Design of Welding Positioning Device for Big-Caliber Steel Tube based on TRIZ Theory

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Abstract: TRIZ theory is one of the most practical and efficient methods of innovation in modern times, The article aims to solve the problem of "low efficiency in welding production of Big-caliber steel tube ", based on TRIZ theory, the design of large diameter steel tube auxiliary welding positioning device can be flexible clamping of various sizes of steel tubes, ensure that the big-caliber steel tube fitting can be welded flexibly after being fixed, The practical problem of repeated clamping during welding is solved.

1 APPLICATION OF TRIZ THEORY

1.1 Initial Investigation of Positioning Device Design

According to market research, the main function of existing auxiliary welding positioning devices is to completely fix the workpiece, ensure smooth operation of welding, its usage characteristics lead to the tube cannot be rotated or moved after the welder has fixed it, after welding some welds, the rest parts are difficult to be welded, it needs to be fixed and welded again, the working process is time-consuming and laborious, and easy to appear the sealing-off welding situation, the equipment is not easy for operators to use.

Based on the analysis of existing relevant patents, TRIZ theory "SVOP" expression method is used to express the function of the system to be designed, setting design objectives (Countinho J S, 1964):

Technology System(S): Auxiliary welding positioning device;

Apply Action(V): Fixed/rotated;

Action Object(O): Big-caliber steel tube;

Parameters of the action object(P): Displacement changes

Therefore, the function of the design system is expressed as "auxiliary welding positioning device to fix/rotate the displacement change of big-caliber steel tube". The key problem to be solved in its design is how to save time and effort. Single clamping can complete the whole circle welding with less labor, and put the welding personnel in the best position for easy welding.

1.2 Analysis Design System Problem

TRIZ theory has a very systematic analysis method for the problem of innovative design. The main purpose of system analysis is to find the key problems of the whole design system, for the design problems in this article, analysis the function, cause and effect and resources of the design system that can effectively determine the key problems to be solved in the whole system.

1.2.1 System Function Analysis

The function of this system is expressed as "the displacement change of big-caliber steel tube fixed/rotated by the auxiliary welding positioning device", according to the system function model figure 1, the negative function of the system is insufficient control of the driving device and clamping device in the human positioning device (Gofuku A, Koide S, Shimada N, 2006).

1.2.2 Systematic Causal Analysis

5Whys analysis method is adopted to carry out causal analysis on the design system, In the five-question analysis method (figure 2), Let's start with

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the question "why is the efficiency of big-caliber steel tube (round) not high in the welding process?",

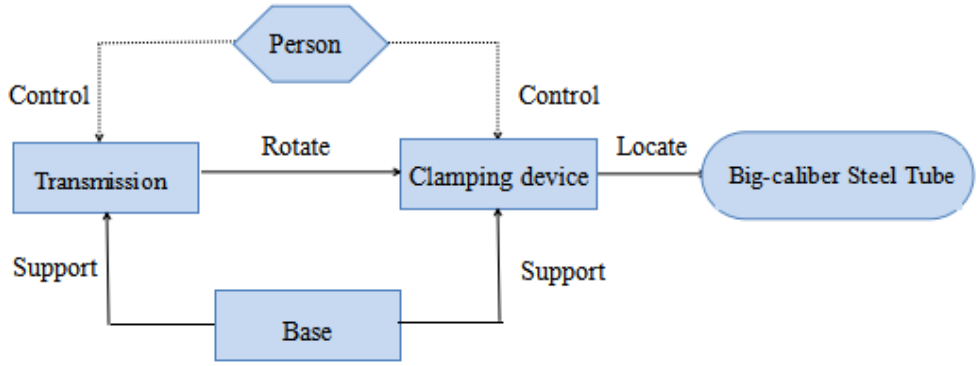

Figure 1. Function model diagram of auxiliary welding positioning device.

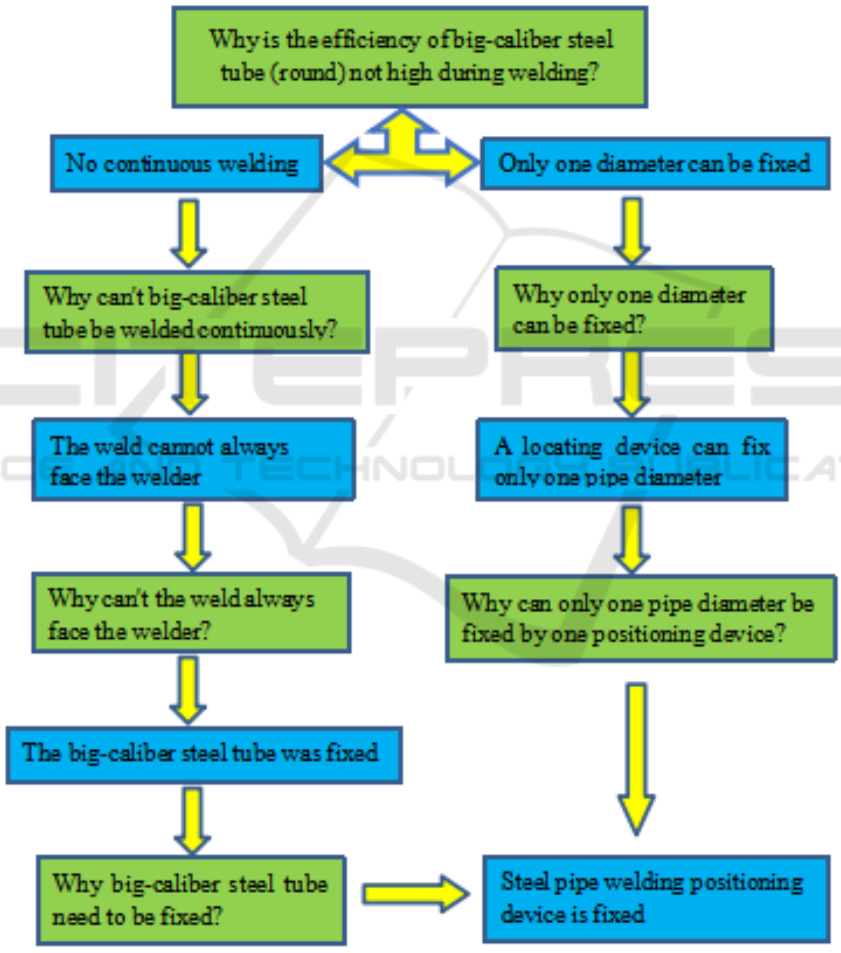

Fig 2. 5Whys method diagram of auxiliary welding positioning device.

explore the cause of the problem through two lines of questions, derive the ultimate cause of the problem finally "Steel tube welding positioning device is fixed", it follows that, We believe that the design of the welding positioning device of steel tube into an overall adjustable type may become a research focus of this product.

1.2.3 System Resource Analysis

The resource analysis list of auxiliary welding devices is shown in table 1.

Table 1. Resource analysis list of auxiliary welding devices.

Resource Type	System level		
	Subsystem	System	Super system
Material resources	Transmission mechanism,clamping mechanism, engine base	Welding positioner device	Welding steel tube
Energy resources	Mechanical energy	Mechanical energy	Mechanical energy, Electrical energy, Magnetic energy
Space resources	Manual operation space	Inside the device, steel tube turnover space	Steel tube connection space
Time resources	Transmission time, clamping time	Steel tube fixing and turning time	Steel tube connection time
Information resources	Personal experience	Mechanical principle	mechanical principle, electromagnetic principle
Functional resources			Control-system

Draw the nine-screen diagram of the auxiliary welding positioning device through the analysis list (FIG. 3), you can see it clearly through the nine-screen image, starting with the initial common welding fixtures, the development of auxiliary welding positioning device has gone through a long evolutionary process. From the nine-screen diagram, we can analyze that the clamping device and the transmission device are one of the most compact subsystems of the auxiliary welding positioning device, so we think the design of clamping and transmission device may become a research focus of this design.

1.2.4 Analysis Summary

Through the above analysis method summary, transform the difficult problems in the system design process into two key problems A and B, Question A - how to clamp the welding parts and adjust the welding position to find the most suitable welding station and Question B - how to design a welding device suitable for welding parts of different sizes, and simple operation of an auxiliary welding positioning device, solving the above two problems is very important for the design of the device.

1.3 Solutions to Design System Problems

TRIZ theory has a clear classification for the solution of quasi-analytical problems, as to this specific problem for the design of this article, the " Idea Final Result " is adopted to establish the solution ideas of the related problems in the overall design, then through the physical contradictions and technical contradictions of design process to solve one by one to improve the system design (Qin Han, 2009).

1.3.1 Idea Final Result

When using TRIZ tools to solve problems, we use the "IFR" analysis method firstly (as shown in table 2).

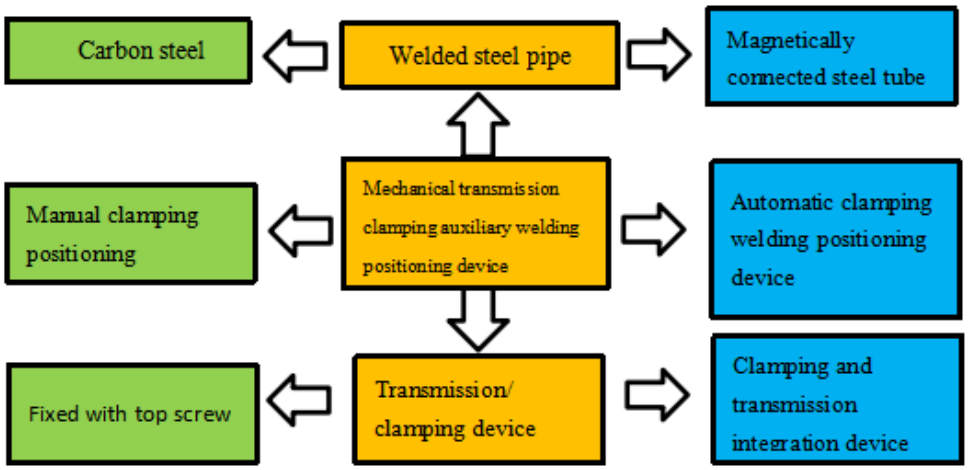

Fig 3. Nine-screen analysis diagram of auxiliary welding positioning device.

Table 2. Idea Final Result Analysis Method Table.

NO	Question	Analysis Results
1	What is the ultimate goal of the design?	Improve welding efficiency of big-caliber steel tube.
2	What is the Idea Final Result?	Easy operation, clamp pipe diameter welding parts of different sizes, continuous turning to ensure that the welding device.
3	What are the obstacles to reaching the idea final result?	Manual labor is laborious and inconvenient, poor regulation of clamping device
4	What is the result of this obstacle?	The welding process requires hand-rolled steel pipe, the device is not suitable for all pipe diameters.
5	What are the conditions for not having this disorder?	Design the mechanism for turning steel pipes, improved clamping device.
6	What are the available resources to create these conditions?	Electrical energy, personal experience accumulation, mechanical related principles

From the above analysis, we can see that we should give priority to our own advantages, therefore, we will improve the structural design and combine the electrical device to realize the final ideal solution of an auxiliary welding positioning device, it is concluded that the diameter of tube is clamped electrically by the rotating device, by improving the clamping device, it is suitable for all Big-caliber welding parts, through the improvement of the positioning device, the device can not only complete the clamping positioning, but also can flip and move.

1.3.2 Solution to Key Problem A - Physical Contradiction

Key question A: how to clamp the welding parts and adjust the welding position to find the most suitable welding station? Through analysis, it is found that the circular tube needs to be clamped and fixed in the welding process to ensure the quality of welding. The weld of circular tube needs to move to the front of the welder to ensure the smooth welding, so we use physical contradiction analysis.

Firstly, the problem is transformed into a physical contradiction, which can be expressed as follows: The circular tube needs to be clamped and fixed to ensure the welding quality, and it needs to be moved to the front of the welder to ensure the smooth operation of welding.

TRIZ theory uses the separation principle to solve physical contradictions (Guang Yang, 2004). Based on the above description of physical contradictions, the principle of space separation is more reasonable. After analyzing the invention principle, we believe that principle 7 may help solve the problem. The specific scheme is shown in table 3 below.

Table 3. Solutions to key problem A.

Inventive Principle No	Inventive Principle	Concrete Proposal
7	Nested principle	Nest the tube into the positioning fixture

1.3.3 Solution of Key Problem B - Technical Contradiction

For the key question B, how to design an auxiliary welding positioning device suitable for the welding parts of different sizes with simple operation? The analysis shows that:

Increasing the adjustability of the auxiliary welding positioning device means that the stability of the structure decreases.

Simplifying the operation method of auxiliary welding positioning device means improving the maneuverability of the equipment, but at the same time the manufacturability of the equipment becomes complicated.

We believe that this is a technical contradiction, so we use technical contradiction analysis to solve the problem, the specific operation is as follows:

Extraction technology contradiction

Table 4. Technical contradictions of key question B.

Technical contradiction	
If	Want to fit the fixture of welding positioning device to different sizes of welding parts Want to make welding positioning device fixture easy to operate
Then	Increase the adjustability of positioning fixture Save operation time
But	It is necessary to control the clamping strength of tube fittings with different tube diameters Equipment systems are more complex

Table 5. Corresponding contradiction matrix table.

Improved parameter Weakened parameter	Force	System Complexity 36
Adaptability, Versatility	15,17,20	
loss of time		6,29

According to the above contradiction matrix table, the following solution table 6 is obtained.

Table 6. Solutions to key problem B.

Question	Inventive Principles	Concrete Proposal
35-10	15 Dynamic Principle	A telescopic joint is installed in the positioning clamping device to adjust the clamping force
22-36	6 Multipurpose principle	The clamping part of the positioning device is installed with the transmission part, so that it has the function of positioning clamping and transmission performance.

2 DESIGN OF WELDING POSITIONING DEVICE FOR BIG-CALIBER STEEL TUBE

2.1 The Final Design Scheme of Auxiliary Welding Positioning Device for Big-Caliber Steel Tube

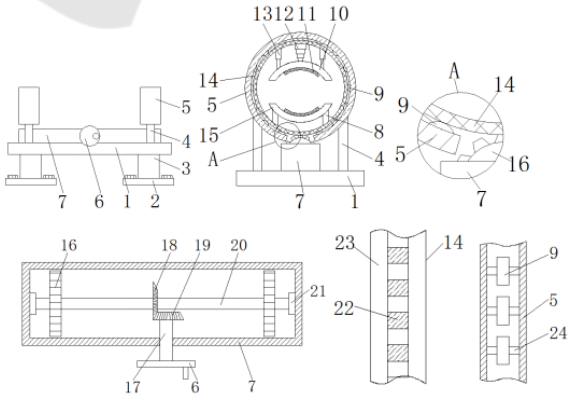

Fig 4. Overall schematic diagram of the device.

As shown in FIG 4, both sides of the bottom of base plate 1 are fixedly connected with supporting leg 3, the bottom of the supporting leg 3 is fixedly

connected with the supporting plate 2, the connection between the bottom of supporting plate 2 and the ground is fixed and connected by foundation bolt, through the foundation bolt, the phenomenon of shaking affecting welding operation can be effectively avoided when the device is in use, improved the stability of the device in use, the top of the base plate on both sides are provided with fixed collar 5, both sides of the bottom of the fixed collar 5 are fixedly connected with dead lever 4, the connection between the bottom of dead lever 4 and the base plate 1 is fixed, the inner cavity of the fixed collar 5 is provided with loose collar 14, the inner groove of the fixed collar 5 is provided with live bearing 9, the inner sleeve of the live bearing 9 is provided with fixed axis 24, both sides of the fixed axis 24 are fixed connected with the joint of the fixed collar 5, both sides of the surface of the loose collar 14 are provided with inclined ramp 23 which is used in combination with the live bearing 9, by live bearing 9 and inclined ramp 23, it can effectively avoid the stuck phenomenon of loose collar 14 during rotation, improved the utility of the device, the top of the inner cavity of the loose collar 14 is fixedly connected with electric telescopic rod 12, the bottom of the electric telescopic rod 12 is fixedly connected with movable jaw 10, and both sides of the top of the movable jaw 10 are fixedly connected with auxiliary telescopic rod 13, the top of the auxiliary telescopic rod 13 is fixed connected with the joint of the loose collar 14, and through the auxiliary telescopic rod 13, it can effectively avoid the deviation phenomenon caused by uneven force of movable jaw 10 when positioning the pipeline, and improve the positioning effect of the device, the bottom of the movable jaw 10 is provided with fixed jaw 15, and both sides of the bottom of the fixed jaw 15 are fixed with joint lever 8, the bottom of joint lever 8 is fixedly connected with the loose collar 14, and the inner sides of movable jaw 10 and fixed jaw 15 are fixedly connected with soft pads 11, the top of the base plate 1 is fixedly connected with the drive box 7, the inner cavity of the drive box 7 is provided with revolving bar 17, the bottom of the revolving bar 17 runs through the drive box 7 and is fixedly connected with the swivel plate 6, the top of the revolving bar 17 is fixedly connected with the active bevel gear 19, the left side of the top of the active bevel gear 19 is engaged with the driven bevel gear 18, the inner cavity of driven cone tooth 18 is provided with crossbar 20, the two sides of the crossbar 20 are movably connected with bearing 21, bearing 21 away from the side of the crossbar 20 and is fixedly connected to the connection of drive box 7, gear 16 is set on both sides of the surface of crossbar 20, the top of gear 16 runs through drive box 7 and extends to the outside of drive box 7, the surface of the loose collar 14 is provided with tooth ace 22 used in conjunction with the drive box 7, The top of the inner cavity of the drive box 7 is provided with straight slot used in concert with gear 16, the bottom of the inner cavity of the fixed collar 5 is provided with notch used in concert with gear 16, through straight slot and notches, it can effectively avoid the phenomenon of collision affecting the use during rotation.

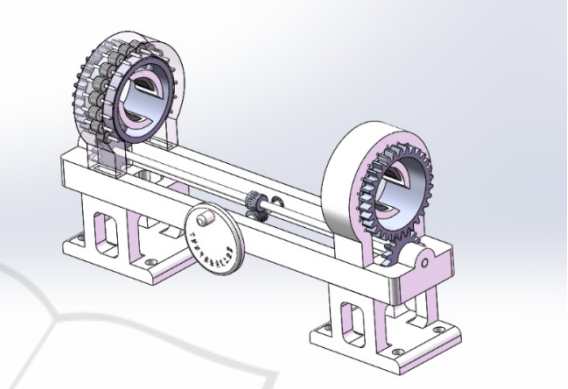

Fig 5. 3d Rendering of Device Structure.

3 CONCLUSIONS

The welding positioning device designed in this article, the welding parts are clamped and adjusted by electric transmission for easy operation and use by the welder, the whole three-dimensional welding of tube diameter can be completed in one clamping, save time and labor, not easy to remove welding, none of the auxiliary welding devices on the market has this function. The TRIZ theory used in the design process provides an efficient and practical innovative method for this design. Great help has been provided to the completion of this innovative design, this method is of great benefit to innovative design and is worth popularizing. We hope you find the information in this template useful in the preparation of your submission.

REFERENCES

Countinho J S. Failure-effect Analysis [J]. Transactions of the New York Academy of Sciences, 1964, 26(2): 564-584.

Gofuku A, Koide S, Shimada N. Fault Tree Analysis and Failure Mode Effects Analysis Based on Multi-level Flow Modeling and Causality Estimation[C]// SICE-ICASE, 2006. International Joint Conference. IEEE, 2006:497-500.

The Development of Welding Automation in China from the Application of Welding Auxiliaries in Gas Shielded Welding [J].Qin Han. Welding. 20009 (10).

Present Situation and Prospect of Welding Automation Technology [J] Guang Yang. Maschinen Markt. 2004 (11).