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# Assembly Simulation Based on Tecnomatix Ps and Its Application in Automotive Suspension Assembly

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**Abstract:** due to the three-dimensional digitization and complication of automotive design and the automated production, process simulation has become a necessary tool in building the automotive automation production line. With the process simulate tool in tecnomatix software, the assembly simulation is used for the virtual verification of all process steps and their details (defined in the manufacturing process plan); industrial robots are programmed and simulated to perform precise and complex equipment functions to expand the flexible automation and increase the productivity of the workshop. Taking the simulation process of the suspension automation assembly stations as an example, the application of process simulate tool in the automobile assembly simulation and automatic production line design is discussed through the simulation of automobile suspension automatic assembly process and industrial robot motion simulation.

## 1. Introduction

Automobile assembly simulation technology relies on software to simulate the whole process of installing parts and components in a dynamic way in the three-dimensional digital environment. Through the simulation of automobile assembly process, the automobile assembly cycle, as well as the research and development costs can be greatly reduced. The digital assembly process simulation replaces the assembly tests of parts and components, so it can greatly shorten the development cycle and reduce the cost, effectively decrease assembly defects and the failure rate of products, reduce assembly process repetition and human errors, reduce design changes and project delay caused by assembly interference and other problems. At the same time, in the stage of tooling structure design, the designer can not only see the whole motion process directly, but also analyze the limit positions, rotation angles, interference, spatial motion positions and motion parameters through the three-dimensional dynamic display on the screen. Designer can accurately predict problems that may occur in the design in advance without waiting for trial production and make timely improvements. The process provides a theoretical basis for the design.

The 3d digital model of product and equipment is the foundation and condition of assembly simulation. At the same time, because the motion of the production line cooperates with the industrial robot, the whole motion link and process must be simulated through simulation to ensure the rational design of production line and control the motion process.

## 2. The Importance of Simulation

Simulation technology stems from the need of system research. It uses the system model to test the real or designed system to achieve the purposes of analysis, research and design of the system.

By adding three-dimensional digital models of products, tooling equipment and industrial robots to the software and displaying them, the dynamic changes in the production process can be determined. Effective system simulation can simulate the real object between single machine manufacturing and production line, shorten the production period, and avoid unnecessary re-design and time waste. Among them, the industrial robot simulation has more complete functions and

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strong authenticity. It can produce simulation pictures which approximate to the real. Its advantages include, shortening the production cycle of products, improving product quality, reducing layout, tooling and other design defects, reducing and optimizing investment, and making products come into the market earlier.

In the automotive automation production, simulation is necessary for all links including the scheme formulation, the beat calculation, the reachability verification, the interference detection, the process verification and feedback, as well as simulation video recording, offline programming and post transformation. Simulation provides the most intuitive standards for all stages of the project.

## 3. Software Introduction

Tecnomatix is a comprehensive digital manufacturing solution system that helps us to achieve innovation by synchronizing product engineering, manufacturing engineering and production. Based on Teamcenter's best Product Life-cycle Management (PLM) platform, Tecnomatix is the most functional manufacturing solution in the market.

Among them, the process simulation, or PS, can provide a three-dimensional dynamic environment fully integrated with the manufacturing center, which is used to design and verify the manufacturing process. Manufacturing engineers can reuse, create, and validate manufacturing process sequences to simulate real processes and optimize production cycles and beats. The Process Simulation can be extended to all kinds of robot processes to simulate and debug the production system.

## 4. Overview of Automotive Suspension Assembly

### 4.1 Process Features

The automotive suspension assembly has following characteristics. First, the automation and production processes require high degree of accuracy and speed. The whole process is a combination of mechanical, electrical, industrial robot and other disciplines, which requires engineers understand all related professional knowledge before undertaking the whole process. Second, the assembly process is controlled by the PLC (Programmable Logic Controller). The mechanized positioning, industrial robots and other mechanical and electrical equipment should closely cooperate to complete the process. Many processes need to be completed with corresponding tooling equipment.

### 4.2 Technological Process

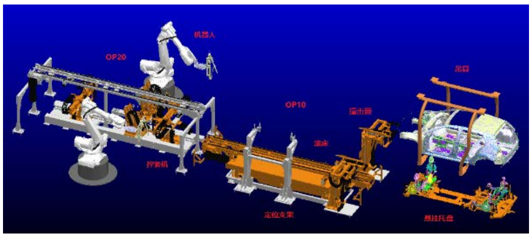


Fig.1 General Structure of the Suspension Automatic Assembly Line.

According to the characteristics of automobile suspension, the designed suspension automatic assembly line can realize the simultaneous mechanical positioning, assembling and screw tightening of the front and rear suspension of automobile. The process is as follows. The lifting appliance transports the car body; the suspension tray carries out the initial positioning for the suspension. The car body moves to the OP10 station; the car body is precisely positioned by the positioning bracket and the striker, and the suspension tray rises through the roller bed and integrates with the car body. After the integration is completed, the roller bed transports to the OP20 station, and then the screw is tightened by the tightening machine and the robot to complete the suspension automatic assembly.

Among them, the striker has three degrees of freedom, which can ensure the accurate positioning of the car body. Two robots on the left and right sides can tighten the two pairs of suspension screws at the same time to improve the production efficiency. The overall structure is shown in Figure 1.

## 5. Key Technology of Assembly Simulation

The assembly simulation plays an important role in analyzing the defects of product design, reasonably planning assembly process, improving product quality and reducing production cost.

The assembly simulation means to simulate the process of product assembly. At the same time, it is necessary to simulate the structure movement of the tooling involved in the assembly process. The assembly simulation plans the assembly path in detail, checks the safety distance and carries out collision tests to ensure the safety and efficiency of the path. The movement simulation of the tooling mechanism mainly involves the establishment of the moving mechanism of the tooling simulation model and the analysis of the tooling movement, so as to ensure that the tooling meets the production requirements.

### 5.1 Establishment of Tooling Motion Simulation Model

The establishment of the dynamic simulation model of tooling needs to go through the following steps. The first is structural planning and distinguishing different moving parts according to the principal and subordinate relationship. The second is to establish the motion mechanism according to the motion type between the principal and subordinate parts. The third is setting initial state position of tooling, namely to set the initial position of each part according to the tooling preparation state. The fourth is the dynamic interference inspection, in order to ensure the safety, speed and effectiveness of the tooling when it works. In this case, the striker can be flexibly adjusted and precisely positioned according to different models. Its structure is composed of two adjustable impact pins, each of which can move in x, y and z directions, so three linear movements need to be established. The moving distance of each direction is designed to meet the production demand, so the upper and lower limit values of each direction are determined to ensure that the tooling movement can meet the production requirements of multiple models. The mechanism is shown in figure 2.

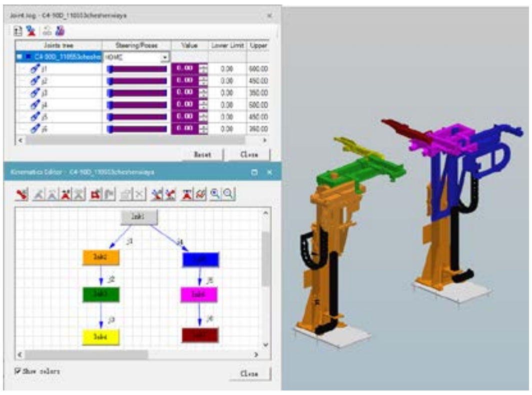

Fig.2 Establishment of the Striker Motion Mechanism.

### 5.2 Assembly Process Simulation and Tooling Motion Simulation

According to the simulation model of motion mechanism established above, the assembly process simulation and tooling motion process simulation are carried out. The contents of assembly process simulation include, the assembly sequence of parts, the simulation of safety inspection of parts assembly and other processes. The simulation of tool movement process is mainly about the safety inspection of the moving mechanism of the tool in the simulation environment. It includes checking whether the tooling itself has collision risks, whether there is the danger of collision with other equipment under working condition and other unsafe factors, as well as the travel inspection at the three directions of x, y, z, in order to meet the design and production needs.

In this case, before verification, when the suspension tray is transported from the place in front of OP10 station to the OP10 station, the suspension on the tray interferes with the positioning bracket of the lifting appliance; the suspension tray is unable to enter the OP10 station as Figure 3 shows. Through simulation verification, the interference can be avoided by raising the height of positioning bracket or lowering the suspension height. Since the former can affect the whole vehicle transportation after lifting the height, the latter is selected. A pit with a depth of 450mm is dug at OP10 station to place the lifting roller bed. The transportation height of the hanging tray is reduced to the same level as the transportation surface of the lifting roller bed in the pit. Thus, when transporting to OP10 station, it can avoid the positioning bracket and slide into OP10 station smoothly. The process after interference is shown in Figure 4.

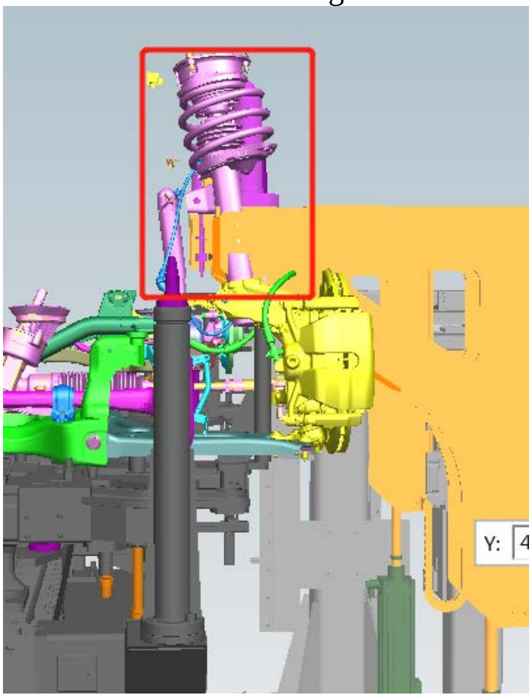

Fig.3 Conflict of Suspension and Lifting Appliance Positioning Brackets.

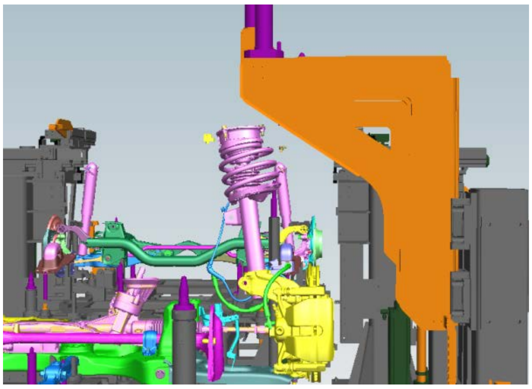

Fig.4 Avoidance of the Conflict between the Suspension and Lifting Appliance Positioning Brackets.

### 5.3 Robot Motion Analysis

The industrial robot is a high and new technology combining mechanics, computer science, sensor technology, artificial intelligence technology, bionics and other disciplines. Therefore, it is widely used in the field of automobile manufacturing.

In this case, the car body is suspended at OP20 station and fixed by screw machine and robot, as shown in Figure 5. Therefore, in the PS simulation environment, the Robot Viewer (as shown in Figure 6) is used to observe each joint value of the robot to ensure the working accessibility of the robot. During the execution of the working track, the whole process of the robot can also be dynamically observed to avoid singular points, system errors and joint limits brought by large-scale attitude transformation and other problems, so as to improve the working speed and efficiency of the robot.

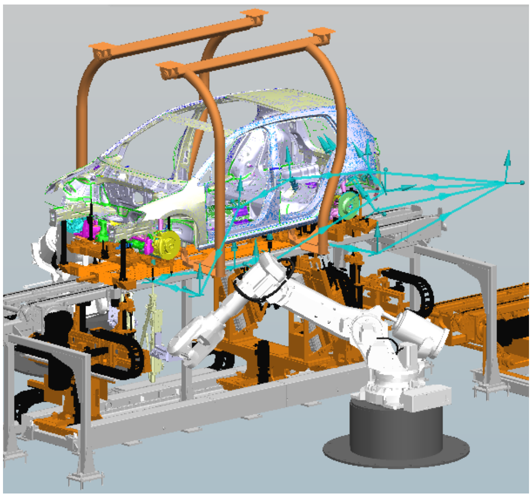

Fig.5 Op20 Station.

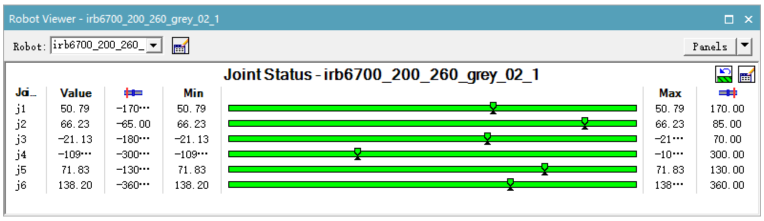


Fig.6 Robot Viewer.

## 6. Off-Line Programming of Robot

At present in China, the majority of robot debugging is completed through manual teaching programming, but there are also shortcomings in manual teaching programming, such as the tedious programming process, the need for teaching experience, low production efficiency and the difficulty in accurate teaching of complex tracks. In new tasks the machine needs to be stopped. Offline programming can make up these shortcomings of manual teaching programming; it can also more intuitively show the programming trajectory, robot working dynamics and activity range. It can improve the programming environment, facilitate the movement trajectory, and improve the working efficiency.

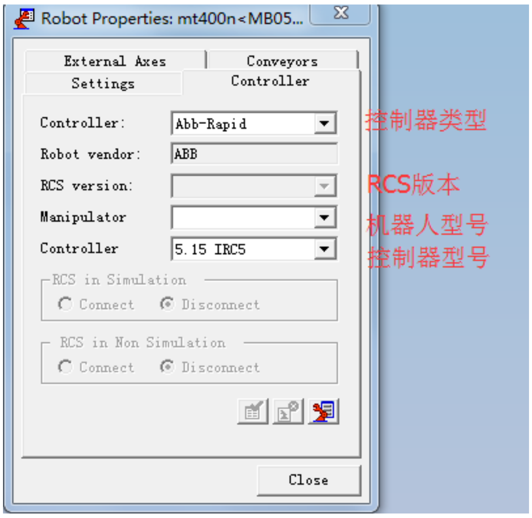


Fig.7 Interface of Robot Property Setting.

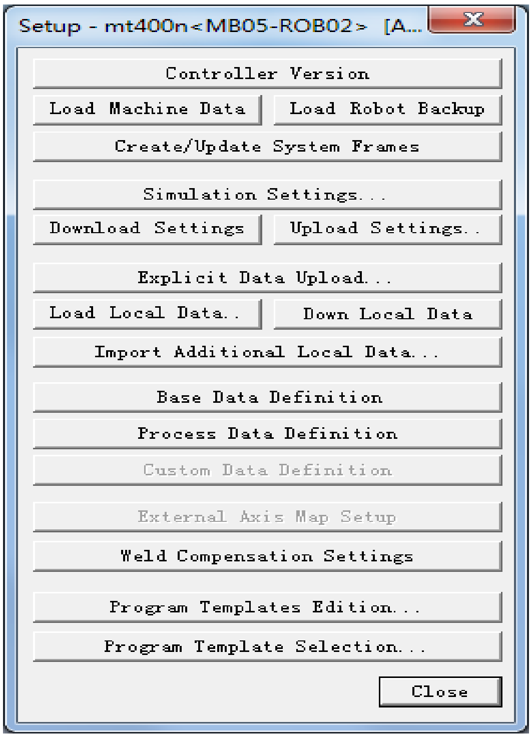


Fig.8 Interface of the Detailed Robot Property Setting.

In the RRS (realistic robot simulation) controller, that is, the Robot Properties interface, all the offline data related to the robot are set as shown in Figure 7 and Figure 8. The offline data can be divided into two categories: the coordinate system and the offline program. The coordinate system is divided into tool coordinate system (Tool) and work-piece coordinate system (Base).

### 6.1 Coordinate System

In the off-line programming of robot, most of the operation tasks are defined in the work-piece coordinate system. Therefore, the accurate calibration of the work-piece coordinate system is of great significance for THE off-line programming. The tool coordinate system refers to the coordinate system established in a fixed position on the end actuators of industrial robots by fixing special components as tools.

In the PS simulation environment, engineers need to install the tool digital model on their flange plate when using the robot, move the default tool coordinate tool0 from the center of the robot flange to the tool end to be used, and establish a new tool coordinate. The work-piece coordinates are established with the product origin as the coordinate origin as shown in Figure 7.

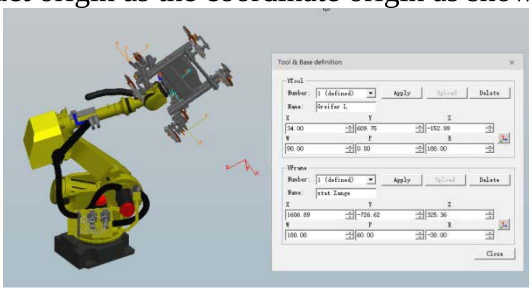

Fig.9 Tool & Base Definition.

### 6.2 Offline Program

The off-line program is to compile and export the motion track of the robot in the simulation according to the program template of the same brand, so that it can be compiled and used in the robot system.

The RCS (Robot Controller Simulation) modules of different brands of robots are authorized by robot manufacturers to provide accurate data for motion planning and inverse kinematics.

Manufacturers use the characteristics and limitations of robots to create accurate joint values for robot motions, and plan the best motion path between space points, that is, using the RCS module can get high-precision simulation results.

In the OP20 station of this case, two robots use the RCS module to compile and export the precise trajectory program, so that they can quickly and accurately complete the work of screw tightening for the suspended car body. Therefore, the application of offline program greatly reduces the workload of debugging personnel, shortens the debugging cycle, saves manpower, reduces cost, and improves product quality.

Through the simulation analysis, the auto suspension assembly line meets the customer's requirements. After verification, the stations of OP10 and OP20 meet 56S beat. Beat analysis is shown in Figure 8 and Figure 9.

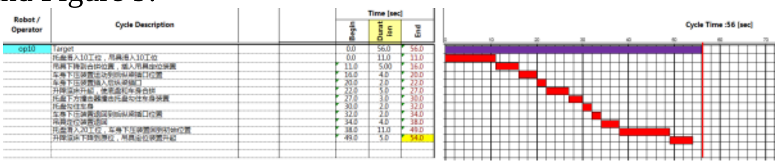

Fig.8 Analysis of Station Beat of Op10.

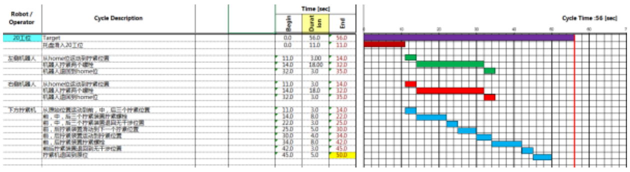

Fig.9 Analysis of Station Beat of Op20.

## 7. Conclusion

In this paper, through the application of the auto suspension assembly line in the PS simulation, the negative effects of station design on production are eliminated. Through the tool motion simulation, the assembly process simulation and robot motion analysis, engineers can not only solve problems that may occur in the assembly process before the actual production, analyze the spatial motion position and carry out interference inspection, but also effectively guide the tool design, and make accurate prediction on possible problems and make improvement in the preliminary design stage of the project. With the use of off-line programming technology of industrial robots, the time of manual debugging is saved; the debugging cycle is shortened; the production quality of products is improved and the production stability is guaranteed.

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