FINANCIAL IMPACT OF POWER QUALITY ON INDIAN PHARMACEUTICAL INDUSTRY – SURVEY RESULTS

Sarat Chandra VEGUNTA  
TNEI Services Ltd – UK  
chandra.vegunta@tnei.co.uk

Jovica V MILANIOVIC  
The University of Manchester – UK  
milanovic@manchester.ac.uk

ABSTRACT
The paper presents results of PQ survey conducted on Indian Pharmaceutical Industry (IPI) to assess the extent of PQ problems (voltage disturbances in particular) facing this important industry sector. The results of the survey quantify the frequency of occurrence of PQ problems, their impact on manufacturing processes, financial losses resulting from PQ disturbances (i.e., cost of downtime) and management approach to mitigation of PQ problems.

INTRODUCTION
Following the success story of its Information Technology (IT) industry, India is now shifting its focus to the most promising industry of the future, Biotechnology [1]. Biotechnology, a sub-category within manufacturing sector, is broadly divided into: healthcare, agriculture, industrial and environmental. The health care or pharmaceutical industry alone is estimated to account for roughly 40% of the total Indian biotech market by the year 2010 [1], suggesting the bulk of manufacturing processes involved. Depending on the type drug type, manufacturing standards and practices, they can include complex processes controlled sophisticated equipment that requires good quality of power supply. Although a nationwide consensus on frequent power cuts is widely acknowledged in the publishing media, utilities, and customers, detailed nationwide or even region wise consensus on Power Quality (PQ) problems in India is lacking or not readily available. This paper summarises results of an opinion based PQ survey conducted on Indian Pharmaceutical Industry to assess PQ problems and their impact on manufacturing processes and consequential financial losses.

RESULTS AND ANALYSIS
This section summarizes the main results of the survey conducted over the period of three months at the end of 2007. The survey involved electronic (internet based) and paper copy questionnaires and telephone interviews.

Survey Coverage
The survey questionnaire was sent to 18 Pharmaceutical companies in India (those who agreed to participate in the survey), which accounted for 14.3% of 126 US FDA approved companies. Seven manufacturing plant responses were received from 6 companies, i.e., 1.16 surveys per company. The six received company responses account for 4.76% of total FDA approved Pharmaceutical companies in India [2]. Though this is a reasonably small statistical sample for any generalisation of the results the survey represents first ever attempt to quantify PQ problems experienced by this import industrial sector in India and provides at least initial indication of the extent of the problem. Five of the received responses came from companies in the state of Andhra Pradesh. The results are thus skewed towards the state of Andhra Pradesh. However, this is also due to the fact that 33% of India’s total bulk drug production is in this region [3, 4]. Figure 1 shows survey population and response distribution per state.

Power Quality Problem Quantification
The first part of developed questionnaire aimed to identify the extent of different PQ problems. The occurrence frequency of different PQ phenomena is indicated in Figure 2. The majority (six out of seven) of the respondents stated that power quality is very important compared to the situation ten years ago, while the remaining one participant suggested that it is important. Four out of seven respondents identified utility networks as the main sources of power quality problems, while the remaining three stated that the sources could be both, utility and customers themselves. Three out of seven respondents suggested that their plants experienced problems as a direct consequence of poor power quality at least once a week, while two suggested that PQ induced problems occur once per year. Figure 3 shows the relative frequencies of various power quality problems. Short interruptions lasting less than a minute and harmonics are seen as the most frequent. However, when...
the two frequency bins, i.e. most often and often, are combined, 4/7 respondents agreed that voltage and current harmonics are the most frequently experienced phenomenon, followed by voltage sags, surges and transients (4/7 respondents), and short and long (more than a minute) interruptions. Only 2/7 respondents suggested that their plants have installed power quality monitors. Among reasons why they would, or already do, monitor power quality, 3/6 respondents suggested the monitoring of voltage disturbances as the primary reason, while the others suggested that they have installed, or would install, PQ monitors in order to monitor harmonics and frequency changes.

Figure 2 Frequency of experienced PQ problems

Figure 3 Frequency of various identified PQ problems

At the customer’s facility, power supplies which involve power electronic equipment (converters, inverters, drives and uninterrupted power supplies) are seen as the main cause (5/7 respondents) of power quality problems, followed by wielding machines (4/7 respondents), lighting equipment (3/7 respondents), motors (1/7 respondents) and personal computers (1/7 respondents).

Voltage Disturbance Attribute Quantification

The majority of the participants identified line-to-ground faults at the distribution system and motor starting (3/5 respondents in each case) as the major causes of voltage sags. These are followed by line-to-ground faults in the transmission system and load changes (2/5 respondents), and three-phase faults on the transmission system and line-to-ground faults on adjacent feeders (1/5 respondents).

Figure 4 shows the individual voltage disturbance occurrences, which lead to production loss. The majority of the voltage sags were seen to have magnitudes above 60% and lasting between 1 and 3 seconds. The majority of short interruptions lasted between 0.5 and 3 seconds, and long interruptions typically lasted for more than 5mins.

Among the various types of widely used industrial equipment offered in the survey form to choose from, Adjustable Speed Drives (ASDs) and Programmable Logic Controllers (PLCs) were identified as the most sensitive, followed by Personal Computers (PCs), motor contactors, fuses and solid state relays. The PLCs and ASDs (5/7 respondents in each case) were also the equipment, whose malfunction was most likely to cause a complete process disruption, followed by motor contactors (3/7 respondents).

Figure 4 Reported voltage sag and interruption parameters

Manufacturing process sensitivity

Mechanical failures are seen as the primary cause of failure (5/6 respondents), while 3/6 respondents suggested that hardware error, software error and PQ-related problems were the primary cause of failure. Finally, 2/5 respondents suggested that human error and inventory delays are primary causes of process disruptions.

Figure 5 Reported sensitivity of various industrial equipment to voltage disturbances.

The majority of the participating plants had an annual disruption frequency of between 5-10 times, while the majority of participating plant disruptions due to voltage disruptions accounted for 1 to 5 times annually. Three out of six respondents suggested that voltage sags caused partial process disruption, while the other three respondents suggested that voltage sags cause little process disruption.
On the other hand, only 1/6 respondents suggested that voltage interruptions lead to complete process disruption, while 2/6 respondents suggested partial disruption, with the remaining 3/6 respondents suggesting little or no disruption at all.

Figure 6 Plant disruption frequency and severity.

Cost of Downtime

The following section of the survey questionnaire was dedicated to the assessment of Cost of Downtime (COD) resulting from the PQ induced process interruption. The participants in the survey were asked to select a range of COD following a typical complete process failure. The results obtained are show in Figure 7.

The total cost (direct + downtime + restart) of complete plant disruption varied from as little as Rs.1000 to as much as Rs.100,000-2,500,000, with the range of Rs.10,000-100,000 being the most probable. By defining the minimum and maximum total cost per disruption per plant, and by adding the minimum and the maximum values of all respondent selected COD ranges respectively, the per plant cost can be estimated using the following equations (Note: £1 = Rs.83.33, as of June, 2008):

\[ TCPD_{\text{MIN}} = \sum_{i=1}^{11} CPD_{\text{MIN}} \cdot U_i = Rs.39,328.57 \] \hspace{1cm} (1)

\[ TCPD_{\text{MAX}} = \sum_{i=1}^{11} CPD_{\text{MAX}} \cdot U_i = Rs.230,242.9 \] \hspace{1cm} (2)

Where,

- \( i=1 \) corresponds to ‘<Rs.1,000’, \( i=2 \) corresponds to Rs.1,000-10,000… \( i=11 \) corresponds to ‘Rs.50,000,000’, etc.

\( CPD_{\text{MIN}} \) = Minimum cost per disruption for selected ‘\( i \)’.

\( CPD_{\text{MAX}} \) = Maximum cost per disruption for selected ‘\( i \)’.

\( U_i \) = Percentage of responses in corresponding range.

Considering the worst annual process disruption frequency of 5-10 events per year (Figure 6a) due to many different factors, the total annual cost of downtime is between Rs.196,571-1,017,143. The cost of downtime due to voltage disturbances alone with the worst annual frequency of 1-5 (Figure 6b) is however, between Rs.39,314-508,571. According to a year 1999-2000 estimate [5], there were a total of 20,053 pharmaceutical manufacturing units which accrued a total production (formulation and bulk drugs) value of Rs.197.37 billion. The cost of downtime due to all events and due to voltage disturbances alone can be extrapolated to the national pharmaceutical production scale in order to estimate their impact on the industry.

Figure 7 Distribution of COD indicated by participants.

Considering the worst case scenario, the cost of downtime due to all events is Rs.20.4 billion (£2.5 billion as of June, 2008), while the cost of downtime due to voltage sags alone is Rs.10.2 billion (£1.25 billion as of June, 2008). It is noted that the cost of downtime due to voltage disturbances alone accounts for 50% of the total cost of downtime due to all events. These costs, i.e., the cost of downtime due to all events and voltage disturbances alone, account for 10.33% and 5.16% of the national annual production of pharmaceutical companies, respectively. A European-wide 2007 PQ survey [6] suggested also that several companies were losing up to 10% of their annual turnover due to poor PQ. Even though the losses due to poor Power Quality may not appear to be excessive (as a percentage of the total annual turnover), they can still be seen as large in absolute figures, and amount to a significant part of the budget of individual business units [6].

PQ Management and Solution Strategy

The final part of the questionnaire dealt with responsibility for maintaining adequate PQ and with actions taken to improve PQ. A survey results suggested that the plant maintenance manager (5/7 respondents) handles the majority of the plant reliability related issues. In other cases, facility manager (1/7 respondents) or other official (1/7 respondents) e.g., the project manager, share this responsibility.
a. Personnel responsible for plant’s reliability.

b. Personnel responsible for electricity supply system changes and upgrade.

The majority of electricity supply system changes and upgrade responsibilities were shared between the maintenance manager and other staff (e.g., quality assurance team, managing director and project manager), while a small portion of respondents (1/7 respondents) indicated that the facility manager carries this responsibility.

a. Problem solution strategy.

b. PQ solution providers.

A detailed opinion based power quality survey of Indian Pharmaceutical Industry was conducted in order to quantify the impact of power quality problems on this important industrial sector. The focus of the survey was on voltage disturbances and manufacturing processes where the interruption of production could lead to significant cost of downtime. The following conclusions are drawn from the survey results presented in this paper: 1) A perception that utility is the main cause and main party responsible for the majority of PQ problems is still dominant, despite the fact that there is very little PQ monitoring at customer’s facilities. 2) While the reported voltage sags at surveyed plants had magnitudes in very wide range, virtually from 0 to 1p.u., the majority of them lasted between 1 and 3 seconds. The majority of short interruptions on the other hand lasted for more than 0.5s; 3) PLCs, ASDs and PCs are found to be the most sensitive industrial equipment to voltage disturbances, followed by motor contactors; 4) Process interruptions (both partial and complete) due to voltage disturbances, represent almost one third of total number of process interruptions caused by all contributing reasons; 5) The annual cost of downtime due to all PQ events can be as much as 10.33% of the total company’s annual turn-over. Voltage sags alone account for about 50% of this cost. 6) When it comes to PQ problem resolution the companies tend to rely largely on internal technical services and external expert solution providers.

Acknowledgments

The authors would like to thank all the industrial participants who responded and contributed to this survey and Sipra Labs Pvt Ltd for the help in preparing and distributing the survey questionnaire.

REFERENCES


Dr Sarat C. Vegunta is working as a Technical Consultant at TNEI Services Ltd, Manchester, UK.

Prof. Jovica V. Milanović is a Deputy Head (Research) of School of Electrical and Electronic Engineering, The University of Manchester, U.K.