International Journal of Advances in Engineering, 2015, 1(9), 644 - 649
ISSN: 2394-9260 (printed version); ISSN: 2394-9279 (online version); url:http://www.ijae.in

SHORT NOTES

Performance Analysis of Three Phase Motor - Pump System on Load Variations and Unbalance Voltage

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Received 2 August 2015 / Accepted 24 September 2015

Abstract - Three-phase induction (asynchronous) motors are widely used to operate centrifugal pumps which is used in irrigation system. To analyzing the performance of of induction motor is a very important.The unbalanced load distribution and variation in load demand leads to voltage variation and unbalance in 3Φ line. Hence the study of the induction motor- centrifugal pump driven system at variable and unbalance voltage condition gives the performance variation about the driven system and also power factor variation of the system. This paper presents the experimental results of a three-phase induction motor-pump system subjected to unbalance voltage and load variations.

Keywords :pump system, load variations, power factor

I. INTRODUCTION

In a three-phase system, voltage unbalance takes place when the magnitudes of phase or line voltages are different and the phase angles differ from the balanced conditions or both.The effects of voltage unbalance involve more on the performance of three-phase induction machines. In Recent years, power quality concerns have increased largely due to economic reasons and problems that affect all industrial consumers. Voltage disturbance is the most form of a Power Quality (PQ) problem in industrial utilities. Among the various types of voltage disturbances, voltage variations and unbalance is of frequent occurrence due to regular switching of 1Φand 3Φ loads. Three-phase induction motors are industrial work-horses, responsible for consumption of 40-50% of generated electrical power. Because of its industrial usage, in recent years, there has been a lot of focus on IM protection at low and medium voltage. Such protection devices typically monitor the motor current and the voltage to provide the motor protection functionalities like current overload, over/under voltage. Voltage unbalance that exists in the system network, in the case of pump loads, as the torque developed by the motor is dependent on the supply voltage, small variation in the voltage or unbalance among the voltages results in a detrimental effect on the application involved. The continuous voltage variation and unbalance throughout the day does have a big impact on the working performance. Industrial utilities make significant amount of investment in order to achieve process efficiency, but many a times it has been found that performance variations in the process equipment are mainly due to external factors, in particular, the quality of the incoming supply. Hence considering the application involved, the knowledge of possible variation in performance due to the impact of voltage variation and unbalance is essential especially when it comes to identifying energy management opportunities.

II. ANALYSIS AT UNBALANCED VOLTAGE CONDITION

At the three different set points by varying the unbalance voltage condition the motor and pump performance are calculated and tabulated. For getting unbalanced voltage condition, we connected three single-phase auto Three-phase induction (asynchronous) motors are industrial work-horses, analyzing the protection of induction motor is a very important topic.

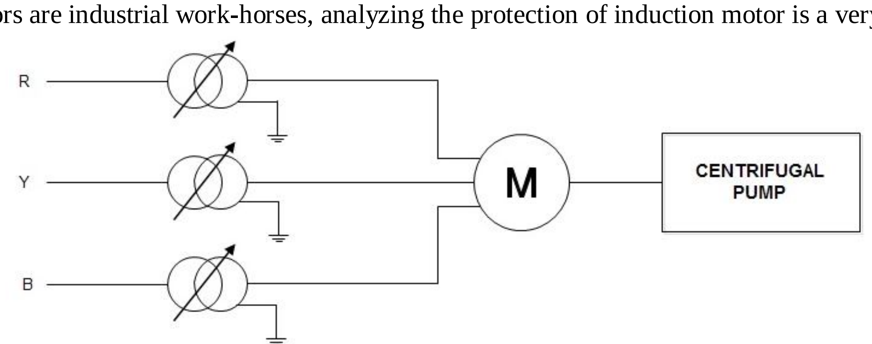

Figure 1. Experimental set up for unbalanced condition

Centrifugal pumps are the most widely used ac motor-driven pump systems mainly for water pumping applications. The unbalanced load distribution and variation in load demand leads to voltage variation and unbalance in 3Φ line. Hence the study of the induction motor- centrifugal pump driven system at variable and unbalance voltage condition gives the performance variation about the driven system and also power factor variation of the system. In autotransformers the neutral wire of the all the single-phase autotransformers are short circuited and connected to ground. The phase terminals of all the three transformers are taken as 3Ω input supply to the induction motor. The unbalanced voltage condition is obtained by varying the three autotransformers supply. We can get the three different phase voltages at the output of the transformers.

Motor Efficiency: The variation of motor efficiency at set point 1 for unbalanced voltage condition is shown in Figure. The motor efficiency variation at set point 1 is in the range of 83.29% - 83.93% for unbalanced over voltage (UBOV) case, 81.29% - 82.22% for unbalanced under voltage (UBUV) case. The variation of motor efficiency at set point 2 is in the range of 83.23% - 83.62% for unbalanced over voltage case, 81.32% - 89.2% for unbalanced under voltage case. The motor efficiency variation at set point 3 is in the range of 83.46% - 84.3% for unbalance over voltage case, 81.92% - 83.56% for unbalance under voltage case. The motor efficiency in unbalanced condition at all the three set points are decreasing in nature, even though the graph is not exactly decreasing some variations are there but it is negligible.

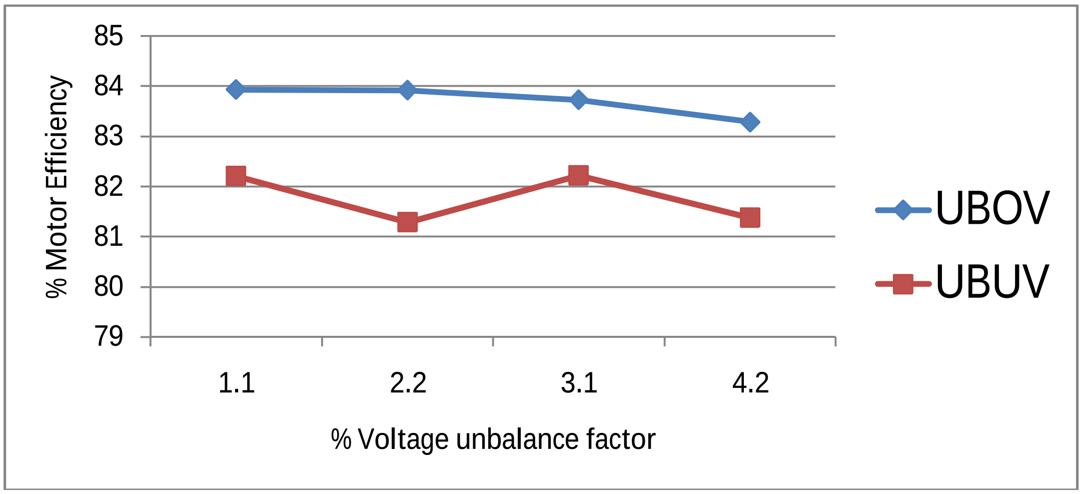

Figure 2. Percentage change in motor efficiency at set point 1

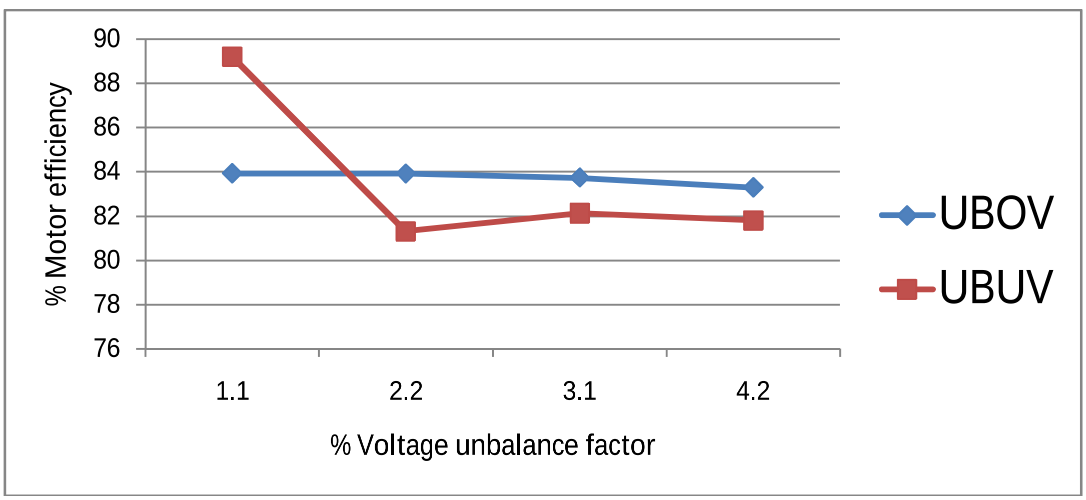

Figure 3. Change in motor efficiency at set point 2 for unbalanced voltage

Pump Efficiency : The pump efficiency variation at set point 1 for unbalanced voltage condition is shown in figure 10. The pump efficiency variation at set point 1 is in the range of 67.60% - 68.85% for unbalance over voltage case, 75.51% - 70.12% for unbalance under voltage case. The pump efficiency variation at set point 2 is in the range of 60.24% - 61.51% for unbalance over voltage case, 62.45% - 70.94% for unbalance under voltage case. The variation of pump efficiency at set point 3 is in the range of 19.53% - 21.33% for unbalance over voltage case, 21.09% - 23.72% for unbalance under voltage case. In all the set points the pump efficiency decreases in nature with corresponding change in voltage unbalance factor (VUF).

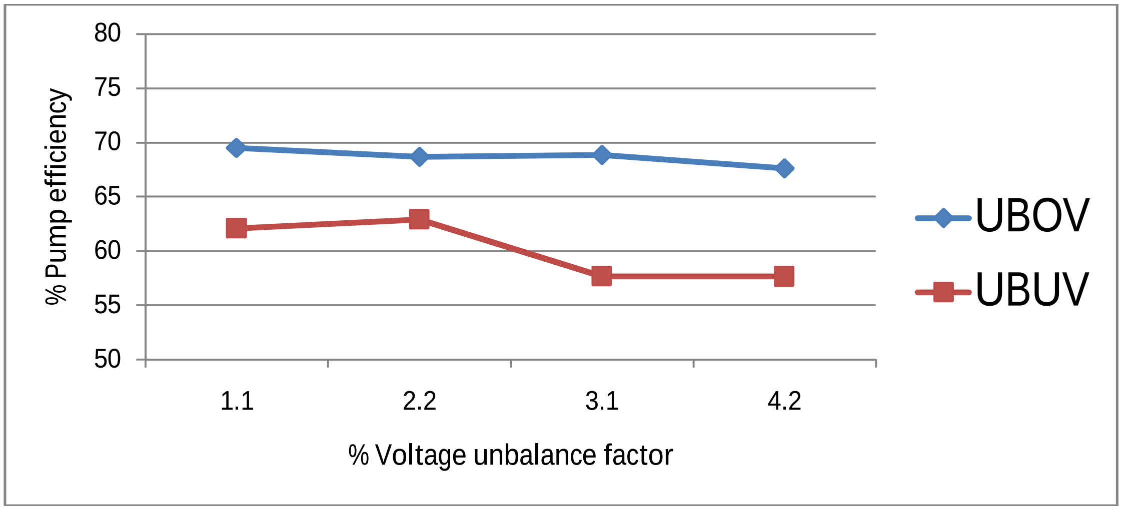

Figure 4. Percentage change in pump efficiency at set point 1 unbalanced voltage

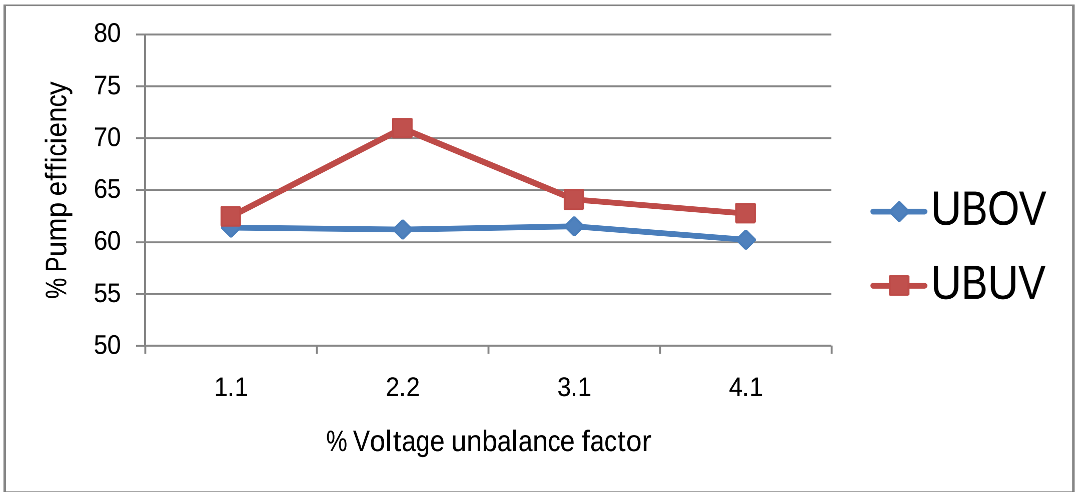

Figure 5. Percentage change in pump efficiency at set point 2 unbalanced voltage

III. CURRENT UNBALANCE FACTOR

Current unbalance factor is important parameter at unbalance voltage condition. The voltage unbalance causes the current unbalance in the line current of the system. The 1% change in voltage unbalance factor causes the current unbalance factor to be in more than 10%. The percentage change in current unbalance at set point 1 for various voltage unbalance combination is shown in Figure 11. The current unbalance factor variation at set point 1 is in rage of 8.69% - 40.8% for unbalance over voltage case, 10.4% - 27.9% for unbalance under voltage case. At set point 2 the current unbalance factor variation is in the range of 13.2% - 42.5% for unbalance over voltage case, 10.8% - 27.5% for unbalance under voltage case. At set point 3 the variation of current unbalance is in the range of 13.7% - 43.9% for unbalance over voltage case, 13.3% - 30.0% for unbalance under voltage case. At all the set points the current unbalance factor increases with corresponding increases in voltage unbalance. The increases in the pressure of delivery side water the current unbalance also increases. For the pressure 1.9kg/cm^2, 2.0 kg/cm^2 and 2.1 kg/cm^2 the current unbalance is in the range of 10.4%, 10.8% and 13.3% respectively for unbalance under voltage case, 8.69%, 13.2% and 13.7% for unbalance over voltage case, hence in all the voltage variations the current unbalance increases with in increases in the outlet pressure.

Power Factor : The power factor is also one of the important parameter to analysis for 3-Φ induction motor in industrial sector. The power factor varies widely for any change in the voltage unbalance. The voltage unbalance condition causes adverse effect in the power factor. Before the installation of the high rating induction motor it is necessary to review the variation in power factor range in industrial sector. At set point 1 the power factor variation is in the range of 0.88 – 0.85 for unbalance over voltage case, 0.9 – 0.83 for unbalance under voltage case. At set point 2 the power factor variation is in the range of 0.882 – 0.848 for unbalance over voltage, 0.9 – 0.86 for unbalance under voltage case. At set point 3 the power factor variation is in the range of 0.877 – 0.841 for unbalance over voltage case, 0.91 – 0.83 for unbalance under voltage case. At all these set points the power factor decreases in nature with corresponding increases in unbalance factor. At both under voltage and over voltage conditions the power factor decreases gradually.

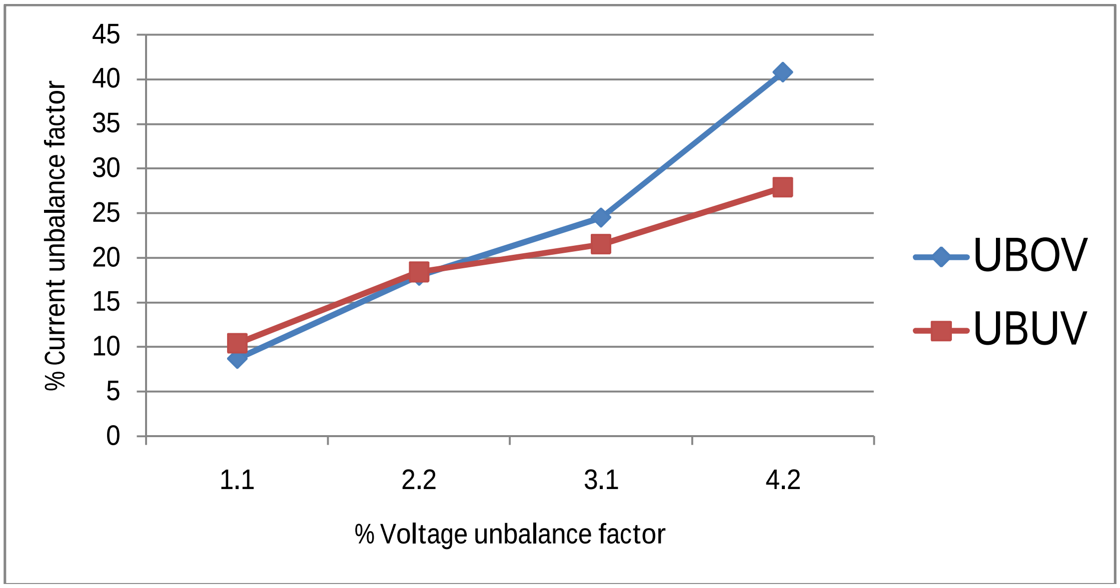

Figure 6. Percentage change in current unbalance at set point 1

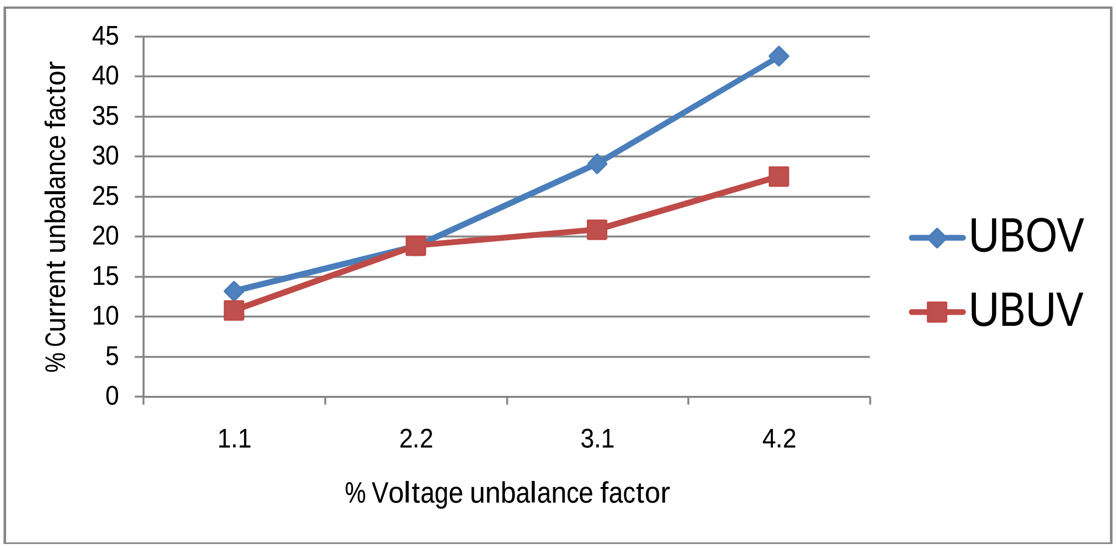

Figure 7.Percentage change in current unbalance factor at set point 2

System Efficiency : The system efficiency variation at set point 1 and 2 are shown in Figure 14 and Figure 15 respectively. The system efficiency variation at set point 1 is in the range of 58.34% - 56.30% for unbalance over voltage case, 62.90% - 57.64% for unbalance under voltage case.

The system efficiency variation is in the range of 51.35% - 50.13% for unbalance over voltage case, 57.68% - 51.35% for unbalance under voltage case at set point2. At set point 3 the system efficiency variation is in the range of 47.93% - 43.74% for unbalance over voltage case, 52.23% - 47.28% for unbalance under voltage case.

From the result it is noted that at all the set points the pump efficiency decreases with corresponding increases in the voltage unbalance factor (both UBOV and UBUV).

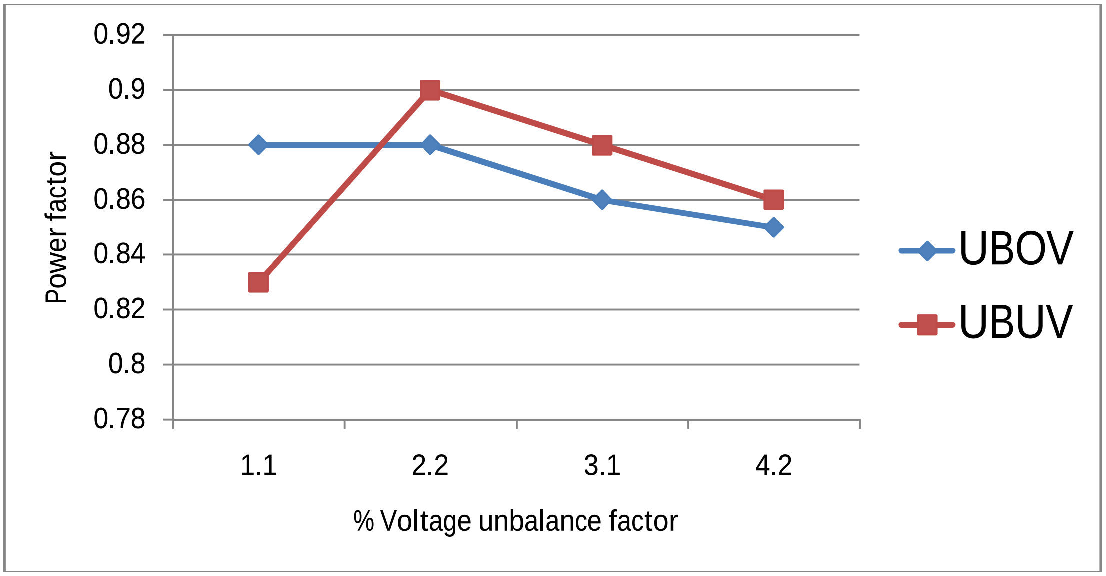

Figure 8. Change in power factor at set point 1

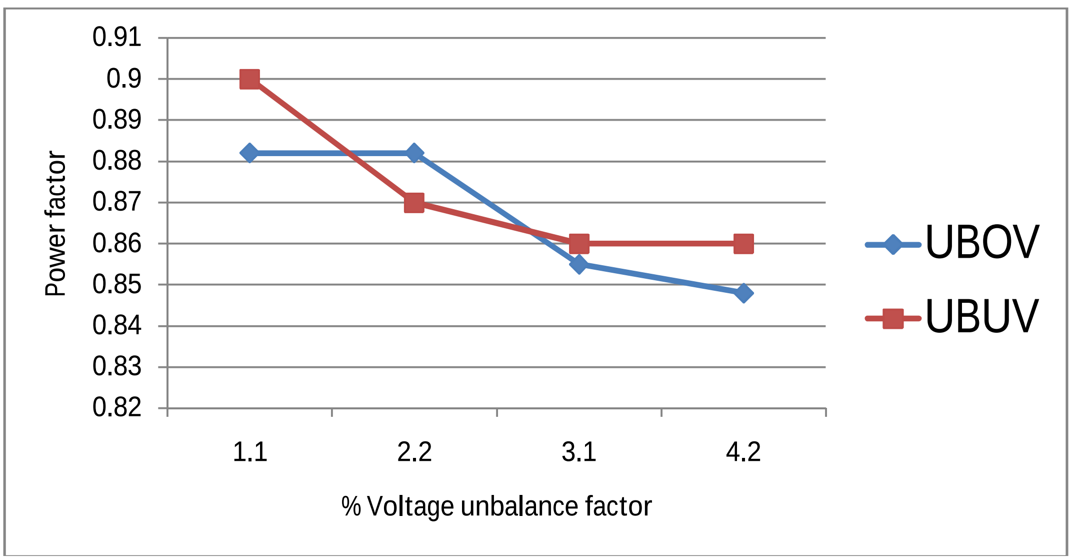

Figure 9. Change in power factor at set point 2

CONCLUSION

- The objective of this paper is to present the performance and power factor variations for a three-phase induction motor-pump system subjected to varying voltage and load conditions.
- The load variation is in the form of varying the flow rate of water by adjusting the delivery side throttle valve. The voltage variation is in the form of unbalanced, over-and under-voltages.
- The results presented for three different throttle set points. The voltage and load variations must be considered together.
- The extensive experimental study in the form of effects of voltage and load variations on motor-pump system is extremely necessary to identify ways for better operating performance.

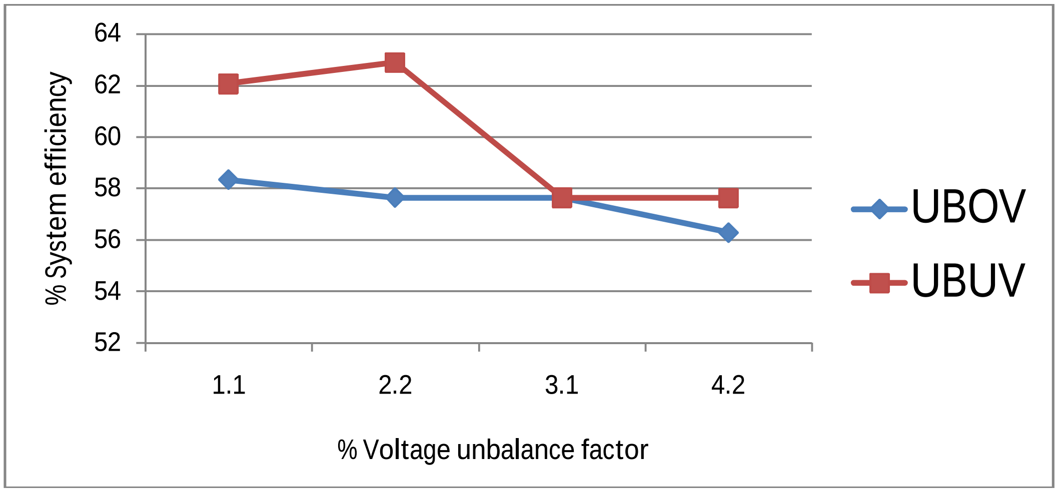

Figure 10. Change in system efficiency at set point 1

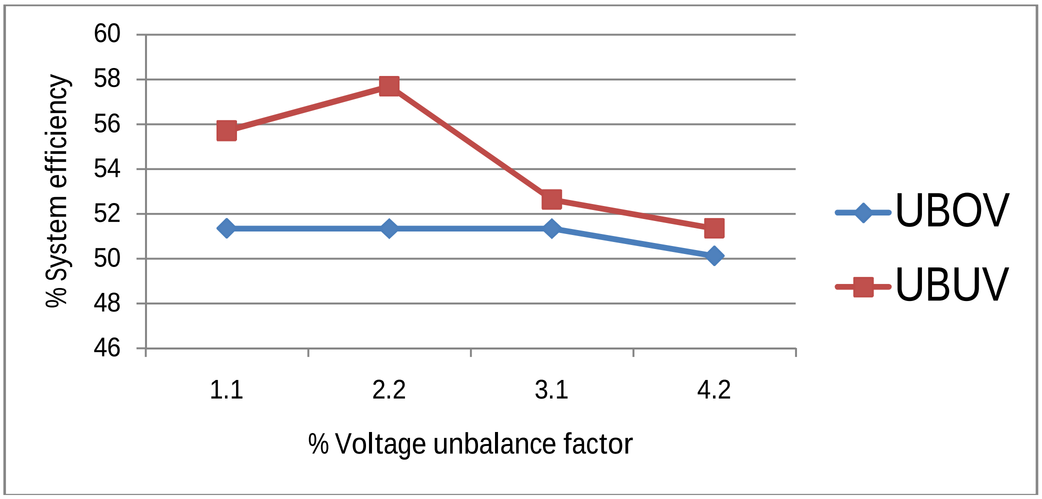

Figure 11. Change in system efficiency at set point 2

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