs to be refurbished, and carbon emissions will also be generated in this process. Generally speaking, the commonly used materials for tooth blanks mainly include forged steel, cast steel and cast iron, which can be recycled and reused after degreasing, drying, and briquetting. Due to different reheating standards, the carbon emissions of different materials and wastes are also different. The method of assessing waste carbon emissions is the same as previously explained. The central idea is to calculate waste carbon emission factors and the amount of standard coal consumed to process these wastes.

B. Analysis of factors affecting precision

Gear hobbing is one of the core processes in the gear shaping process. In the process of gear hobbing, the process system composed of machine tool-workpiece-tool will affect gear precision.

1) Impact of machine tool equipment

As the actuator of gear hobbing, the machine tool's own error will inevitably affect the precision of the gear. Generally speaking, machine tool errors are mainly divided into guide rails, spindles, and transmission chain errors according to different parts. The accumulation and transmission of various errors will change the relative positional relationship between the hob and the gear blank. As a result, they will reduce gear precision.

2) Impact of the hob

The gear hobbing is the process in which the hob and the gear blank mesh with each other. Therefore, when the state of the hob changes, the quality of the gear will also be affected. Specifically, the state of the hob mainly includes changes in hob wear, damage, runout, and movement. The wear of the hob will increase the chip resistance, which will further reduce the hob cutting performance and reduce the gear precision. The destruction will cause the tool to be replaced, which indirectly affects its installation precision; the runout and movement will make the size of the machined gear uneven and increase the tooth profile error.

3) Impact of the tooth blank

The gear blank will also have a certain impact on the precision of hobbing. Due to the uneven geometry and material hardness of the gear blank, the cutting force will be different during the cutting process. As a result, the relative positional relationship got affected and the precision got reduced.

4) Impact of process parameters

In the process of gear hobbing, cutting process parameters will have a significant impact on the efficiency and quality of gear hobbing. Therefore, it is very important to select reasonable cutting process parameters. In the gear hobbing process, the cutting process parameters mainly include the hobbing depth, the hobbing speed and the hobbing feed. Cutting process parameters indirectly affect the rigidity and stability of the process system by influencing the hobbing force, thereby changing the cutting state of the hob and gear blank and ultimately affecting the gear precision.

The increase of the hobbing depth will make the hobbing force getting increase in a subtle way. This is because the hobbing depth is closely related to the gear shape (tooth profile correction coefficient). When the value is small, the effect on the hobbing force is relatively small. The hobbing speed is related to the friction between the hob and the gear, so it will also affect the hobbing force. When processing plastic materials, the hobbing force will increase with the increase of