Survey and Analysis of the Impact of Voltage Sag and Short-term Interruption on Power Users in a Region of Southern China

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Abstract. In order to gain a deeper understanding of the impact of voltage sag in major power users in a region of southern China, the local power supply department led the survey of the impact of voltage sag on many major power users in the region. In order to ensure that the surveyed users have a good representativeness, the selection of surveyed users takes into account factors such as geographical, industry and historical complaints. Through the analysis of the survey information, two sensitive users who were seriously affected by the voltage sag were obtained. As a whole, the present situation that power users are affected by voltage sag has been mastered.

Introduction

According to statistics, the voltage sag (including short-term interruptions, the same below) in developed countries such as Europe and the United States has brought huge economic losses to power users, and has become the power quality issue with the most complaints from power users. And voltage sag has caused widespread concern in the power supply, power consumption and academic research fields. The domestic and international electrical industry has conducted extensive and in-depth discussion and research on voltage sag [1-3].

As an important manufacturing base in China, the region has many high-end manufacturing users such as automobile manufacturing and electronic production. In order to grasp the impact of voltage sag in various industries in the region, the local power supply department led the survey of the main power users in the region. Through in-depth communication with power users, the loss caused by voltage sag and the use of sensitive equipment about the user's production process was inquired. After the survey, two sensitive users were selected, namely: A ceramics company and B electronics company.

Survey and Analysis of A Ceramics Company

Company Profile

A Ceramics Company is one of the most complete and large-scale companies in the domestic roofing tile industry. Its annual electricity consumption can reach 30 million to 50 million kWh.

Power Supply System

The company is powered by the HP line of the 110 kV class YG station (one main transformer with a capacity of 50 MVA). The power supply line is an overhead line about 7 kilometers long. There are 4 factory transformers in the factory, of which 3 are 2000kVA and 1 is 2500kVA (new). The main electrical wiring of the plant is shown in Figure 1.
Production Process and Sensitive Equipment

The production process of the company mainly includes ball mill pulping, spray tower powder drying, press stamping forming, drying, glazing, firing, edging, grading into the warehouse, etc. The specific process flow is shown in Figure 2.

![Figure 2. Tile production process.](image)

The functions of each link are described as follows:

1) Ball mill pulping: The raw materials such as mud, sand and stone powder are sent to the ball mill through the belt, and the mud water having a water content of 20-30% is obtained at the discharge port.

2) Spray tower powder drying: The mud is atomized in the drying room of the spray tower, and the finished powder with a water content of 5~6% enters the storage box through the feed pump.

3) Press stamping forming: The powder is pressed into a block brick by a brick press. Forming is a very important process. If it is not properly controlled, it will produce quite a few defects.

4) Drying: The green body having a water content of 5-6% is passed through a roller dryer to a dried billet having a water content of 1% or less, and the strength is remarkably enhanced.

5) Glazing: A thin glaze is applied to the surface of the dried body to provide decoration and protection.

6) Firing: After printing, the bricks are fired in a high temperature furnace (generally around 1200 °C) to achieve the process of vitrification into porcelain.

7) Edging: The semi-finished products burned from the furnace are passed through the edging line to reach the finished product that meets the standard.

The typical voltage sag sensitive equipment names, capacities and types sag are analyzed as follows.

<table>
<thead>
<tr>
<th>Sensitive equipment</th>
<th>Type</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ball mill and punch motor control equipment (ball mill pulping, stamping)</td>
<td>Punching machine: 100kW/set, about ten sets</td>
<td>ACC (contact current 250~750A)</td>
</tr>
<tr>
<td>Ball mill: 200~300kW/set, about 20 sets</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control device for inkjet printing machine (glazing)</td>
<td>---</td>
<td>PC</td>
</tr>
<tr>
<td>Feed pump (powder drying)</td>
<td>---</td>
<td>ASD</td>
</tr>
<tr>
<td>Furnace control cabinet (firing)</td>
<td>---</td>
<td>PLC</td>
</tr>
<tr>
<td>Power distribution room protection switch</td>
<td>---</td>
<td>Trip unit</td>
</tr>
</tbody>
</table>

Through a large number of tests, the upper and lower limits of ACC, PC, ASD, PLC, Trip unit is \{[30%,60%], [10ms,120ms]\}, \{[29%,31%], [97ms,92ms]\}, \{[55%,75%], [10ms,35ms]\}, \{[15%,32%], [20ms,433ms]\}, \{[30%,45%], [5ms,20ms]\} respectively.
Voltage Sag Impact

According to relevant personnel, the company is affected by sag for about 5-6 times a year, with a single sag loss of about 250,000 to 300,000 yuan, and the annual sag loss can reach more than 1 million. Based on the analysis of the previous section, it is found that the links that have been or are susceptible to voltage sag in the process of the company are spray tower powder drying, press stamping forming and firing.

Existing and Planned Measures to Mitigate the Voltage Sag

At present, the company has adopted four 500kVA UPS to deal with the key links of firing, which can immunize power quality disturbance within 5min.

The main reason for the impact of the sag of the factory power distribution room is that the trip unit is too sensitive to voltage sag. Therefore, for the problem, the simplest and most economical treatment method is to appropriately extend the action time of the trip unit. For the problem that the sensitive equipment is affected by the voltage sag, take ASD as an example. Consider adding a small UPS or VSP (DC-Bank type equipment) to compensate it. The latter directly compensates the ASD DC slot without switching time.

Survey and Analysis of B Electronics Company

Company Profile

B Electronics Company is one of the world's largest suppliers of mobile phones and PC power. The market share is 20%, and the company has about 7,000 employees. At present, the company is preparing for the construction of a new production line, and it is estimated that electricity consumption will increase by about 50%.

Power Supply System

The company is powered by the YD line of the FC station (two main transformers, capacity 40MVA, 31.5 MVA respectively) No. 2 bus line. The line uses overhead lines with a total length of about 1000m. After the line is divided by the 10kV high-voltage power distribution room, it supplies power to the two factories in the enterprise. There are 10 transformers in the plant, the total capacity is 10945kVA, of which, the first phase of the plant is 4945kVA, and the second phase is 6000kVA. The annual electricity consumption is more than 30 million kWh. The main electrical wiring is shown in Figure 4.

![Figure 4. Schematic diagram of the company's electrical main wiring.](image)

Production Process and Sensitive Equipment

The production process of the company is shown in Figure 5. It mainly includes the links of SMT patch, assembly, aging test, laser marking, packaging and storage.
The functions of each link are described as follows:

1) SMT patch: rely on the placement machine, dispenser, reflow soldering machine, cleaning machine and other equipment to solder the small components to the PCB board.

2) Assembly: The assembly process relies on the combination of man and machine to fix the larger plug-in components to the PCB.

3) Aging test: The product is placed in an aging workshop for a 24-hour uninterrupted live working test to verify product reliability and stability.

4) Laser marking and Packaging and storage: The products that pass the aging test are laser-marked and placed in stock.

There are many sensitive equipment in all links, and the name, type, capacity and typical voltage tolerance capability of the main equipment sensitive to voltage sag are shown in Table 3 below.

Table 3. Typical voltage sag sensitive equipment of the company's production process.

<table>
<thead>
<tr>
<th>Sensitive equipment</th>
<th>Capacity</th>
<th>type</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMT patch machine control computer, laser marking main control computer, reflow soldering machine control computer, assembly process main control computer</td>
<td>---</td>
<td>PC</td>
</tr>
<tr>
<td>Air nozzle, pneumatic dispenser, reflow soldering machine, circulating fan</td>
<td>Air compressor is about 710kW/set</td>
<td>ASD</td>
</tr>
<tr>
<td>Automatic placement machine, reflow soldering machine, aging test main control board</td>
<td>---</td>
<td>PLC</td>
</tr>
<tr>
<td>Power distribution room protection equipment</td>
<td>---</td>
<td>Trip unit</td>
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</tbody>
</table>

The upper and lower limits of the voltage sag tolerance curve of PC, ASD, PLC, Trip unit is \{[29%,31%], [97ms,92ms]\}, \{[55%,75%], [10ms,35ms]\}, \{[15%,32%], [20ms,433ms]\}, \{[30%,45%], [5ms,20ms]\} respectively.

**Voltage Sag Impact**

According to the staff estimates, the average annual impact of the factory is 7-8 times. In a serious year, the impact of the sag is 12 times in one year (2014), the loss of single sag is about several hundred thousand, and the cumulative loss is more than 5 million. After survey and analysis, it is found that the link of the production process that has experienced a voltage sag accident or is susceptible to voltage sag is SMT patch, assembly, and aging test.

**Existing and Planned Response to Mitigate the Voltage Sag**

At present, the company has adopted a small UPS to protect the monitoring center, fire protection system and factory service system, and the effect is good. For the production line, the company proposed to adopt DC power supply to control the frequency conversion equipment to reduce the loss. For the main economic losses (labor loss and capacity loss) of the enterprise, it is possible to start from the power supply part and increase the reliability of the power supply of the power grid.

**Conclusion**

After surveying and analyzing many large-scale power users in the region, Based on various factors, we have selected two voltage sags sensitive company which are large in scale and have large losses,
involves a variety of sensitive equipment: A Ceramics Company and B Electronics Company. Comparing the two companies is not difficult to find, not only high-tech companies are sensitive to voltage sag, but also traditional manufacturing companies who after the technology upgrade, use many voltage sag sensitive equipment, show higher voltage sag sensitivity. After this survey, we basically grasped the impact of voltage sag in various industries in the region, laying the foundation for the governance of voltage sags.

**References**

