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Comprehensive quality evaluation system for manufacturing enterprises of large piston compressors

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Abstract

Piston compressors are necessary dynamic equipment in chemical engineering and petrochemical industry. Establishment of a quality evaluation system for Chinese manufacturing enterprises of large piston compressors is important for the proper evaluation of production quality. The evaluation system can serve both government decision-making and user selection-making. Furthermore, the quality evaluation system is beneficial for identifying production bottleneck and improving production quality. A hierarchical analytic process is adopted in this paper to establish a comprehensive quality evaluation system. The system characteristics can be summarized into three levels, two main lines, and one correction. The first level consists of two main routes, external effects and intrinsic effects. The second level includes 6 external factors and 7 intrinsic factors. The third level is composed of 81 elements. In addition, the product accident history is introduced at the first level as a correction item. The evaluation system was implemented using B/S architecture and the standard SSM framework with MVC design pattern.

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Keywords: Quality assessment; Manufacturing enterprise; Piston compressor; Malfunction.

1. Introduction

In the industry, compressors play a very important role in chemical, petrochemical and refining processes [1]. However, there is a huge gap between the most advanced level in the world and that of our country in terms of the manufacturing capability for large piston compressors. The gap lies in the design and development of new products,

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the manufacturing management, the integrated control, manufacturing with new materials, equipment supervision and many other aspects. With a suitable and effective manufacturing quality evaluation system, not only can the production quality for manufacturing enterprises acquire proper assessment and users be provided with ease for selection, but the short board of the entire manufacturing process can also be readily detected. Ultimately, the establishment of a proper quality evaluation system will contribute to advancing independent manufacturing of major equipment in China and matching it with our national economic development.

As there is need for evaluation and decision making about various objects, many kinds of evaluation methods have been proposed. They are expert grading method, ante benefit-cost approach, data envelopment analysis, mathematical statistics analysis method, multi-objective evaluation method, hierarchical analytic process, fuzzy mathematical method, intelligent evaluation method, etc. [2]. Each method has different performance in the qualitative, quantitative and subjective influence, as well as data dependence and multi-factorial interference.

Characteristic parameters of large piston compressors are listed in Table 1. Product quality may be affected by many factors in the production process. According to the 5M1E method [3], there are six main causes to production quality fluctuation. The causes are Man, Machine, Material, Method, Measurement, and Environment. The hierarchical analytic process is adopted in this paper to address the specific characteristics of piston compressors.

Table 1. Characteristic parameters of the large piston compressor.

Parameters	Numerical value	Unit
Discharge capacity	≥30	m^3/min
Shaft power	≥250	kW
Rotating speed	250～500	r/min
Piston rod load	≥80	kN

2. Malfunction analysis

Large compressors in petrochemical, chemical, natural gas and other industries belong to core dynamic equipment. The working medium is often high-pressure, flammable, explosive, toxic, high-temperature or low-temperature, and is therefore extremely dangerous. Hence malfunction is an important factor in compressor quality evaluation.

The types of piston compressor malfunction are mainly divided into two categories: non-mechanical faults and mechanical faults. The former is represented by inadequate exhaust, pressure anomaly, temperature anomaly, etc. The latter includes vibration anomaly, sound anomaly, overheating, etc. More specifically, the faults are (1) inadequate discharge capacity, (2) pressure anomaly, (3) temperature anomaly, (4) vibration anomaly, (5) sound anomaly, (6) mechanical overheating, (7) gas leakage, (8) coke combustion under high temperature and high pressure, (9) liquid impact, (10) piston rod fracture, (11) cylinder cracking, (12) cylinder head cracking, (13) crankshaft breakdown, (14) fracture and deformation of connecting rod, (15) connecting rod bolt fracture, (16) piston stuck and cracking, (17) body fracture, (18) valve rupture and (19) burning of bearing liner.

There are two main fault sources. About 60% faults of piston compressors occur at the valve, and the piston rod fracture accounts for 25% of major accidents. The causes to and proportions of major compressor accidents are (1) unreasonable design and manufacturing defects, 35%, (2) operational violations, poor maintenance and management, 40%, (3) poor inspection and repair, 12%, (4) electrical faults, natural disasters and others, 13% [4].

The direct embodiment of high-quality compressor is no or few major accidents and low failure rates. The malfunction factor carries weight at all levels of the assessment system, which is in line with the national advocacy of safety, environmental protection and energy saving. In general evaluation of the first level index, accident history is introduced as a correction item. The correction is calculated based on accident statistics of individual compressors during the last 5 years. The potential fault rate and accident severity are taken into major consideration for the weight assignment of the third level indices. For instance, the weight of piston quality is significantly increased in view that the piston rod fracture accounts for 25% of major accidents.