Computations of Line Reactor Parameters and DC Bus Capacitance for Inverter

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Abstract - This paper proposes a novel analysis method for calculating inverter DC bus capacitance and line reactor parameters. In the realization process, DC bus capacitance parameter and ripple current, life of DC bus capacitor, interaction between DC bus capacitance can be calculated by using Newton-Raphson procedure. The design scheme of DC bus capacitor and line reactor, specific parameters such as capacitance, loss, ripple current, central average temperature, life, ripple current, loss, size, central temperature of the reactor were given. Simulation results show that this scheme can accurately calculate the DC bus capacitance and line reactor parameters. Compared with calculation result of references, cost and volume are half. The indicators meet the demand of practical engineering. It had affirmed precision of the analytical method and verified correctness and feasibility of this method.

1. INTRODUCTION

In recent years, variable frequency AC speed control technology has gradually replaced the DC speed control systems due to its high speed control performance, significant energy-saving ability and wide suitability [1]. But due to factors such as nonlinear inverter itself, to produce a large number of harmonic, not only results in the decrease of local power electronics device life, power factor, but utilization rate of dc voltage is also reduced, and may harm the electric network and electric equipment.

Based on this, this paper proposes a novel analysis method for calculating inverter DC bus capacitance and line reactor parameters, the capacitance value and sense of value calculation scheme, etc. In this paper, design of DC bus capacitance and line reactor and experience design value and experimental value are presented. Results show that the design of the bus capacitor and the line reactor, and the technical specifications meet the demand of inverter design which has reduces the cost.

2. SYSTEM SUMMARY

The parameters of the speed control system are shown in Table 1 while the topology is shown in Fig. 1, including rectifier, current limiting circuit, bus capacitance, and DC-AC circuit.

Table 1 Parameters of the speed control system

<table>
<thead>
<tr>
<th>Item</th>
<th>Value</th>
<th>Item</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated voltage</td>
<td>114V</td>
<td>Maximum current multiple</td>
<td>25</td>
</tr>
<tr>
<td>Rated current</td>
<td>48.3A</td>
<td>Overload time</td>
<td>1 min</td>
</tr>
<tr>
<td>Rated power</td>
<td>75kW</td>
<td>Overload multiple</td>
<td>1.1</td>
</tr>
<tr>
<td>Rated speed</td>
<td>1278 rpm</td>
<td>Rated frequency</td>
<td>50 Hz</td>
</tr>
</tbody>
</table>

Fig. 1 Topology of the speed control system

3. LINE REACTOR PARAMETERS ARE CALCULATED

The one phase voltage drop of line reactor is

\[ V_{AN} = \frac{V_N}{\sqrt{3}} = 660V \]  

(1)

Voltage drop of line reactor is 3% of one phase voltage drop in normal conditions. So voltage of line reactor can be expressed in (2).

\[ V_s = \omega L N_s = 3\% V_{AN} = 19.8V \]  

(2)

Where, \( \omega \) is power angular frequency, \( L \) is inductance of line reactor, \( I_N \) is rated voltage of speed control system. Calculated \( L = 1.3mH \).

4. BUS CAPACITANCE PARAMETERS ARE CALCULATED

The main purpose of the DC bus capacitor is to absorb the ripple current, and make the system output more stable in the inverter. When the value of DC bus capacitor is large enough, output voltage waveform of rectifier in a cycle is show in Fig. 2.

Load power supply during \( t_0 - t_1 \) is analyzed from which it can be obtained as

\[ C_{DC} = \frac{P_{dec}(\frac{\pi}{3} - \arccos(1 - \alpha))}{\omega U_{N}^2(2\alpha - \alpha^2)} \]  

(3)

Where, \( C_{DC} \) is DC bus capacitance, \( P_{dec} \) is output power of DC bus voltage, \( \alpha \) is DC bus voltage drop percentage.

Loss, life, and current ripple can be calculated by the following formula.

\[ \begin{align*}
L &= L_2 \times 10^{-10} \\
I_r &= \left( \frac{\sqrt{3}M \sqrt{ \frac{4}{3} + \cos \psi (\sqrt{3} \cdot \frac{9}{16} M)}}{4 \pi} \right) + \\
&\quad \left[ 0.5 \% C_{DC} \sqrt{2} U_{N} \left\lfloor \frac{1}{t_r} \left( \frac{1}{t_r} + 1 \right) \right\rfloor \right] \\
L_{sc} &= \frac{1}{\alpha C_{DC} \sqrt{2} U_{N} \left\lfloor \frac{1}{t_r} \left( \frac{1}{t_r} + 1 \right) \right\rfloor} \\
\end{align*} \]  

(4)
5. SIMULATION OF LINE REACTOR AND DC BUS CAPACITANCE

Fig. 4 shows a DC bus voltage, Fig. 5 shows ripple current of DC bus capacitance, and Fig. 6 shows output current. Table II shows DC bus capacitance size with different calculation schemes, and Table III shows simulation results of line reactor and DC bus capacitance.

As shown in Fig. 4, Fig. 5, and Fig. 6 which propose calculation method and references[2-4] calculation value get DC bus voltage, ripple current of DC bus voltage, and output current is good output effect. Meanwhile as show in Table II and Table III that this paper calculates value on the premise that it can satisfy the system requirements compared with the calculated value of the literature, that cost and volume are half.

6. CONCLUSION

This paper proposes a novel analysis method for calculating inverter DC bus capacitance and line reactor parameters. And by using Newton-Raphson procedure DC bus capacitance parameter can be calculated. The value of DC bus capacitance, value of line reactor, ripple current, life, and loss can be detailed derived. The simulation results show that this scheme can accurately calculate the DC bus capacitance and line reactor parameters. Compared with calculation result of references[2-4], that cost and volume are half. The indicators meet the demand of practical engineering.

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[References]