In view of the common and difficult to solve vehicle vibration problem, taking a large truck manufacturing enterprise in China as an example, an improved model for solving truck vibration problem is established by using the G8D method, and the unbalanced excitation force of the wheel system is analysed. The coupling of the excitation frequency and the natural frequency of the system leads to the resonance phenomenon, as well as the inadequate damping function of the system, is the fundamental cause of the vibration problem. After verifying and implementing permanent correction measures at the same levels of components, devices, and the entire vehicle, the acceleration of the seat guide rails for the vibration performance of the truck reduces from the original state 1.04 m/s² to 0.6 m/s², a decrease of 42.3%, which reaches the best level of mainstream cars in the country and is close to the optimal level of 0.5 m/s² among the same kinds of cars in Germany. Therefore, the improved model can improve the sustainability of product manufacturing, provide industry guidance for solving the quality problem of truck vibration, and provide a sustainable guarantee for social public transport safety.

1. Introduction

The vibration of the truck mainly refers to the vibration produced by the cab when the truck is running on the smooth road surface, which is the most common and difficult quality problem in truck vibration [1]. This vibration will not only make the truck occupants feel uncomfortable but also affect their normal operation and even increase the risk of causing traffic accidents [2]. At the same time, the vibration problem is the quality problem which the customer repeatedly requests to correct, directly affects the customer to the product cognition, and negatively blocks the passage of the product manufacture sustainable development [3]. But, in the actual work, most of the researchers only analyze a certain vibration phenomenon and then propose a single solution, which is lack of systematic solutions.
applicability and sustainability to the quality improvement of truck manufacturing industry [5].

2. Theory and Methodology

2.1. G8D. The G8D method is one of the most widely used problem-solving tools related to the prevention of repeated nonconformities in the manufacturing process and is often used for complaint management in the automotive industry. Ford Motor Company pioneered 8D problem solving in mid-1980 [6] for use by its suppliers to improve problem solving. The G8D has been widely used in the automotive industry service or product problem solving [7], including supplier quality issues, manufacturing process deviation, defect [8], maintenance, customer complaints, returns, and other issues. The main area of current research is in industrial process quality improvement [9], which facilitates increased productivity and timely handling of customer complaints [10].

For the study of vehicle vibration problem, most of the researchers only analyze a certain vibration phenomenon and then propose a single solution, which lacks systematic solutions. And, the situation of recent research is shown in Table 1.

This paper introduces a set of improved models of G8D in solving truck vibration problem, provides a general process to effectively identify and solve the problem, and provides a method to identify the root cause and implement appropriate corrective action. This approach identifies the changing needs of the system, emphasizes teamwork, increases management understanding of the problem itself and the problem solution, encourages direct and open problem resolution, and prevents the recurrence of the same problem and other similar problems. Compared with the traditional research methods, it is more universal to solve the vehicle vibration problem systematically.

2.2. Related Theories on the Fundamental Causes of Vehicle Vibration

2.2.1. Exciting Force. The exciting force comes from several aspects: the imbalance of the wheel system, the imbalance of the drive shaft system, and the unsmoothness of the road surface.

2.2.2. Ability of Vibration Isolation and Absorption. The system has a front axle shock absorber and cab front and rear suspension shock absorber [15], and the engine suspension forms the vibration isolator of the vehicle system and provides the system with the ability to reduce vibration.

2.2.3. Resonance Phenomenon. The frame, the suspension spring of the front axle, and the shock absorber of the front axle constitute a “mass-spring-damping” system [16], and the powertrain with its front and rear suspensions forms the “mass-spring-damping” vibration system [17]. A mass-spring-damping vibration system [18] is formed between the cab and the following suspension springs and dampers.

Each of these systems has its own resonant frequency. The frequencies of these systems should not be the same or close enough to form resonant coupling; at the same time, these resonance frequencies should be as far away as possible from the excitation frequencies of the system, such as the excitation frequency of the tire, if the resonance of the system is inevitable. If the exciting frequency of the tire coincides with the resonance frequency of a certain system, the vibration absorber of the system should reduce the vibration amplitude of the system as much as possible.

3. Improvement Process of Truck Vibration

In view of the vibration problem existing in truck manufacturing, the G8D is used to establish an improved model for solving the truck vibration problem. In the application of the G8D, step D1 “establishing a team” and step D8 “summing up and commending” are omitted because its implementation can be carried out by the enterprise management department. Therefore, the improved model of vibration problem is elaborated mainly from D2 to D7, and the quality improvement tools in G8D are used to solve the problem of vibration. The specific model is shown in Figure 1.

3.1. Reaction to the Problem (D0). To prepare the application of G8D, it is necessary to analyze the characteristics and objectives of the problem. Taking a large truck manufacturing enterprise in China as an example, there may be some problems of installation technology or improvement of some manufacturing methods in the production process of localization of technology and drawings in Germany.

Truck vibration has the following characteristics: for the same type of truck, some vehicles have vibration problems, but the rest of the vehicles do not have this problem, which shows that there is no problem in the design of vehicles. Therefore, it can be considered that the vibration of the vehicle is caused by the manufacture and installation of some parts, and this kind of problem is very suitable to be solved by G8D.

The G8D requires defining the objectives to be solved by using this method: one is to solve the vibration problem of the truck, the other is to confirm whether the vibration of the cab exists, and the third is whether the existence of the problem is serious enough to affect the delivery of the vehicle.

3.2. Description of the Problem (D2). The first key step to solve the truck vibration problem is to describe the truck vibration problem accurately, including the accurate description of the characteristics and manifestations of the vibration. Based on the facts, the paper states problems from the following aspects as in Table 2.

3.2.1. 5Whys. Through observation and test, it is found that the acceleration of the seat guide rail near the vehicle speed (65 km/h) is the largest and the vibration is very serious in the vertical direction of 2.10 m/s² and in the longitudinal
direction of 2.02 m/s² calculated from formula (1). From formula (2), the vibration frequency is near 5.55 Hz. This kind of vibration is produced only on the smooth road surface, the speed maintains in the vibration speed, and the vibration is more serious, which causes the passenger discomfort [19]:

\[
a_{jb} = \sum_{i}^{n} (F_{ia} \times VTF_{ia,jb}),
\]

(1)

where \(a_{jb}\) is the acceleration response of point \(j\) direction \(b\) (m/s²); \(F_{ia}\) is the load force of point \(i\) direction \(a\) (N); \(VTF_{ia,jb}\) is the vibration transfer function from point \(i\) direction \(a\) to point \(j\) direction \(b\) (m/s²/N). The formula means the vibration response is the load force of each driver point and each direction produces the VTF from the driver point to the response point. If the vibration acceleration of response point is to be reduced, the following three aspects need to be controlled [20]:

\[
f = \text{num} \times \frac{n}{60},
\]

(2)

where \(\text{num}\) is the order and \(n\) is the speed. Formula (2) indicates that each order frequency of the vibration signal is closely related to the wheel speed.
In order to find out the corresponding problems and define the root causes of vibration, the five-question method ("repeatedly ask why") is adopted in this paper as in Figure 2.

3.2.2. "Yes and No" Worksheet. The Yes and No worksheets describe the extent of the problem as in Table 3, and only the correct information is included in this table, which is part of the observation phase as part of the problem resolution process. The information in the Yes section of the worksheet determines the root of the problem and the No section helps narrow the scope of the problem.

3.2.3. Truth Factor Assessment. (1) Manifestation of Vehicle Vibration. The vehicle vibration is represented by the vertical, transverse, and longitudinal vibration of the steering wheel [21]; vibration of the gear; vibration of the floor in the vertical direction; vibration of the seat in the vertical and forward and backward directions; and vibration of the left and right rear mirrors in the cab.

(2) Evaluation Method of Vehicle Vibration. The vibration of the vehicle is evaluated by measuring the vibration acceleration of the seat guide rail in three directions with the help of data acquisition equipment. In the absence of any testing means, it is also possible to evaluate the vibration of a vehicle with the subjective evaluation method, as well as the end-user, and judge whether the vibration exists and its severity and acceptability from the point of view of a product consumer to determine that it can be put on the market.

(3) The True Cause Evaluation of Vehicle Vibration

(1) Quality problems of core components: the processing of some rotating parts (such as transmission shaft, semishift, rim, hub, tyre, and brake hub) does not meet the technical requirements, and deviation results in mass eccentricity when assembly does not meet the technical requirements. These eccentric masses produce periodic exciting forces when the vehicle is running.

(2) Tyre exciting force: the periodic exciting force produced by the unbalanced wheels in the running of a vehicle is transmitted to the frame through the leaf spring and then to the cab.

(3) Tire vibration mode: there are two modes of tire vibration, jumping mode and swinging mode. The first is the run-out mode, in which the vibration phase of the left and right tires is the same, that is, when the left tire jumps to the top, the right tire jumps to the top, and when the left tire jumps to the bottom, the tire on the right jumps to the top, and the tire on the left jumps to the bottom. The tire on the right is also bouncing to the bottom. The second is the swing mode, in which the vibration phase of the left and right tires is just the opposite, that is, when the left tire jumps to the top, the right tire jumps to the bottom, and when the left tire jumps to the bottom, and the tire on the right, however, leaps to the top.

(4) Cab and seat vibration: the vibration problem dissatisfied with by the end-user is often the cab and seat vibration [22]. And, the overwhelming majority of the unbearable vibration of the cab and seat is that the body is in the jumping mode [23]. The reason for this vibration is that the exciting force produced by the static and dynamic imbalances of the tire is in the run-out mode, the front tire is in the run-out mode, or the rear tire is in the run-out mode. Another is the front and rear tires are in the bounce mode. The frequency of the jumping mode may be consistent with the mass of the frame and the rear axle plate spring and the natural frequency of the spring system, or with the mass of the frame and the front axle plate spring and the natural frequency of the spring system, which puts the frame into a resonant state at the same frequency as the radial force on the tire. The resonance state of the frame is transferred to the cab through the cab suspension. If the stiffness of the cab suspension is not matched properly, the excitation frequency of the wheel system coincides with the mass of the cab and the body suspension and the natural frequency of the spring system and then, resonance occurs again.

3.3. Development of Immediate Corrective Action (D3). In the case of vibration problems, it is necessary to take emergency response measures and choose Immediate Corrective Action (ICA), to solve the vibration problems provisionally, but the premise of the proposed measures is that the existing design, manufacturing, and installation methods and processes cannot be changed and no cost can be increased. Thus, the vehicles will be put into use so that the customers who purchase these vehicles will not be affected by the vibration of the vehicles and damage the reputation of the quality of the vehicles. The criteria for selecting emergency response measures are shown in Table 4.

Based on the above criteria, immediate corrective actions adopted include, but are not limited to, are as follows:

(1) The front right wheel and the rear right wheel tire are rotated 180 degrees before reinstallation

(2) Under the condition of keeping (1), the rear axle tires are cross-suspensioned on the left and right sides

(3) Use a better cab suspension [24]

(4) Use a better front axle damper [25]

(5) Select tires, brake drums, and wheels with small dynamic unbalances

3.4. Analysis and Identification of Root Causes (D4)

3.4.1. Describing Root Causes and Missing Points. The missing point is a point that is very close to the root cause; that is, it omits to analyse what should have been the problem. No missing points were found in this particular vibration problem of the enterprise.
Based on the results of the problem method stated in D2, the "Yes and No" worksheet, the "5Whys," and the truth factor assessment, the enterprise can tentatively determine that the cause of the truck vibration is the unbalanced excitation force of the vehicle's wheel system, the coupling of the excitation frequency and the natural frequency of the system that leads to the resonance phenomenon, and at the same time, the insufficient damping function of the system, as described in detail as follows:

(1) Wheel systems (including tires, hubs, and rims) have significant manufacturing defects [26], such as nonroundness of wheels and rims. The unevenness of the inner and outer edges of the rim (that is, the inner and outer edges are not in the same plane) results in the imbalance of the tire system. In the operation of the vehicle, these unbalanced forces become the excitation force of the system vibration.

(2) The dynamic imbalance of the drive shaft system is one of the factors that cause the vibration of the system.
(3) Because the frequency of exciting force produced by the wheel train in the 65~70 km/h is about 5.5 Hz, this resonance frequency obviously coincides with one of the frequencies of the above three vibration systems and produces resonance. The connection to the cab through the system causes the cab to resonate. Another reason is that the natural frequency of the cab itself is consistent with the excitation frequency, resulting in resonance.

(4) Shock absorbers for vehicles due to manufacturing quality inconsistencies [27] cause the component fail to meet the technical requirements of providing sufficient damping during resonance [28], thereby reducing the resonance amplitude of the system. The damping force of the shock absorber of the front axle is not large enough [29]; when the front axle resonates, the amplitude of the resonance cannot be attenuated to the design level; the shock absorbers of the engine and the cab are unable to provide sufficient damping because of inconsistent manufacturing quality.

3.4.2. Confirming Description. As shown in Figure 3, the vertical acceleration of the middle rear axle near 65 km/h is large [30], up to 4.76 m/s²; magnified to 5.21 m/s² from the vertical acceleration of the middle rear axle near 65 km/h is attenuation the vibration (3.11 m/s² to 2.05 m/s²). The acceleration of the cab is reduced from 2.10 m/s² to 0.68 m/s², and the longitudinal acceleration of the cab is reduced from 2.02 m/s² to 0.56 m/s². The cab vibration is obviously improved. There is no significant difference in the isolation rate between the two types of spiral spring shock absorbers.

(2) Replace the Dynamic Balance Brake Hub and Dynamic Balance Tire. The acceleration comparison before and after dynamic balancing is shown in Table 6.

After dynamic balancing, the vibration acceleration of the main seat guide rail decreased by 30.36% in longitudinal direction and 45.59% in vertical direction. The vibration acceleration at the left wheel of the rear axle is still large and becomes the main excitation, which may be caused by the poor dynamic balance of the left rear axle tire and brake hub or the assembly error.

The manufacturing inconsistency of the wheel hub, the uneven flatness of the inner and outer edges of the wheel rim, and the uneven roundness of the rim can also be confirmed by observation. Overall, the test results show that the brake hub and tire with dynamic balance have a great attenuation effect on the vibration.

3.5. Selection and Validation of Permanent Corrective Actions for Root Causes and Missing Points (D5). In order to determine the permanent corrective action (PCA), the principle is to reduce the amplitude of the exciting force, separate the modes of the system [14], and increase the damping force of the system [33]. There are six permanent measures listed in Table 7. If you have more than one vendor for these 6 components, you can use the decision table in Table 8 to select a good vendor.

According to the data in Table 8, the standard score expected by supplier A is 52 and the standard score expected by supplier B is 48 (the full score is 60). Meanwhile, supplier B cannot meet the standard of "not increasing the cost of the product." In the light of the above decisions, vendor A should be selected.

3.6. Implementation and Validation of Permanent Corrective Action (D6)

(1) Dynamic balance of transmission shaft: put forward, check, and carry out the technical requirements about the size and dynamic balance of transmission shaft and have corresponding quality inspection mechanism

(2) Dynamic balance of wheel hub: put forward, check, and carry out the technical requirements of roundness dimension and dynamic balance of wheel hub and have corresponding quality inspection mechanism

(3) Dynamic balance of wheel rim: propose, check, and implement the technical requirements of rim size, roundness, and dynamic balance and have the corresponding quality inspection mechanism

(4) Dynamic balance of tire assembly: put forward, check, and implement the technical requirements of static and dynamic balance of transfer tire assembly and provide technical assistance to suppliers to...
Table 5: Acceleration (m/s²) on both sides of cab suspension near 65 km/h.

<table>
<thead>
<tr>
<th>Cab shock absorber</th>
<th>Front suspension body side</th>
<th>Front suspension frame side</th>
<th>Front suspension vibration isolation rate</th>
<th>Rear suspension body side</th>
<th>Rear suspension frame side</th>
<th>Rear suspension vibration isolation rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original air spring</td>
<td>3.05</td>
<td>1.78</td>
<td>−4.68 dB</td>
<td>2.05</td>
<td>3.11</td>
<td>3.62 dB</td>
</tr>
<tr>
<td>Ex-brand 1, post-brand 2</td>
<td>1.39</td>
<td>2.37</td>
<td>4.63 dB</td>
<td>1.29</td>
<td>2.01</td>
<td>3.85 dB</td>
</tr>
<tr>
<td>Both are brand one</td>
<td>1.96</td>
<td>3.30</td>
<td>4.53 dB</td>
<td>1.61</td>
<td>2.55</td>
<td>3.99 dB</td>
</tr>
</tbody>
</table>

Notes: Vibration isolation rate = 20log (active side vibration amplitude/passive side vibration amplitude).

Table 6: Acceleration comparison before and after dynamic balancing (m/s²).

<table>
<thead>
<tr>
<th>Measuring point position</th>
<th>Before dynamic balancing</th>
<th>After dynamic balancing</th>
<th>Reduced percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main seat guide (longitudinal)</td>
<td>0.56</td>
<td>0.39</td>
<td>30.36%</td>
</tr>
<tr>
<td>Main seat guide (vertical)</td>
<td>0.68</td>
<td>0.37</td>
<td>45.59%</td>
</tr>
<tr>
<td>On the left wheel of the middle axle (vertical)</td>
<td>4.31</td>
<td>1.41</td>
<td>67.29%</td>
</tr>
<tr>
<td>On the right wheel of the middle axle (vertical)</td>
<td>4.76</td>
<td>1.85</td>
<td>61.13%</td>
</tr>
<tr>
<td>At the left wheel of the rear axle (vertical)</td>
<td>3.31</td>
<td>3.21</td>
<td>3.02%</td>
</tr>
<tr>
<td>At the right wheel of the rear axle (vertical)</td>
<td>3.19</td>
<td>2.15</td>
<td>32.60%</td>
</tr>
</tbody>
</table>

Figure 3: Transmission of vibration acceleration.
purchase static and dynamic balance equipment of tire

(5) Provide the supplier with hardness and technical requirements for reinforced powertrain suspension rubber, and urge and assist them to achieve these technical requirements and consistency of product characteristics; it can be listed in Table 9

(i) The technical requirements for the damping characteristics of the hysteresis curve of the front axle damper are presented to the supplier

(ii) The technical requirements for the damping characteristics of the hysteresis curves of the front and rear suspension dampers of the cab are proposed to the supplier

The quality of these components must meet the quality and technical requirements of the enterprise, and there is a systematic mechanism to implement and verify the implementation of the quality and technical requirements of these components.

There are three levels of validation for these permanent corrective measures:

(1) Component level: correct the dynamic balance of the rotating parts of the vehicle: drive shaft, wheel hub, rim, and tire assembly [34], ensure the supplier’s

Table 7: Decision worksheet on permanent corrective measures.

<table>
<thead>
<tr>
<th>Expected standard</th>
<th>Importance (1–10, 1: minimum, 10: maximum)</th>
<th>Criteria that must be met</th>
<th>Final result: eliminate or reduce vibration in operation of this type of vehicle to the extent acceptable to the customer</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Deviation quality and consistency of transmission shaft</td>
<td>8</td>
<td>(a) Do not change existing design</td>
<td>(b) Do not change the manufacturing process</td>
</tr>
<tr>
<td>(2) Technical requirements for hub: roundness and flatness and consistency</td>
<td>9</td>
<td>(a) Do not change existing design</td>
<td>(b) Do not change the manufacturing process</td>
</tr>
<tr>
<td>(3) Rims meet technical requirements: roundness and consistency</td>
<td>9</td>
<td>(a) Do not change existing design</td>
<td>(b) Do not change the manufacturing process</td>
</tr>
<tr>
<td>(4) Dynamic balance and consistency of tire assembly</td>
<td>9</td>
<td>(a) Do not change existing design</td>
<td>(b) Do not change the manufacturing process</td>
</tr>
<tr>
<td>(5) Damping force of front axle shock absorber meets technical requirements and consistency</td>
<td>8</td>
<td>(a) Do not change existing design</td>
<td>(b) Do not change the manufacturing process</td>
</tr>
<tr>
<td>(6) Cab-suspensioning shock absorber meets technical requirements and consistency</td>
<td>9</td>
<td>(a) Do not change existing design</td>
<td>(b) Do not change the manufacturing process</td>
</tr>
</tbody>
</table>

Table 8: Vendor decision worksheet.

<table>
<thead>
<tr>
<th>Vendor A</th>
<th>Vendor B</th>
<th>Criteria that must be met</th>
<th>Criteria that must be met</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do not change existing design</td>
<td>Do not change existing design</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do not change the manufacturing process</td>
<td>Do not change the manufacturing process</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No increase in product cost</td>
<td>No increase in product cost</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Expected standard</th>
<th>Good or bad (1–10)</th>
<th>Score</th>
<th>Expected standard</th>
<th>Good or bad (1–10)</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Deviation quality and consistency of transmission shaft</td>
<td>Good</td>
<td>8</td>
<td>(1) Deviation quality and consistency of transmission shaft</td>
<td>Good</td>
<td>9</td>
</tr>
<tr>
<td>(2) Technical requirements for hub: roundness and flatness and consistency</td>
<td>Good</td>
<td>9</td>
<td>(2) Technical requirements for hub: roundness and flatness and consistency</td>
<td>Good</td>
<td>8</td>
</tr>
<tr>
<td>(3) Rims meet technical requirements: roundness and consistency</td>
<td>Good</td>
<td>8</td>
<td>(3) Rims meet technical requirements: roundness and consistency</td>
<td>Good</td>
<td>8</td>
</tr>
<tr>
<td>(4) Dynamic balance and consistency of tire assembly</td>
<td>Good</td>
<td>9</td>
<td>(4) Dynamic balance and consistency of tire assembly</td>
<td>Good</td>
<td>7</td>
</tr>
<tr>
<td>(5) Damping force of front axle shock absorber meets technical requirements and consistency</td>
<td>Good</td>
<td>9</td>
<td>(5) Damping force of front axle shock absorber meets technical requirements and consistency</td>
<td>Good</td>
<td>8</td>
</tr>
<tr>
<td>(6) Cab-suspensioning shock absorber meets technical requirements and consistency</td>
<td>Good</td>
<td>9</td>
<td>(6) Cab-suspensioning shock absorber meets technical requirements and consistency</td>
<td>Good</td>
<td>8</td>
</tr>
</tbody>
</table>
Table 9: Problem prevention worksheet.

<table>
<thead>
<tr>
<th>Key step</th>
<th>Nature</th>
<th>Possible obstacles/causes of problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Deviation quality and consistency of transmission shaft</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(2) Technical requirements for hub: roundness and flatness and consistency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(3) Rims meet technical requirements: roundness and consistency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(4) Dynamic balance and consistency of tire assembly</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(5) Damping force of front axle shock absorber meets technical requirements and consistency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(6) Cab-suspensioning shock absorber meets technical requirements and consistency</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Use your experience to identify your plans and steps

Determine which steps require your attention and resources most

Identify possible obstacles to completing these key steps. (people, methods, materials, machines, measurements, and environmental problems)

Notes: questions such as the nature of the form need to be filled out later.

3.7. Prevent Problem Recurrence (D7). The “5Whys” method is still used here to determine the root cause of the problem and the permanent measures that should be taken to prevent the recurrence of the problem. According to the theory of G8D, it can be used to find out the problems about system, operation, process, or policy. Systemic problems arise from full references to previous organizations, technical processes, policies, and practices. These past processes, policies, and practices are often not applicable to the current situation and are not traceable.

The method proposed in this paper is very effective in solving the vibration problem systematically and makes the vibration problem be systematically tracked and controlled. According to the above analysis and the actual situation, this paper puts forward some suggestions on the existing system of the enterprise in order to prevent the recurrence of the problem.

(1) The quality inspection mechanism of enterprises needs to be perfected. This is responsible for formulating product quality inspection standards, checking the quality of parts provided by suppliers, spot checking the qualified rate of products; the supplier shall provide quality product certification according to the requirements of the enterprise; if it does not meet the requirements, it will not accept the supply.

(2) The supplier quality evaluation system is yet to be established. The related personnel is responsible for supplier quality review and supplier classification management. In the case of unqualified products, enterprises need to have accurate technical means, to provide suppliers with accurate technical evidence of nonconforming products and specific rectification programs for suppliers to rectify according to specific technical objectives.

(3) Technical support for supplier quality improvement is to be provided. The relevant departments are responsible for technical guidance and help suppliers to improve quality, suppliers, and enterprises in the quality of a virtuous circle; that is, enterprises do their best to promote suppliers to improve quality, reward, and punishment system for suppliers and launch mechanisms. The quality of suppliers is gradually improved due to technical feedback and assistance.

(4) Supplier product quality feedback system is to be established. Let the supplier define the technical and quality requirements of the enterprise and form a closed loop between the quality of the product of the supplier and the requirements of the enterprise. The
enterprise forms the complete system and the mechanism, causes the supplier and the enterprise main engine factory’s technical information to form a closed loop, strengthens the system information exchange between each other, and forms the technical accumulation for the past problem solving to prevent similar problems from happening in other locations or on other models.

4. Discussion and Conclusions

By applying the G8D, an improved model for solving the truck vibration problem is established. At the same time, according to the results of the statement problem method, the Yes and No worksheet, the 5Whys method, and the truth factor assessment, the reason for determining the truck vibration is the unbalanced excitation force of the vehicle wheel system, the resonance phenomenon caused by the coupling of the excitation frequency with the natural frequency of the system, and the insufficient damping function of the system. Therefore, the corrective measures for changing the wheel hub of cab suspension and dynamic balance brake hub and dynamic balance tire are put forward. Then, the permanent correction measures are verified from three levels of components, devices, and whole vehicles by using “decision worksheet” and “problem prevention worksheet” to ensure the accuracy and feasibility of the model and make recommendations for the existing system of the enterprise to prevent recurrence of problems in the future.

After the implementation of the abovementioned complete and improved model, the acceleration of the seat rail of the truck’s vibration performance has been reduced from 1.04 m/s² to 0.6 m/s², 42.3% lower than that of the original car, reaching the level of 0.6 m/s² of the major domestic models and close to the level of 0.5 m/s² of its German counterpart, which prevents users from returning their cars. For the company to reduce certain economic losses, the sustainability of product manufacturing and enterprise economic benefits have to be improved [36]. The practical implementation of G8D can solve many technical problems, but the whole enterprise needs to pay attention to G8D training, which enables G8D become a sustainable solution to the problem of enterprises. This is of great significance for solving the truck vibration problem and even the quality problem of the whole automobile manufacturing industry, which is meaningful for the sustainable construction of the industry. Most importantly, it contributes to the sustainable guarantee of the public traffic safety of the society [37].

Data Availability

The numerical data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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