Design and Optimization of Frame Steel Pipe Beveling Machine Based On FSC Racing

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Abstract. In recent years, with the enrichment of people's material life, the demand for various competitive sports has also increased, and the racing industry is one of them. In a racing competition, manual polishing of the steel pipe grooves of the racing frame is a task with huge workload, harsh working environment and long working cycle, which is laborious and laborious. The research direction of this paper is to develop a semi-automatic steel pipe bevel cutting machine to reduce the workload of steel pipe bevel grinding of racing car frame.

Keywords: racing frame; bevel polishing.

1. Introduction
In racing competitions, the frame is an indispensable part of the racing car and the basis for the loading of parts of the entire racing car. In Formula Racing, the frame is generally a steel tube truss, a carbon fiber aluminum honeycomb sandwich material or a composite frame combining the two. However, the technical complexity and high cost of monocoque frames discouraged many teams. Therefore, steel tube frames have become their first choice; even for fuel formula racing teams that have the technical and economic conditions to make monocoques, there will still be engine heat dissipation, etc. The problem is that a large number of frames in the engine compartment can only use steel tube truss structures. Especially in the Formula Race, teams using the steel pipe truss structure will inevitably need to finely polish the steel pipe grooves (as shown in Figure 1) to achieve a better connection between the steel pipes. It can be seen that the steel pipe truss structure will still be in great demand for a long time in the future, and this article also carried out further research in this direction.
2. Technical status
At present, the common groove processing technology is relatively backward, the processing process needs to withstand huge cutting noise for a long time, the high-speed wheel is dangerous when used, and the high-temperature chip splashing can easily burn the skin and eyes. The scene conditions are shown in Figure 2. The conditions for this type of groove processing need to be improved urgently to reduce work risks and speed up the progress of vehicle processing.

The machines that can process grooves commonly available on the market are as follows:

2.1. Abrasive belt beveling machine (Figure 3)
The operator holds the steel pipe, judges the position of the bevel by the operator's eyes, and controls the feed of the steel pipe on the moving belt. The function of the belt beveling machine is relatively single. The disadvantage is that the user needs to constantly judge the bevel processing condition with the naked eye, hold the workpiece to position, and the accuracy is poor; the belt runs unstable and easily runs off; the belt is for different wall thicknesses and different materials. The steel pipes of steel pipes have relatively strict restrictions. One abrasive belt cannot be used, and the durability of the abrasive belt is insufficient. It needs to be replaced regularly to maintain its grinding efficiency. The replacement process is cumbersome. Large-volume machines will take up a lot of space in the fleet workshop. And the risk of use is relatively high; the size of the processed steel pipe is also limited. Although the price is not very expensive, this machine cannot be the best choice for the team to cut grooves.
2.2. Hydraulic punching machine (Figure 4)
The operator holds the steel pipe, extends the end into the punching range, and the machine punches out an arc groove. The hydraulic punching machine has many functions, but the disadvantage is that it is expensive (every 3,000 yuan or more), and most functional fleets do not need it. Groove processing is not its main function, so its ability in this area is limited. The steel pipe is difficult to control when processing a groove with a small angle; the machine is large; and during operation, it is difficult to observe the shape of the groove in real time, and it is difficult to judge the position of the groove whether it is correct; its operation requires a certain technical basis, which is not easy for newcomers to the fleet; it is noisy after starting.

2.3. Pipe drilling machine (Figure 5)
Similar to the hydraulic punching machine's machine structure and operating mechanism, it does not use hydraulic punching but uses a cylindrical bimetallic hole opener made of cemented carbide for high-speed rotary drilling. This machine has the same shortcomings as the punching machine: expensive, redundant functions, insufficient precision, high risk, bulky, and high technical requirements for users. Although the machine itself cannot be used by the team, the steel pipe hole opener (as shown in Figure 6) used in it has great inspiration for the research and development of this project.
The above-mentioned beveling machines have different mechanisms, processing effects, and operating costs, but for the introduction of the fleet, they are not practical and cost-effective. Based on this, this project intends to independently develop and research a beveling machine with a certain degree of automation and suitable for fleet use, freeing fleet members from the heavy manual processing work. Three technical route and flow chart

2.4. Status analysis
In view of the needs of the current team work, a beveling machine that can be applied to the team work is particularly important. The problems that the project team currently needs to solve are: the accuracy of steel pipe clamping and positioning; the control of the direction of chip movement when the machine is working; the selection of tools and cutting speeds when cutting different workpieces; the balance and disassembly of the connection between the tool and the post Process simplicity issues; miniaturization, durability, and precise positioning of laser transmitters; safety issues.

2.5. Technical route
In view of the above problems, the existing machine is used to design the process on the basis of meeting the demand, and the process is optimized while retaining the existing advantages of the machine. The machining mechanism of various machine processing grooves is not the same. In the early design stage, we first imagined using them on our groove machine. Based on this, we discussed the layout of machine frame parts, fixtures, tools, etc., and then discussed the advantages and disadvantages. Choice.

2.5.1. Positioning of steel pipe clamping rotation posture. When the steel pipe rotates around the axis, the relative position of the cut groove will change. The frame generally uses steel pipes with the same outer diameter and the axes are connected to each other. Therefore, the groove is usually a part of a plane ellipse, and the main groove of a steel pipe usually contains the lowest point and the axis of symmetry. Based on the characteristics of this use, this machine installs a laser at the height of the axis of the steel pipe fixture to generate a stable linear beam, which is projected on the intersection of the clamped steel pipe and the horizontal plane of its axis, and is not affected by changes in pipe diameter.
2.5.2. Axial positioning of steel pipe clamping. Using the movement principle of the lathe slide box to control the tool coordinates, the guide rail is installed on the base of the beveling machine, the steel pipe clamping device is fixed on the slide, and the worm drive is used to convert the shaking of the hand wheel into the translation of the slide along the guide rail. The clamped steel pipe can move horizontally and axially freely. Adjust the axial position of the steel pipe to ensure the correct cutting point when the cutter feeds. Afterwards, it is locked with the slide plate to complete the axial positioning of the steel pipe.

2.5.3. Positioning of the angle between the tool and the steel pipe. The base of the tool holder is connected by a hinge, and the holder can rotate around a fixed axis of the hinge. A slider and pointer are installed at the tail of the bracket. The sliding block can move along the sliding rail, and can also be mechanically locked at the sliding block to limit the movement of the tool holder; the tail pointer cooperates with the angle dial to position the angle of the bracket. The cutter and the bracket are connected by bearings. After the angle of the bracket is fixed, the cutter can only move axially and rotate around the axis, so as to realize the positioning of the angle between the cutter and the steel pipe.

2.5.4. Part modeling and virtual assembly. After having the overall design plan, this article will draw the three-dimensional model of the designed machine parts on the CATIA modeling software, and simulate the assembly in the assembly design module, check the interference, and analyze the human-computer interaction under the working condition. The impact of cutting work on the machine. Then import the model into ANSYS finite element simulation analysis software for simulation analysis under cutting conditions to ensure sufficient safety and reliability.

2.5.5. Parts processing and use test. After the virtual analysis work is over, the design of all parts is completed. Afterwards, the 3D model is sent to the corresponding processing factory for processing, and if necessary, some parts are processed by oneself, and the required standard parts and consumable parts are purchased. Then follow the design steps to assemble the machine to form a prototype. The prototype is tested in actual work, looking for the existing defects and remediying by modifying the design, cutting, modifying the original part or directly modifying the part model and reprocessing. In the long-term use test, continuous improvement, summary use experience, and finally determine the final form of the machine.
2.6. Technical route flow chart

![Flow chart of technical route](image)

Figure 9 Flow chart of technical route

3. Conclusion
The technical complexity and high cost of monocoque frames have discouraged many teams, so steel tube frames have become their first choice; even for fuel formula racing teams that have the technical and economic conditions to make monocoques, there will still be problems such as engine heat dissipation. Therefore, a large number of frames in the engine compartment can only use steel tube truss structures. It can be seen that the steel pipe truss structure will still be in great demand for a long time in the future. This paper has done a lot of research work, has a clear understanding of the direction of the beveling machine developed, and has proposed the design scheme and optimization scheme from the principle. At the same time, the feasibility demonstration has been carried out using CATIA modeling software and ANSYS analysis software. At present, the description and design of the parts of the machine that need lubrication are not thorough enough in this article. I hope that later ones can conduct a more in-depth study on this aspect.

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