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Analysis and Improvement of Early Wear and Fracture of Generator Belt

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Abstract: In this paper, in view of the early wear and fracture problem of generator belt in a batch of engines, the troubleshooting process is described in detail. Through the analysis of fault phenomenon and theoretical calculation and analysis of gear train size, the frequent fracture reason is determined to be the belt length error and elongation out of tolerance. Finally, by improving the design of the gear train and strictly controlling the length of the belt, the frequent fracture of the generator belt is effectively solved.

1. Introduction

Belt transmission is one of the most important transmission forms of mechanical transmission[1]With the continuous improvement of industrial technology level and the mechanical equipment precision, lightweight, functional and personalized requirements, constantly to high precision, high speed, high power, high efficiency, high reliability, long life, low noise, low vibration, low cost and compact development, its application scope is more and more wide, more and more and more transmission form. The problem of belt fracture in a batch of engine occurs many times during the use of users. This paper analyzes the fault phenomenon and analyzes the size of the wheel system. Finally, the fault was effectively solved by improving the method of the wheel line.

2. Background introduction

Six of the 10 engines purchased by a user appeared the early wear and fracture of the generator belt, and the generator, crankshaft, air conditioning pump and tightening wheel inler into a straight line, belt installation without distortion phenomenon, generator, air conditioning pump and tightening wheel inler bearing no lag and loose phenomenon. The faulty engine has been replaced with the generator belt 2-3 times, and the interval between each replacement is about 3000-4000 km.

3. Generator belt drive structure

Generator belt drive structure[2]It mainly consists of the generator belt pulley, belt, tensioning wheel, air-conditioning compressor belt pulley, idler wheel, crankshaft belt pulley and other components. The main components involved in this article are shown in Figure 1.

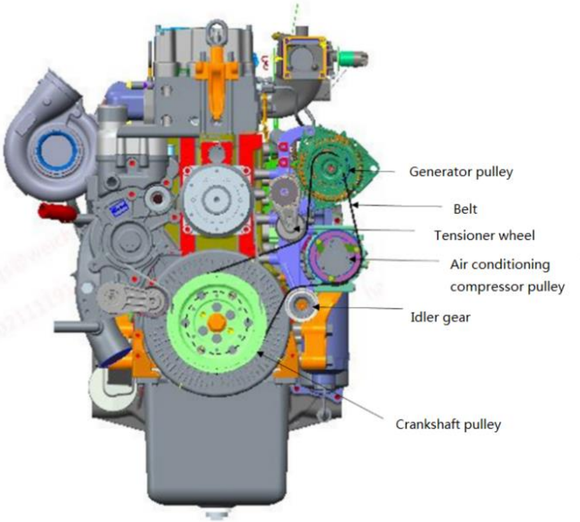

Figure 1: Generator belt drive structure diagram

4. Fault analysis

After getting the fault feedback from the user, the faulty belt and its wheel tie structure are analyzed from the fault phenomenon and the wheel tie size to determine the final cause of the fault.

4.1 Wear analysis of idler paint

By observing the outer circle of the inler wheel, it is found that most of the paint of the inler wheel did not show wear, and the whole circle should appear under normal circumstances. The specific wear situation is shown in Figure 2 below. According to previous cases, this situation can be attributed to belt slip, and the inler has no power consumption. When the belt and inler slip with only a small moment of inertia, it means that the belt tension is sometimes absent, that is, the belt is too loose.

Figure 2: Figure of idler wear

4.2 Analysis of belt tension

In the wheel tie, the tension of the belt can only be achieved through the torque output of the tension wheel. When the tensioning wheel rocker arm is in or near the free position, as shown in Figure 3 below, the rocker arm of the belt constantly hits the free position limit block by driving the crankshaft operation. Only when this situation occurs, the tension of the belt is sometimes absent.

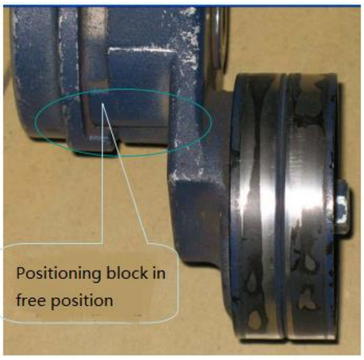

Figure 3: Physical diagram of the positioning block being in a free position

4.3 Impact analysis of tight wheel rocking arm

The Angle of the tension wheel swing arm is defined according to the belt tolerance and extension rate, namely after the installation of the new belt needs to be defined at a reasonable working angle, after meeting the belt extension rate of the swing arm shall not contact with the free position (general design requirements of 5 degrees), and the tension wheel swing arm can not interfere with other parts in the free position. Therefore, it is known that the tolerance and extension rate of the belt directly lead to the no tension of the belt, that is, the tensioning wheel does not work.

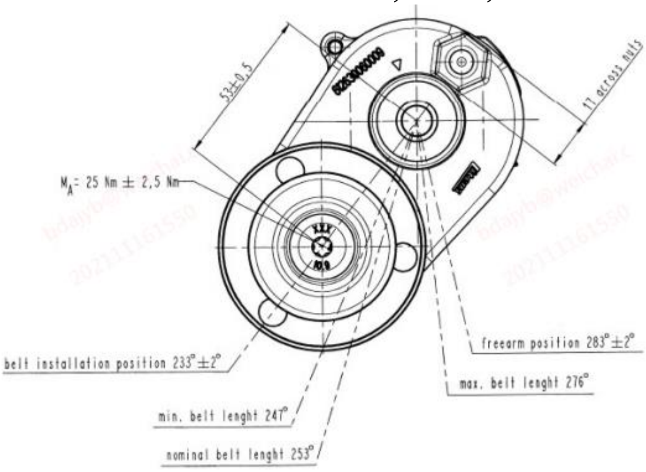

Figure 4: Tight wheels, position diagram

4.4 Theoretical calculation and analysis of wheel line size

From the analysis of the wheel system layout, the belt parameters (see Table 1), tensioner parameters (see Table 2), wheel system layout parameters (see Table 3) three parameters as input data, by calculating the data in the input system, the calculation results are shown in Table 4 and Table 5, the current wheel system problems can be observed from the calculation results:

Table 1: The Belt Parameter Table

Belt name	MultiV Belt
Belt rib Geometry type	PK / EPDM
No.of Ribs/Cord Material	6 /Polyester
Stretch and Wear Allow	≤1% of Length

Table 2: Tighsioner, Parameter Table

Tensioner Type	Automatic
Pivot Point {x,y} [mm]	{114.90, 210.00}
Tensioner Arm Length	53.0 [mm]
Tensioner Arm Angle	253 [deg]

Table 3: Wheel System Layout Parameters Table

Pulley	X Coordinate	Y Coordinate	Flat Diameter	Pitch Diameter	Effective Diameter	Pulley Type
CRK	0.00	0.00	/	219.20	216.80	Grooved
IDR	164.90	15.00	76.00	78.00	80..40	Flat
A-C	221.90	120.00	/	118.20	115.80	Grooved
ALT	228.90	337.20	/	57.20	54.80	Grooved
TEN	99.40	159.32	70.00	72.00	74.40	Flat

Table 4: Belt Data Output Table

Belt name	MultiV Belt	Geometric Dimension	
Belt rib Geometry type	PK / EPDM	Belt Flat to Pitch	1.0 [mm]
No.of Ribs/Cord Material	6 /Polyester	Belt Flat to Effective	1.2 [mm]
Stretch and Wear Allow	≤1% of Length	Eff.Drive Length (ref.ISO 9981)	1393 [mm]
Max Stretch(Free Arm)	0.99% of Length	Length Tolerance	±7 [mm]

The length of the belt is 1393mm with the length tolerance of ± 7mm. The maximum extension rate of the belt under this wheel tie is 0.99%, which is less than 1% permanent extension rate, and the maximum extension rate of the belt at free position should be greater than the permanent extension rate, so the belt extension rate cannot meet the wheel requirements.

Table 5: Output table of round-series calculation results

Tensioner Position	Pulley Position		Arm Position [deg]	Effective Belt Length [mm]	Tensioner Torque [Nm]	Belt Design Tension [N]	Idler Wrap Angle [deg]
	X	Y					
Install -5/TEN	83.00	167.67	233.00	no install	no install	no install	53.51
Min Belt	92.09	162.16	244.51	1386.20	21.89	459.06	59.82
Nominal Belt	99.40	159.32	253.00	1393.20	19.35	416.00	63.82
Max Belt	107.42	157.53	261.89	1400.20	16.68	383.76	67.34
Stretch & wear	127.07	158.42	283.28	1414.20	10.43	343.00	73.17
Free Arm	126.82	158.36	283.00	1414.00	10.35	337.99	73.12

The output result of the above table is that the corresponding arm Angle and the belt length of the wheel is in different positions. When the belt reaches the maximum elongation rate, the arm position Angle is 283.28 degrees. When the arm reaches the free position, the Angle position is 283 degrees. According to the design requirements, the tensioning wheel impact free arm position should be greater than or equal to 5 degrees. Therefore, it can be judged that there is a mismatch between the belt and the wheel line. If the size of the belt is improved, the length of the belt can be shortened, but as it can be found from the first line of the above table, it will appear that when the size of the belt can be shortened, it cannot be installed.

Therefore, the reduced belt elongation rate can only be considered. If the belt elongation rate is too large, the failure mode shown in Figure 5 below will appear.

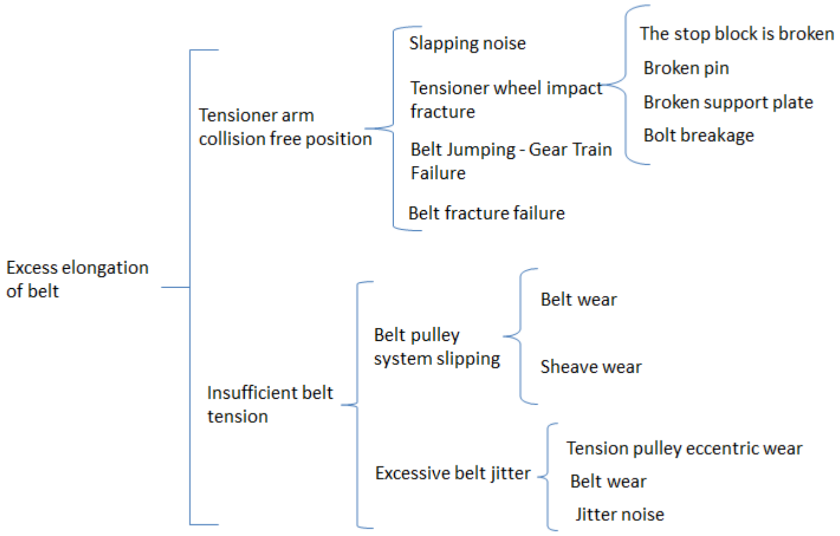

Figure 5: Failure mode diagram of belt hyperelongation

5. Fault improvement

5.1 Determine the direction of improvement

Through experiments, it is found that when the belt elongation rate is 0.7% and the belt tolerance is ± 5mm, the specific data are shown in the following table, and the whole system is in an acceptable state. Except for the Angle of 272.84 degrees and the 276 degrees in the design. The output results are shown in the table below.

Table 6: Belt Data Output Table

Belt name	MultiV Belt	Geometric Dimension	
Belt rib Geometry type	PK / EPDM	Belt Flat to Pitch	1.0 [mm]
No.of Ribs/Cord Material	6 /Polyester	Belt Flat to Effective	1.2 [mm]
Stretch and Wear Allow	≤0.7% of Length	Eff.Drive Length (ref.ISO 9981)	1393 [mm]
Max Stretch(Free Arm)	1.13% of Length	Length Tolerance	±5 [mm]

Table 7: Output table of round-series calculation results

Tensioner Position	Pulley Position X	Pulley Position Y	Arm Position [deg]	Effective Belt Length [mm]	Tensioner Torque [Nm]	Belt Design Tension [N]	Idler Wrap Angle [deg]
Install -5/TEN	83.00	167.67	233.00	1373.70	25.35	546.74	53.51
Min Belt	92.12	161.24	246.92	1388.20	21.17	445.36	61.01
Nominal Belt	99.40	159.32	253.00	1393.20	19.35	416.00	63.82
Max Belt	105.04	157.92	259.28	1398.20	17.46	392.11	66.38
Stretch & wear	117.53	157.07	272.84	1407.90	13.40	356.03	70.76
Free Arm	126.82	158.36	283.00	1414.00	10.35	337.99	73.12

Continue to correct the input, correct the belt permanent elongation rate to 0.845%, and the rest of the input will remain unchanged. The output results are shown in Table 8. From the output results, the system is still acceptable, and the movement track of the tension wheel rocking arm is exactly in line with the position angles in the design.

Table 8: Output table of round-series calculation results

Tensioner Position	Pulley Position		Arm Position [deg]	Effective Belt Length [mm]	Tensioner Torque [Nm]	Belt Design Tension [N]	Idler Wrap Angle [deg]
	X	Y					
Install -5/TEN	83.00	167.67	233.00	1373.70	25.35	492.24	76.32
Min Belt	94.12	161.24	246.92	1388.20	21.17	452.16	62.07
Nominal Belt	99.40	159.32	253.00	1393.20	19.35	439.78	56.11
Max Belt	105.04	157.92	259.28	1398.20	17.46	429.30	50.13
Stretch & wear	120.45	157.29	276.02	1410.00	12.44	409.08	35.03
Free Arm	126.82	158.36	283.00	1414.00	10.35	402.65	29.01

Through the above test analysis, it can be found that the original wheel system design layout is reasonable, but two conditions are required: 1) the belt elongation rate is very small, 0.845%; 2) the belt tolerance is very small, for ± 5mm. The nominal design tension of the belt is 416N, so the output torque required by the system is 19.3±1.9Nm. According to shown in the drawing, the tensioning wheel torque is 20.1±2.1N m. At the same time, it can be seen from the wheel system analysis that the torque output by the tensioning wheel rocking arm with the belt extends puts the belt tension at 349.77N, so the risk of insufficient belt tension in the failure mode does not exist. In conclusion, the root causes of the mentioned problems are the large length error and poor elongation rate. From the point of view of the belt, the length and tolerance accuracy of the new belt under this wheel system can be strictly controlled, and the wire rope material is replaced as spandex.

5.2 Provide an improvement plan

According to the precision requirements of domestic belt manufacturers and rope material requirements, only from the belt Angle to solve, this problem is more difficult. Therefore, we can use the domestic belt manufacturing accuracy and rope materials (i. e., elongation rate), from the Angle of the wheel system layout to improve.

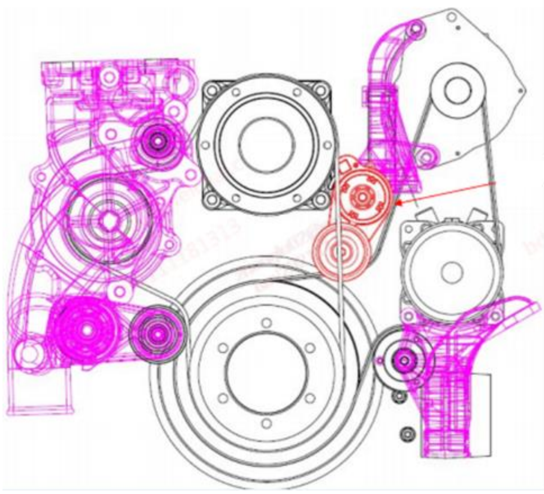

Figure 6: Layout of new round series

To accommodate the belt length tolerances and the permanent elongation of the polyester rope belt, update as little as possible. Based on this, according to the new layout of the wheel system, a tension wheel of 70mm (originally 53mm for the long arm) is designed. The structure is shown in Figure 6, and the variation of the tolerance of the belt and the amount of extension are satisfied by lengthening the rocking arm. Detailed analysis results are shown in Tables 9 to Table 11 below:

Table 9: Improved belt parameter output table

Belt name	MultiV Belt	Geometric Dimension	
Belt rib Geometry type	PK / EPDM	Belt Flat to Pitch	1.2 [mm]
No.of Ribs/Cord Material	6 /Polyester	Belt Flat to Effective	1.3 [mm]
Stretch and Wear Allow	≤1% of Length	Eff.Drive Length (ref.ISO 9981)	1400 [mm]
Max Stretch(Free Arm)	1.35% of Length	Length Tolerance	±7 [mm]

Table 10: The improved tensioning parameters table

Tensioner Type	Automatic
Pivot Point {x,y} [mm]	{114.90, 210.00}
Design Torque[Nm]	24.1Nm ±2.4Nm
Design Tension[N]	360.00N
Nominal Working Angle	25.0[deg]
Tensioner Arm Length	70.0[mm]
Tensioner Arm Angle	249.0[deg]
Spring Rate Factor	0.30[Nm/deg]
Belt Take-up/Arm Ratio	1.164[mm/deg]
Total Travel Angle(Min)	≥50[deg]

Table 11: Output table of round-series calculation results

Tensioner Position	Pulley Position		Arm Position [deg]	Effective Belt Length [mm]	Tensioner Torque [Nm]	Belt Design Tension [N]	Idler Wrap Angle [deg]
	X	Y					
Install -5/TEN	115.58	213.89	260.00	1369.10	25.53	502.20	45.48
Min Belt	138.62	213.29	276.99	1383.50	20.10	392.44	56.99
Nominal Belt	149.31	215.37	285.00	1390.50	17.53	360.00	61.89
Max Belt	160.33	219.22	293.58	1397.50	14.79	331.99	66.90
Stretch & wear	184.16	235.44	314.88	1411.50	7.97	266.67	79.24
Free Arm	188.88	249.57	320.00	1414.00	6.33	244.13	82.48

6. Conclusion

Through the cause analysis and fault improvement of a certain batch of engine belt early wear and frequent fracture, the problem of belt fracture is finally solved. Even if the wheel system layout design is carried out according to the normal requirements of the general characteristics of the belt in the industry, it is still necessary to strictly control the material selection and manufacturing accuracy of domestic belt manufacturers, otherwise the wheel system failure problem will still occur.

References

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