

Structure topology optimization based design of tank support system of tunnel continuous washer

Su Shijie^{1, a*}, Li Erdong^{1, b}, Zhang Jian^{1, c}

¹ School of Mechanical Engineering, Jiangsu University of Science and Technology, Zhenjiang Jiangsu 212003, China

^adecand@163.com, ^b1020160835@qq.com, ^czhjian127@163.com

Keywords: tank support system, structure topology optimization, tunnel continuous washer

Abstract: In order to optimize the structure of tank support system of tunnel continuous washer, the 3D model was established by Pro/E and was imported to HyperMesh, then finite element static analysis and topology optimization analysis have been carried out. The optimum results showed that the weight of tank support system reduced by 39.27%, the stiffness and strength can completely satisfy the needs of the design.

1 Introduction

Tunnel continuous washer is a highly integrated washing system. It can be recycled washing more batch of fabric, compared with the traditional industrial washing machine, it has the advantages of high washing efficiency, less environmental pollution, good quality of washing, water saving, energy saving and so on. Since early 1970s, Tunnel continuous washer has become the indispensable equipment for washing industry in western developed countries. At present, Tunnel continuous washer on international market was monopolized by the developed countries. Currently, in domestic the equipment is still in its infancy^[1].

The tank support system is one of the main components of tunnel continuous washer, it should bear static load and dynamic load at the same time, so the support system must have sufficient strength and rigidity to guarantee the normal work of the washing machine^[2]. This article first introduce the topology optimization technique in the design of the main cage support system, and have the initial design of spatial topology optimization analysis to the support system; Then combined with the result of topological optimization technology of processing and considering components, a new tank support system has been designed.

2 Structure of the tank support system

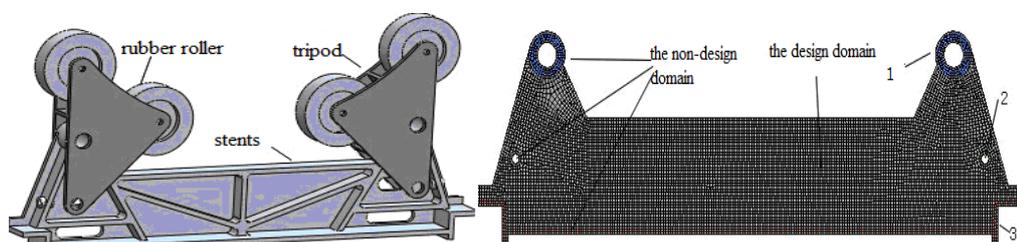


Figure 1 the tank support system

1 bearing 2 bolt location 3 Chassis

Figure 2 the finite element mesh model

The tank of tunnel continuous washer has the characteristics of thin wall and large diameter, long span. The tank support system will suffer the direction changing of torque, bending, impact, such as periodic alternating load. Therefore the advantages and disadvantages of the structure of the tank support system are directly related to the stability of the whole system. As shown in figure 1, the support system including: rubber roller (roller), tripod, stents and some auxiliary parts.

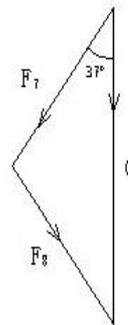
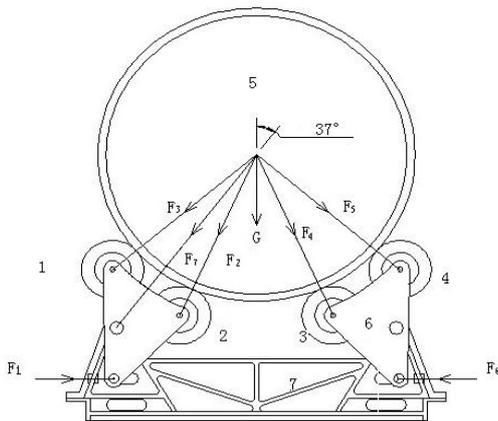
3 Finite element model of the tank support system

3.1 Finite element mesh model

According to the structure and mechanical characteristics of the original support system, the finite element mesh model is set up as shown in figure 2^[3]. And get the unit of a total number is 68139, the node number is 81073, including hexahedron unit 67026, heptahedron unit 1113. The design space is divided into the design domain and the non-design domain. In the process of optimization, the design domain remains the same, optimal computation only dig the Spare parts of the design domain.

3.2 Load boundary conditions

As the existing 13 the storehouse of the tank for the object, each compartment is equipped with linen 80 kg and 400 kg of water, and the weight of the drum is 2968 kg, so the support system in static condition to support the total weight is 9208 kg. A single support structure as shown in figure 3.



1, 2, 3, 4 support roller 5 tank 6 lamp stand 7 stent
Figure 3 force diagram of the tank support system
Figure 4 the force diagram of the third working condition

The following according to the working condition of several installations and after installation of static condition to calculate for the Support load cases^[4].

- 1) Condition 1 (2, 3 and 4 are installed, lack of support roller 1);
- 2) Condition 2 (1, 3 and 4 are installed, lack of support roller 2);
- 3) Condition 3 (1, 2, 3, 4 are installed).

Due to the working condition of 1, 2 is the assembly, only write the 3 kinds of working condition of force analysis. After installation, the stress distribution is shown in figure 4; this is a kind of ideal condition. But as a result of a single support roller deformation difference, To guarantee the cylinder center positioning, so it need fine-tuning trace adjusting bolt, Considering this kind of situation, when optimizing should give corresponding parameter a initial value which is lower than F8. Using the formula (1), is obtained $F_7 = F_8 = 28.249 \text{ kN}$.

$$\frac{F_7}{\sin 37^\circ} = \frac{G}{\sin 106^\circ} = \frac{F_8}{\sin 37^\circ} \quad (1)$$

4 Static topology optimization and results discuss

4.1 Topology optimization of the support system

Due to the condition 1 and conditions 2 in the actual operation time is shorter, So it's not included in the actual process of the topology optimization, Only in the support system optimization performance comparison back and forth need be consideration^{[5][6]}. As shown in figure 5, p is set to 3, f separately is set 0.1, 0.2, 0.3, and get the optimization results.

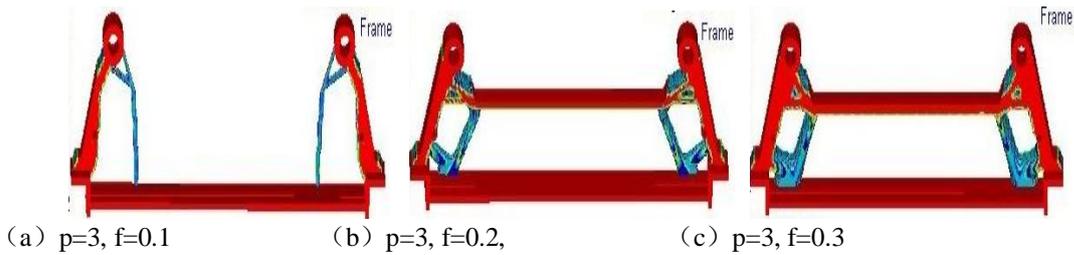


Figure 5 different topology optimization results under the static conditions

In the Figure 5 different color from blue to red stand for the cell density expand from a small to a large value. Compared with (a), (b), (c) three figure can be seen when $p=3$, $f=0.2$ the topology of the software which is automate generate is the most appropriate beam trapezoidal for the support structure. So take 0.2 is more appropriate values. When take $f=0.2$, p separately takes 3.5, 4, figure 7 shows the optimization results.

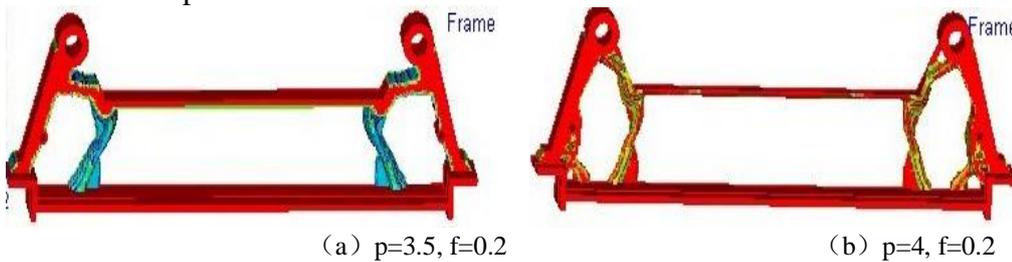


Figure 6 Topology optimization result contrast about different p values

From figure 6 (a), (b) it can be seen with the p rising, the cell density is more tend to 0 or 1, it makes the dense cell of constraint point part more concentrated, it shows that the value of p is too high will lead to high density unit concentration. So two results are not accurate for the actual support production.

Comparing with the results above, we know when take $p=3.5$, $f=0.2$, the optimization results that obtained is the most suitable, and the computational efficiency is relatively high too.

4.2 Structure design about the new tank support system

According to the optimization result and manufacture technologic performance, the structure of the new tank support system is shown in figure 7, and the photo of the tank with new support system is shown in figure 8.

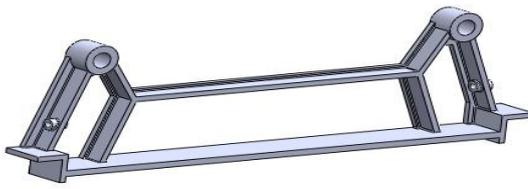


Figure 7 the structure of the new tank support system



Figure 8 the photo of the tank with new support system

4.3 Optimized results contrastive analysis

As shown in table 1, the performance of tunnel continuous washer tank support system were compared before and after the structure optimization, Comparative aspects include: Before and after optimization quality, maximum stress, maximum deformation.

Table 1 the performance contrast between before and after optimization

	The original support system	The optimized support system
quality (kg)	369.7	224.5
stress (Mpa)	Condition 1	34
	Condition 2	37
	Condition 3	16
transformation (mm)	Condition 1	0.12
	Condition 2	0.19
	Condition 3	0.09

5 Conclusion

Based on analysis of the function and load of tank support system of tunnel continuous washer, an accurate finite element model by taking into consideration the boundary conditions has been established; Secondly the parameters of topology optimization has been defined, the topology optimization design was carried on; Then a full consideration to the parts of the manufacturing process has been given, and designed a new structure of the tank support system; At last, a performance contrast between before and after optimization has been carried out. The results show that: by optimizing, tank support system has a 39.27% reduction in weight, and the stiffness and strength meet the design requirements completely.

Acknowledgements

This work was financially supported by Union Innovation Research Foundation of Jiangsu Province (Grant No. BY2013066-05).

References

- [1] Owe Schramm, Harold Thomas and Ming Zhou. Manufacturing Considerations and Structural Optimization for Automotive Components [J]. SAE, 2002.
- [2] SISSELL K. Industry disputes findings of cleaning products study [J]. Chemical Week, 2012, 174 (8): 33-35.
- [3] Lie Xiao Juan, Zhao Changing Lin jaunting, etc. the Tunnel type vegetable research of hot air drying machine [J]. Journal of agricultural mechanization research of china, 2008, (7): 113-115. (in Chinese)
- [4] Chen Minzhi, zhang xu-ming, xu Feng Jun. Methods of topology optimization design [J], Shanxi building of china. 2005, 31 (21): 63-64. (in Chinese)
- [5] Shi Xinglai, the Industrial washing machine rotor cage structure design of the finite element analysis [J]. Journal of light industrial machinery of china, 2010, 28 (1): 87-90. (in Chinese)
- [6] Boqiang Lin, Li Zhang, Ya Wu. Evaluation of electricity saving potential in China's chemical industry based on co integration [J]. Energy Policy (S0301-4215), 2012, 44(5): 320-330. (in Chinese)