Research on Eliminating Active Over-constrained Flutter of Suspension Rail Based on Magnetic Damping Magnetic Technology

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Abstract. In actual production practice, the strong vibration of the suspension rail will cause the wear and trigger of the suspension rail accessories, especially the connection point of the suspension rail, the connection point between the suspension rail and the accessories and the connection point between the suspension rail and the bracket; due to the alternation of vibration Stress leads to fatigue damage. Therefore, the vibration analysis of the suspension rail system is a necessary condition for the design of the suspension rail system. For the suspension rail system that vibrates in practice, only when scientific and correct analysis methods are used to determine the main cause of vibration, In order to take reasonable attenuation measures, this article analyzes them.

Keywords: Magnetic damping; suspension rail; vibration reduction

1. Introduction
In the guide rail, the vibration intensity increases with the increase of pressure and flow rate and the vibration frequency of the suspension guide rail changes with the frequency of the unbalanced force; if the unbalanced force is not enough to trigger the forced vibration of the pipe, only when the frequency of the unbalanced force is close to or equal to The natural frequency of the tube will trigger the resonance of the tube. In some cases, the unbalanced force is mainly affected by the medium flow, pressure and valve opening. The changing frequency of the unbalanced force is also affected by the fluid state and the factors that affect the fluid state change are more complicated. In addition to the operating state parameters, it is also affected by many accidental factors. Therefore, the force of the stimulus may trigger the resonance of the system.

2. Magnetic damping technology
Electromagnetic damping means that when the closed conductor and the magnetic pole move relative to each other, electromagnetic resistance will be generated between the two to hinder the relative movement[1]. This phenomenon can be explained by Lenz's law: when the closed conductor and the magnetic pole cut the magnetic lines of induction, the closed conductor will produce induced current, or called motion current, due to the change of the magnetic flux penetrating the closed conductor. The
magnetic field generated by this current will hinder the relative movement of the two. The resistance is proportional to the magnetic induction intensity of the magnet, relative movement speed and other physical quantities. The electromagnetic damping equipment is shown in the figure below.

3. Overview of over-constrained flutter of suspension rail

3.1. Overview of electronic control vibration reduction technology for suspension rail system

With the continuous development and improvement of the electronically controlled vibration damping technology of the suspension rail system, three main types of electronically controlled damping technologies for the suspension rail system have emerged. They are the semi-active suspension rail system electronically controlled vibration reduction technology and the active suspension rail system. System electronic control vibration reduction technology and passive suspension rail system electronic control vibration reduction technology\(^2\). Through the flexible use of the electronically controlled vibration damping technology of these three suspension rail systems, the functional characteristics of elastic elements and basic damping elements are fully utilized and the road cushioning force during driving is optimized. By using a vibration exciter, the suspension rail system is electrically controlled. Vibration damping technology fully exerts its effect, reduces the vibration amplitude of the suspension rail during driving, improves the ride experience of the driver and passengers, improves the safety factor of the suspension rail during driving and brings a lot to people's work and life. convenient. The suspension rail is shown in the figure below.

3.2. Active suspension rail system electronically controlled vibration reduction technology

Active suspension rail system electronically controlled vibration damping technology is the technology with the best damping effect among the three damping technologies. Compared with the other two technologies, the implementation conditions of this technology are more stringent and the basic price of technical design is also the highest\(^3\). The energy consumption of the technology is very...
large and it is easy to cause a waste of resources from the perspective of environmental protection. At present, this technology is only suitable for applying this technology to relatively high-end models\textsuperscript{[4]}. 

3.3. Semi-active and passive suspension rail system electronically controlled vibration reduction technology

In contrast, the damping effect of the semi-active suspension rail system electronically controlled vibration damping technology and the passive suspension rail system electronically controlled vibration damping technology is better, but the semi-active suspension rail system electronically controlled vibration damping technology is better. The technical difference between the electronic control damping technology of the suspension rail system and the active suspension rail system is not very big, but in contrast, the damping coefficient and spring stiffness coefficient of the semi-active suspension rail system electronic control damping technology are flexible. It is more flexible, so it has a relatively better shock absorption effect.

3.4. PID Technology

Elimination site sensors will analyze the detected signals and then feed back the data to the control system. The signals received by the control system will be compared with the pre-set signals, and the results will be automatically adjusted according to the pre-set procedures. Until the signal comparison value reaches the standard interval set by the program, the automatic adjustment procedure ends. Once the signal value exceeds the standard range, the automatic adjustment procedure starts. For the rail PID closed-loop control system, the determination of the controlled quantity is very important. If you want to stabilize a controlled quantity in the variable frequency speed regulation system at about the set target value, the PID control function circuit of the inverter needs to feedback the signal constantly compare with the target signal, and then according to the comparison result, adjust the output frequency of the inverter in real time to change the motor speed. In the frequency conversion speed control system, if you want to use PID to control the output value of the frequency converter, there are at least two signals in the frequency conversion speed control system to achieve the control function. These two signals are the target control signal and the system's feedback signal. The target signal refers to the electrical signal corresponding to the ideal stable value of a controlled quantity, and can also be called the target value or the given value; and the electrical signal corresponding to the actual value measured by the sensor is called the feedback signal, the feedback quantity or the current value. For the PID control system itself, there are generally no special requirements on how to determine the controlled quantity. A single value or multiple values can be used as the controlled quantity. Limited by its control principle, we generally use the least controlled quantity to control as much as possible, so that the control system can run more stable. In addition to the PID control system itself, the core of how to select and confirm the controlled quantity is to be determined according to process requirements. For the guide rail, the main process requirement is to ensure that the equipment is always in a positive pressure working state, and to meet the pressure before and after the guide rail according to the actual product model and technical standards. Due to the different influence factors of the production process, the corresponding process requirements of the guide rail in the use of various fields are not completely the same. In addition to the determination of the controlled quantity of the guide rail, it must be considered from the perspective of safe operation. It is determined according to the actual requirements of the production process.

4. Elimination of over-constrained flutter of suspension rail

4.1. Basic optimal control

In the electronic control vibration reduction technology of the suspension rail system, optimal control is the most basic goal. In the application process of the suspension guide system electronic control vibration reduction technology, the premise of realizing linear control and predictive control is to realize the basic optimal control. The prerequisite for achieving the minimum energy operation is to
ensure timeliness and sufficient management time[5]. The suspension system obtains overall feedback under the premise of ensuring the realization of optimal control, so as to achieve double-acting management control and obtain better results through the optimization of basic procedures Vibration reduction effect.

4.2. Overall adaptive control
The electronically controlled vibration reduction technology of the suspension rail system should first realize the basic optimal control and then implement the overall adaptive control and reduce the unstable factors that may occur during the driving process of the suspension rail under the premise of realizing the overall adaptive control[6]. Through the control and implementation of the adaptive system, the adaptive system automatically obtains the driving parameters of the suspension rail, which is calculated through a series of functional algorithms and comprehensive feedback is provided to the electronic control damping technology of the suspension rail system to achieve better driving Experience.

4.3. Basic fuzzy control
The basic fuzzy control is a necessary condition for the intelligent upgrade of the electronic control vibration reduction technology of the suspension rail system. This technology can be said to be the most advanced electronic control technology at present. Through the implementation of basic fuzzy control, the suspension guide system electronic control vibration reduction technology improves the manual experience and operation The practical steps are to build more algorithm models, collect more values and data and control the suspension rails autonomously to achieve the purpose of optimizing the vibration effect.

4.4. Pressure pulse control
The damping of the suspension rail can be obtained by controlling the pressure pulse of the suspension rail flow, so that no resonance occurs; the natural frequency of the pipe structure is adjusted to avoid mechanical vibration. Since the crude oil flow and pressure of the plant are affected by actual production conditions and cannot be adjusted by itself, measures have been taken to change the natural frequency of the suspension rail. Under the premise of installation on the ground, the front and rear valves of the suspension rail are changed to horizontal installation; the branch pipe and the manifold are connected by a 45 elbow and the suspension rail pipeline riser is added with a guide bracket. Renovate the piping structure of the suspension rail area. The manifold of the suspension rail area was changed from above ground installation to underground installation. The upper bypass valve of the manifold was bent out of the ground for installation; the inlet and outlet valves of the suspension rail were installed on the riser to minimize the number of elbows in the inlet and outlet pipelines of the suspension rail. The tube adopts a guide bracket. The plan modified the suspension rail at the inlet and outlet of the suspension rail. After the construction acceptance, it was confirmed that the suspension rail at the inlet and outlet of the suspension rail had no obvious vibration when the crude oil transportation volume reached the designed capacity. Although various reasons may cause the suspension rail to vibrate, the above situation is mainly caused by the fouling of the shell side tube bundle of the high pressure heat exchanger. Therefore, in order to avoid similar situations, it is recommended that the refinery pay sufficient attention to the overhaul and maintenance of the key equipment of the hydrocracking unit. In particular, the high-pressure heat exchanger should be cleaned regularly to ensure that it is thorough and clean. Cleaning effect. And to ensure the filling amount of the raw material scale inhibitor, especially in the early stage of construction, to ensure that the filling amount of the scale inhibitor reaches twice the normal filling amount to prevent the scale resistance layer from quickly appearing on the outside of the heat exchanger tube bundle.

5. Conclusion
The vibration of the suspension rail is a very complicated problem. In order to buffer the vibration of
the suspension rail, various factors must be considered, conflicts must be dealt with and each other must not be ignored. For example, the reinforcement or installation of the support points of the suspension rail can significantly increase the rigidity of the system and change the vibration characteristics, but the solid support points will not change the stimulation force of the pressure pulse. The thermal stress of the suspension rail is in contradiction with the vibration attenuation of the suspension rail. Therefore, when designing the suspension rail, this contradiction should be properly handled and the best solution should be found. Effective measures are taken in time to thoroughly clean the heat exchanger, so that the vibration problem of the suspension rail is solved and the safe production of the device after the replacement of the agent is ensured.

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References
[1] Yahui Zhang, Wei Wang, Huajiang Ouyang. Dynamic reliability evaluation of vehicle–track coupled systems considering the randomness of suspension and wheel–rail parameters [J]. Proceedings of the Institution of Mechanical Engineers, Part O: Journal of Risk and Reliability, 2019, 233(6).
[2] Zhang Yahui, Wang Wei, Ouyang Huajiang. Dynamic reliability evaluation of vehicle–track coupled systems considering the randomness of suspension and wheel–rail parameters[J]. Proceedings of the Institution of Mechanical Engineers, 2019, 233(6).
[3] Liu, Yang, Wang, Chen, Wei. Metamodel-based robust collaborative optimization for the suspension parameters of rail vehicles [J]. Journal of the Chinese Institute of Engineers, 2019, 42(8).
[4] Bin Yan, Gaoxiang Zhang, Zhongshu, Han, Ping Lou. Longitudinal Force of Continuously Welded Rail on Suspension Bridge with Length Exceeding 1000 m [J]. Structural Engineering International, 2019, 29(3).
[5] Robert Keqi Luo. Creep prediction with temperature effect and experimental verification of rubber suspension components used in rail vehicles [J]. Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science, 2019, 233(11).
[6] Luo Robert Keqi. Creep prediction with temperature effect and experimental verification of rubber suspension components used in rail vehicles [J]. Proceedings of the Institution of Mechanical Engineers, 2019, 233(11).