Analysis and Elimination of Shutdown Fault Caused by Mechanical Overspeed Protection of Diesel Engine

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Abstract. The article introduces the phenomenon of a single auxiliary engine overspeed fault alarm and stopping during a certain sea voyage. Through analysis and investigation, the post personnel finally accurately located the fault because the micro switch of the mechanical overspeed protection device was loose. Post personnel were eliminated in time and the status of the remaining units was also checked to ensure the stable operation of the ship's power generating diesel engine.

1. Introduction
A cruise ship is equipped with five L23/30H diesel engines, which are four-stroke medium speed diesel engines produced in Zhenjiang diesel engine factory using the technology of MAN B&W company. The diesel engine adopts the control and monitoring system of KangShiBo, and the governor adopts the Europa electronic-hydraulic governor which is connected with the throttle joystick of the diesel engine through the Lambda air cylinder.

2. Fault phenomenon
During the long voyage of a cruise ship, three diesel engines 2#, 3# and 5# were connected to the grid for operation. At that time, the load was 1100kW, and the power grid allowance was 1200kW. At 17:20:11’, the diesel engine 5# was shut down due to overspeed alarm (the alarm of KangShiBo displayed was “DG5 OVERSPEED ALARM, DG5 OVERSPEED SHD and DG5 LO INLET PRESS”). The operator on duty quickly started the diesel engine 4# and connected it to the grid. At the same time, the operator went to the site to check the diesel engine 5#, and examined the mechanical overspeed protection device and Lambda air cylinder. It was found that there was no obvious action of the mechanical overspeed protection device. The ejector rod of Lambda air cylinder did not contact with the main throttle joystick, and the throttle was at the zero position. The alarm of KangShiBo was eliminated by manually resetting the mechanical overspeed device, but it reappeared after the reset button was released.

3. Control principle
The governor is installed on the flywheel end of the diesel engine and is driven by a pair of bevel gears and the cylindrical gear driven by the camshaft gear. The function of the governor is to adjust the oil supply of the injection pump, so as to keep the speed of the diesel engine within a certain range without changing with the load. The governor rotates the longitudinal regulating shaft through the rocker arm and elastic rod, and the regulating shaft is equipped with a combined rocker arm relative to each oil
injection pump. In this way, the governor can adjust the oil supply of other injection pumps even if the pump plunger of one cylinder is jammed.

When the overspeed protection device of diesel engine works, the piston in the air cylinder of Lambda controller pushes the stop rocker arm, rotates the regulating shaft, and moves the oil injection pump rack to the "stop" position, so the diesel engine stops. However, the rocker arm of the governor is still in the "running" position at this time. Because there is a compressible elastic rod between the rocker arm of the governor and the rocker arm of the regulating shaft, the regulating shaft can still turn to the "stop" position without being limited by the rocker arm of the governor.

The mechanical overspeed protection device is installed at the cover of the lubricating oil pump and driven by the pump. If the revolving speed of diesel engine exceeds the set value, the elastic flyweight (1) will move outward and press down the arm (2). The arm is connected with the locating pin (3) and is acted by the spring (4). The air valve (6) opens while the arm (2) presses the mandrel (5). The cylinder piston moves downward, rotates the speed regulating rod to the "stop" position, and directly pulls the oil supply rack of the diesel high-pressure pump to the zero position, so as to stop the oil supply to the diesel engine to shut it down, and the elastic pull rod connected to the governor is compressed. Press down the button (7) to make the elastic flyweight (1) move through the rod (8), so as to make the diesel engine stop manually.

If any overspeed action has occurred, the overspeed protection device must be reset before the diesel engine is restarted. It can be reset by pressing the button (10).

4. Analysis and elimination of failure
After the occurrence of the fault, the personnel quickly carried out the analysis and elimination of failure.

By showing the operation curve of diesel engine 5# on the display screen ROS1 in the central control room, it was found that the speed was within the normal range, and it was not stopped because of a real overspeed, which might be caused by misoperation.

By checking the status of diesel engine 5# on site, it was found that there was no obvious action of the reset button of mechanical overspeed protection device and the Lambda controller, which confirmed that the shutdown was not caused by the action of Lambda air cylinder. At the same time, the mechanical overspeed protection device was disassembled and inspected. The test button was pressed down...
manually. It was found that the reset button acted but not completely. It was inferred that the sensitivity of the locating pin and spring in the reset button decreased due to vibration and fatigue. Due to the lack of technical conditions for adjusting the overspeed protection device, in order to ensure the normal operation of the diesel engine, the mechanical overspeed protection device assembly was replaced as a whole.

After replacement, the mechanical overspeed protection shutdown procedures of diesel engine 5# was tested. Under the normal condition of each system, the mechanical overspeed protection device was released manually, where the diesel engine stopped and the Lambda air cylinder also acted, which did not conform to the fault phenomenon at that time. In order to prove that the mechanical overspeed alarm can cause the electrical equipment to stop, the maintenance personnel carried out the following tests. In the case of no compressed air, by manually releasing the mechanical overspeed protection device, the diesel engine stopped, and the Lambda air cylinder did not act, which was exactly consistent with the phenomenon when the fault occurred. It is proved that in the case of mechanical overspeed alarm, the diesel engine will be stopped by two ways of control. One is Lambda air cylinder action, and the other is governor action, but the Lambda air cylinder did not act in this fault, so the action of overspeed protection device is not the cause of the shutdown. It is determined that the shutdown is caused by the action of governor, so the electrical equipment was checked.

In view of the fact that the alarm of KangShiBo can be eliminated by manually resetting the mechanical overspeed device, but it reappeared after the reset button is released, we inspected whether the electrical circuit was loose and focused on the limit switch of the mechanical overspeed protection device.
device at the same time. We opened the cover of the protection device and checked the microswitch circuit, which was normal. However, the fixed bolt on the protection device tightened by the microswitch was loose, so it can be judged that the alarm will be given due to the unintended contact between the microswitch and travel switch due to the vibration, which will cause the diesel engine 5# to stop when the shutdown solenoid valve of governor is powered on. Then the two fixing bolts were replaced and fastened, and the gasket was added between the microswitch and the cover of the protection device to prevent alarm caused by unintended contact due to vibration.

5. Conclusion
Generator diesel engine overspeed protection mainly has two protection functions: (1) electronic overspeed protection. When the speed reaches the electronic protection value (850rpm), the governor operates. Then the parking solenoid valve is energized. The diesel engine stopped normally and alarmed. (2) Mechanical overspeed protection. When the electronic overspeed fails, the speed reaches the mechanical overspeed protection value (860rpm), the mechanical overspeed protection device will act. The lambda cylinder moves, and the diesel engine is forced to stop and alarm. To this end, regular maintenance and functional inspections should be done. Failures often have no response time. Therefore, during the cruise, we should ensure that 3 diesel generators are connected to the grid, leaving sufficient margin to prevent the impact of such failures on power.

6. Management considerations
During the operation of the diesel engine, the vibration is relatively large. The overspeed protection device is installed on the side of the oil pump, and the vibration is more serious. Therefore, the spring and bolt on the device are more likely to be loose due to vibration and will fall off in serious cases. Therefore, it is necessary to check the parts of the device regularly to ensure that they meet the working requirements.

In case of automatic shutdown of diesel engine, immediately check whether other standby units start automatically to keep stable power supply. At the same time, check the KangShiBo monitoring system to see if there is an alarm, and carry out targeted inspection and maintenance according to the alarm information.

Regularly maintain the mechanical overspeed protection device, generally once every two years. Regularly check the hydraulic oil level of the governor and test the oil quality.
Before each voyage, the functional test of the mechanical overspeed protection device shall be carried out to ensure that it is in normal working condition.

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References
[1] Sun Xianwei, Zhang Qingfeng. (2018) Optimization of standardized parameters matching for a certain series of diesel engines and electronic governors. J. China Ship Repair., 165:27-292.
[2] Chen Jian. (2018) Research on Mathematical Modeling and Simulation of Speed Governor for Marine Diesel Engine. J. Journal of System Simulation., 203:937-942.
[3] Zhao Tianxiang, Cao Xinyu. (2018) A case of failure handling of auxiliary engine overspeed protection device. J. Navigation Technology., 153:61-64.
[4] Hou Xiaoqin. (2012) Analysis and Application of Different Types of Overspeed Protective Parking Devices. J. Diesel Engines., 175: 37-39.
[5] Song Qiang, Yang Jun. (2016) Treatment and Prevention of Diesel Engine Speeding. J. 121: 51-52.