

# Route Analysis of Trail Adjustable Wagon Based on Crank Rocker Mechanism

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**Abstract.** The trajectory analysis of a transport wagon is a prerequisite for its rational path planning. In order to analyze the influence of crank and rocker lengths on the trajectory of a transport wagon in a four-bar spatial mechanism, two kinds of trajectories, single "8" and double "8" were simulated. The results show that changing the crank length will obviously change the trajectory shape, and changing the rocker length will mainly change the walking angle. This conclusion provides a basis for the route adjustment and planning of transport vehicles.

## 1. Introduction

In the increasingly busy workshop transportation production line, the trajectory of the transport wagon is more complex. On the one hand, with the increase of production line function, more requirements are put forward for the traveling path of the transport wagon. On the other hand, in order to reduce the overall production cost, the space utilization rate of the production line workshop is constantly improving, which makes the traveling space of the transport wagon smaller and smaller, so it is necessary to design a more flexible transport wagon. Crank rocker mechanism is a common mechanism in the steering part of transport wagon, and it is the most basic form of four-bar mechanism. It is widely used in feeding mechanism of bullhead planer, radar adjustment mechanism, foot mechanism of sewing machine, compound pendulum jaw crusher and steel conveyor. Aiming at the steering part of the transport wagon, this paper analyses the trajectory change rule and adjustment strategy of the trajectory based on crank rocker mechanism.

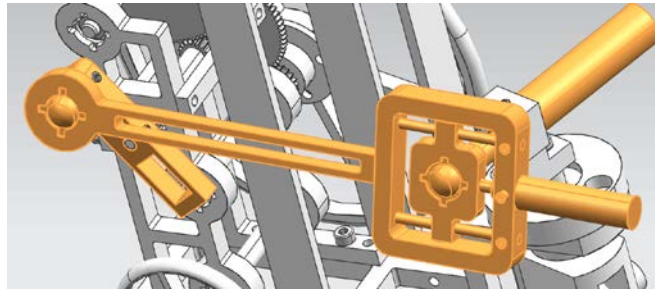
## 2. Steering Structure of the Wagon

As shown in Figure 1, the steering structure of the transport wagon is mainly composed of a hinged four-bar crank-rocker mechanism consisting of a crank and a rocker. Among them, the crank is the active part, driven by the motor or other energy devices, and rotates at the same speed, while the rocker is the follower to swing back and forth at variable speed, and the connecting rod is a plane compound motion. In order to make the spatial rotation of the connecting rod more stable, the joint connecting bearing between crank and rocker adopts universal coupling, thus turning the steering structure into a spatial crank rocker mechanism.

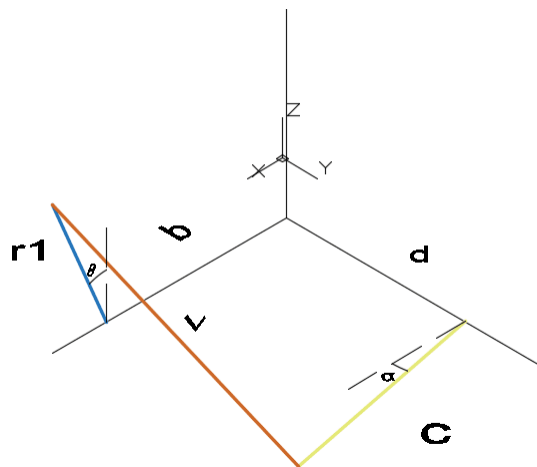
In order to calculate and analyze the trajectory of steering mechanism, assuming that  $r_1$  is the length of crank,  $L$  is the length of connecting rod,  $C$  is the length of rocker,  $b$  is the length of crank to origin, and  $d$  is the length of rocker to origin, the motion coordinate system of steering mechanism of transport wagon can be established, as shown in Figure 2. Consider the steering wheel of the transport wagon as a starting point. In practical application, in order to facilitate manufacture and installation,



the length of crank and connecting rod will not be changed. Therefore, in order to simplify the calculation, the length of crank and connecting rod is set constantly.



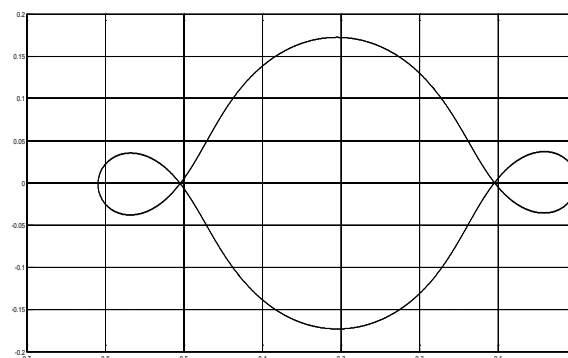
**Figure 1.** Steering Structure of the Wagon



**Figure 2.** Motion Coordinates of Steering Mechanism

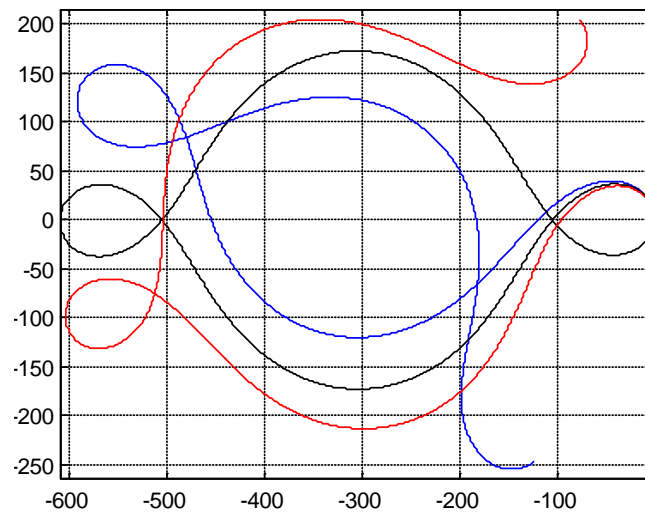
### 3. Trajectory Change Analysis

In order to compare and analyze the changed paths, the initial trajectory is designed as shown in Figure 3. Starting from the horizontal direction of the X-axis at the right end of the trajectory, the moving wagon moves along the left X-axis at a certain angle to the horizontal direction. During walking, the crank rocker mechanism makes the steering mechanism constantly change its angle. The car moves along the curve to the left end of the X-axis and then continues to move along the curve to the starting point, forming a closed circular curve. The whole trajectory is similar to an double "8" placed horizontally.

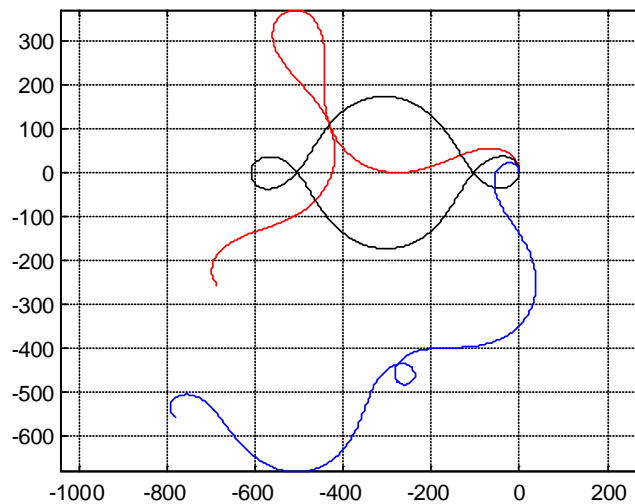


**Figure 3.** Initial Trajectory

For ease of analysis, it is assumed that the length  $b$  of the crank to the origin varies in the range. The limit position values  $b-3$  and  $b+3$  are taken respectively, and the trajectory of the car is shown in Figure 4. Among them, the blue track is the shortest crank-to-origin length; the black track is the same crank-to-origin length; and the red track is the longest crank-to-origin length. From Figure 4, it can be found that changing the  $b$  value can change the upward or downward migration angle of the trajectory, but does not change the distance of the trajectory in the horizontal direction. Increasing or decreasing the value of  $b$  will affect the downward or upward migration angle of the trajectory, and has no significant effect on the trajectory shape.



**Figure 4.** Crank Length Changing in Double "8" Path

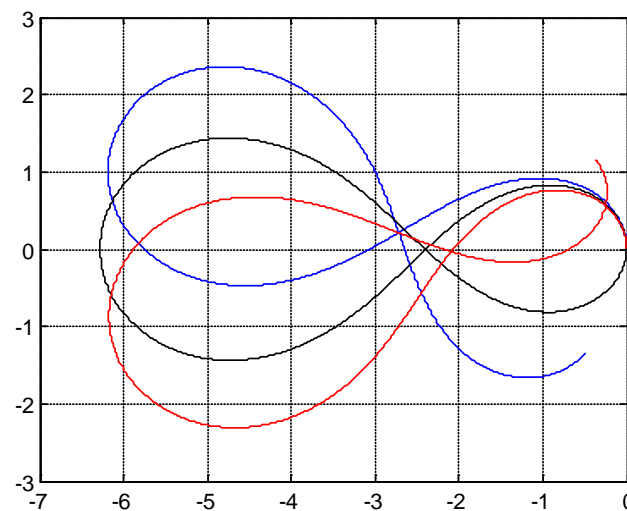


**Figure 5.** Rocker Length Changing in Double "8" Path

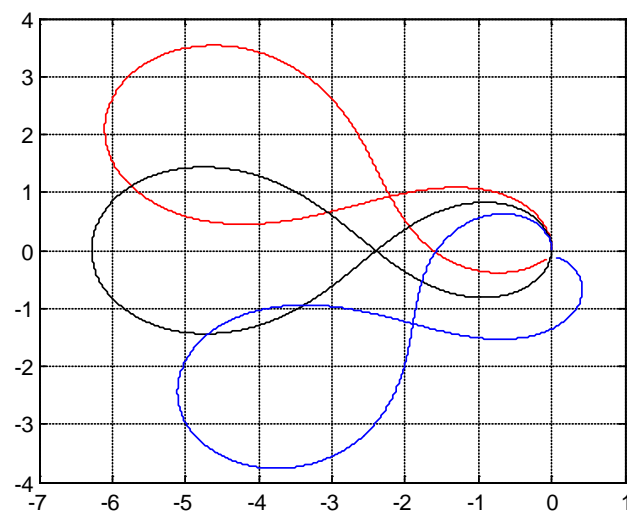
Similarly, assuming that the range of the length  $C$  of the rocker is the limit values  $C-3$  and  $C+3$ , the trajectory diagram of the wagon is shown in Figure 5. Among them, the blue trajectory is the shortest case of rocker length; the black trajectory is the case of rocker length unchanged; and the red trajectory is the case of rocker length is the longest case. Figure 5 shows that when the length of rocker decreases, the trajectory will rotate counterclockwise, and the route will change from closed to open; when the length of rocker increases, the trajectory will rotate clockwise, and the trajectory will change to "8". Thus, changing the length of the rocker will significantly change the shape of the trajectory. Therefore, when adjusting the angle of steering mechanism, it is not appropriate to adjust the length of rocker.

#### 4. Path Change Analysis

In order to compare different planning paths, the horizontal double "8" path is changed to the horizontal single "8" path. By changing the length of crank, rocker or connecting rod respectively, the change of trajectory is observed. As shown in Figure 6, the blue trajectory reduces the length of the crank to the origin; the black trajectory keeps the length of the crank to the origin unchanged; and the red trajectory increases the length of the crank to the origin. From Figure 6, it can be found that when the length of the crank to the origin decreases, the trajectory will rotate clockwise, while the shape of the trajectory remains the trajectory "8"; when the length of the crank to the origin increases, the trajectory will rotate clockwise, while the trajectory remains the word "8". Thus, when the angle of the path needs to be changed without changing the shape of the path, the length of the crank to the origin can be moderately increased or reduced.



**Figure 6.** Crank Length Changing in Single "8" Path



**Figure 7.** Rocker Length Changing in Single "8" Path

Figure 7 shows the change of steering mechanism path caused by changing the length of rocker in a single "8" path. Among them, the blue trajectory is the shortest case of rocker length; the black trajectory is the case of rocker length unchanged; and the red trajectory is the case of rocker length is the longest case. From Figure 7, it can be found that when the length of rocker decreases, the

trajectory will rotate counterclockwise while the shape of the route remains unchanged; when the length of rocker increases, the trajectory will rotate clockwise and the trajectory will remain "8". It can be seen that changing the length of rocker has no obvious effect on the shape of the path, but it will obviously change the deviation angle of the path.

## 5. Conclusions

By changing the distance from crank to origin and the length of rocker, the trajectories of double "8" and single "8" of steering mechanism of transport car are simulated and analyzed. It is found that changing the distance from crank to origin and the length of rocker will change the trajectory of transport wagon. At the same time, in the change of crank or rocker length in four-bar space, the angle of counter-clockwise rotation of the wagon is larger than that of clockwise rotation. These laws provide a basis for the trajectory planning of transport vehicles.

## 6. References

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