Voltage Drop Compensation in Long Tunnel Driller and On-Line Parameter Estimation

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ABSTRACT
In order to increase the efficiency of desired work inside the long tunnel drilling, rating of electrical drives at tunnel face has significantly increased. Due to the high rating concentration of electrical drives at tunnel face significant voltage must be required which is need of an hour to finish the work in given time interval and to avoid the various dangers. Therefore, planning of electrical power distribution is required and voltage drop across each electrical drives must be taken into account. While power planning drill machine, Armored Face Conveyors (AFC), Shearer, breaker, Stage loader, face lightning, etc. must be given due importance as starting power required to them is very high. Breakaway torque of the AFC is not maintained because of low power, so it is required to start constantly requiring high power as well as it will heat the environment, which is often hazardous. In order to provide the required power drop and reduce the dangers, some alternative methods must be used.

In the present investigation voltage drop compensation technique is developed by providing with optimization of position of transformer. Even though the voltage drop cannot be maintained in such cases boosting transformer with the power thyristor with tap changing is used to control the power instead of tap changer mechanism.

In order to operate the various drives in long drilling tunnel and finish the work in desired period one must know the various parameters involved in the system. On line parameter such as voltage, currents, temperature, etc. of electrical drives and environment are measured through PC using various sensors, the sensed data is compared with the standard data. The comparison will help to take necessary decision and helps to reduce the forth-coming dangers in the tunnel or electrical drives.

Keywords
Voltage Drop, Parameter estimation, Voltage compensation,.

1. INTRODUCTION
A careful planning of power is required in the tunnel drilling. The work efficiency of the tunnel depends on the efficient use of various electrical drives concentrated at tunnel face. Any failure or breakdown of electrically operated equipment will reduce the availability of the system and hence work inside would hamper and the task of the work is not done in the given time. Power planning is complex in tunnels, see shore drilling, underground mine due to the space and various other dangers. Quality voltage is the major requirement at the tunnel face because most of the power fed is consumed near the face by various electrical drives. So power at the face must be uninterrupted and adequate.

An electrical aspect of mining technology was suggested by G. Cooper [1] in 1983. However the performance parameter estimation was carried out by Reezek [2] but the starting problems and its compensators have suggested by Mishra [3] while the estimations of electrical drives and its performance was given by Kumbhar and et.al. [4]. Tieying and Wnag, worked on the 'Low voltage early warning system of colamine power grid' [5] to avoid further problems. The "Kawahara K and et.al. described the application of Static variable compensator (SVC) ac electric railway system [6]. The single phase SVC reduces the voltage drop in the feeding circuit and improves the power factor at the substations by compensating the reactive power. When the voltage drop takes place small power is added. The control problems in Armored Face conveyors for longwall mines was given by the Alan Broadfoot and Robert Betz [7]. They stated the outlines of the difficulties experienced in longwalll by AFC drives. They also highlighted on variation of motor parameters, transient torque, thermal effects, Voltage dip etc. The hazard Management on longwall has been presented by B. Lyne [8] in which he specified the various parameters that affecting the human and machine disturbances. Many researches worked on the improvement and predicting motor load, power requirements, control strategies [9-10] for the long wall drilling machines. The speed adjustment of drive is also important which decides the power consumption inside the tunnel drilling. This was proposed by B. K. Bose [11] while the selective selection of line harmonics are carried by Dube and et.al. [12]. The line shafting control with the brief theory and torque analysis control techniques were developed [13-14]. The measurement and control strategies are always improving their measurement and analysis techniques. Still the compensation of voltage at the face is one of the major issues.

Keeping all these views a scheme is developed to provide the quality voltage at the face as well as reduce the various dangers in tunnels. A voltage drop in long tunnel cannot be eliminated completely but using proper optimization of the size of cables, Quality voltage, transformer distance from electrical drives can be minimized. Voltage drop in the long tunnel drilling can cause starting problem in AFC / Shearer. These motors are designed for fixed number of starting per hour as the limit increases, insulation of motor may get damage in adverse condition due to surge current generated by repeated switching. Repeated switching also gives rise to increase in temperature inside the long tunnels and may lead to fire. Consequently the voltage drop across the long tunnel must be minimized. In order to operate the various drives in long tunnel various parameters involved in the system are measured. Various on line parameter such as voltage, currents, temperature, etc. of electrical drives are measured through PC and stored in the file for comparison. The error data will decide what necessary action is to be taken, which helps to reduce the forth-coming dangers in the long tunnels or electrical drives. The developed software will provide the measurement of various electrical drive parameters and helps to fast switching of the tapping boost transformer.

Fig. 1 shows the block diagram of the power management system of long tunnel face. In order to increase the work power required at the long tunnel must be provided with quality, otherwise there will be seriously capital loss. The system consists of hardware as well as software. The aim of present system is to provide the quality voltage to the various electrical drives. The required software is written in higher language 'C'.

2. SYSTEM BLOCK DIAGRAM

2.1 Transformer

Two Very high KVA rating transformers are required for this system. One of them is working transformer and other is of thyristor based tap changer transformer, which helps to boost the voltage at the long tunnel face on the 11000 V panel. Power drop is measured by the signal conditioning circuit, which consists of step down transformer to 5 V.

2.2 Voltage Sensing Circuit

In the present work voltage measurement is done by using peak detector. Fig. 2 gives the voltage sensing block diagram. With the help of isolation step down transformer high panel voltage is stepped down to low (0-5 v) and this variation is given to the peak detector circuit. The variation in the voltage of step-down transformer is proportion to the variation voltage drop and corresponding change in the peak detector is given to ADC card. The output voltage of the ADC varies with (0-5V) range and variation is converted into actual voltage in the range 0 - 5V through the software. If there is deviation then correction factor is applied through the software if the panel voltage drops below 10500 V then computer through switches of thyristor tapping adds the voltage to the panel. The tapping selected will depend on the drop in panel voltage if large drop, high voltage boosting transformer is connected to panel board, if low drop in line voltage then low voltage boosting transformer tapping is selected. The selection of tapping is done by the computer through software. If the voltage of panel increases beyond upper limit then the boosting transformer taping cuts from the main line.

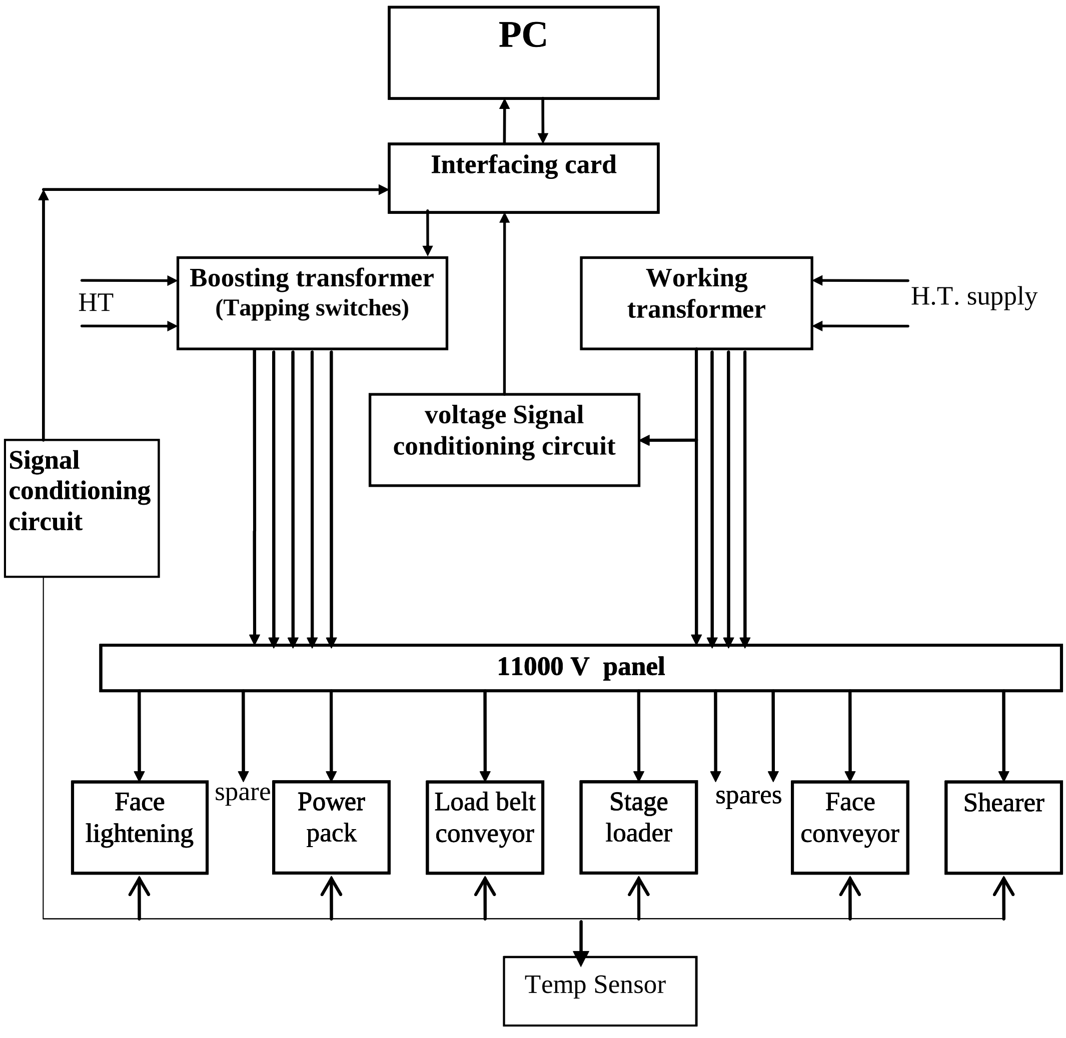

Fig.1 block diagram of the power management system of long tunnel face

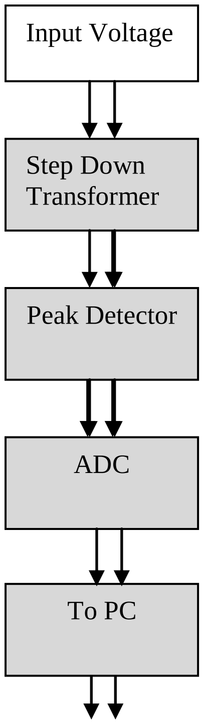

Fig. 2 Voltage sensing circuit

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2.3 Temperature Sensing Circuit

Temperature sensing circuit consists of temperature sensor whose output is proportional to the temperature inside the long tunnel in the form of voltage. The range of temperature sensor is from -55^{0}C to 150^{0}C. The output signal generated by the temperature sensor is very weak which is amplified through a signal conditioning card and generated signal is in the range of 0-5V & proportional voltage will be displayed after applying correction factor for variation of 0 - 5 V.

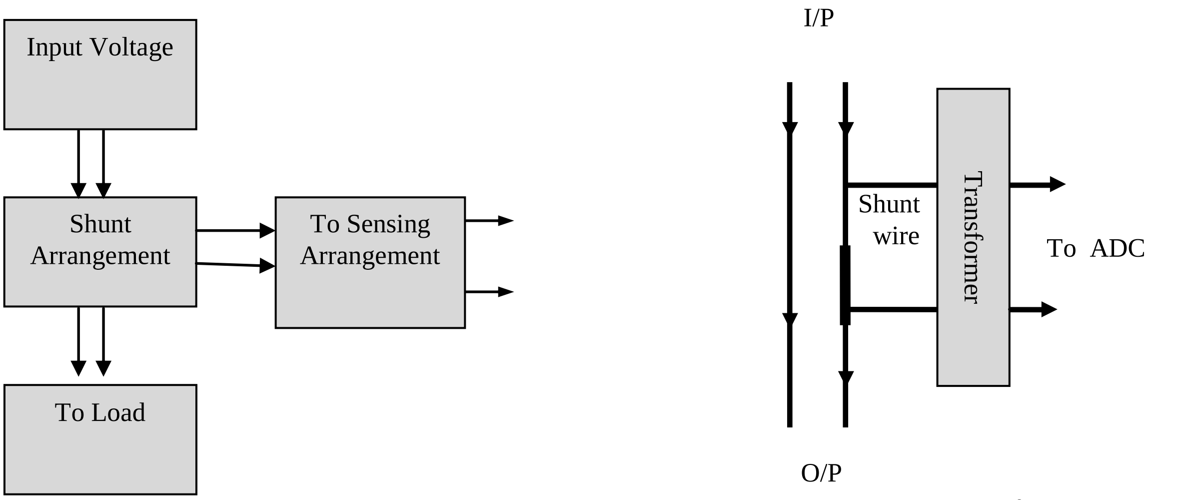
Fig. 3 Block Diagram of the temperature sensor

2.4 Current Sensing Circuit

For current measurement a simple technique is used which is shown in the Fig 4. It consists of step-down transformer. The primary L.T. of the transformer is short circuited by the shunt wire having 1 ohm resistance and the voltage across the shunt measured. The voltage drop across the shunt wire is proportional to the current passing through it, which is proportional to change in the secondary voltage. The proportional transformer change produced across the shunt wire is sensed in the form of voltage. This variation is in the range 0-5V and converted into actual current by applying the multiplication factor using the software program to get the current in the range 0 - 750 Ampere. This is the simple arrangement and least cost technique used in the present system.

2.5 Selection of Face Cables

At the long tunnel face cable size includes High tension, Low tension and various connecting loads. For H.T. cross section of the cable must be taken into account. Always minimum size of the cables with the appropriate standards are selected.



Experimental Arrangement of current sensing

Fig. 4: Current Sensing Experimental Arrangement

3. CORRECTION CURRENT SENSING PARAMETERS

The Fig. 5a shows the graph of measured current versus the sensed current in amperes. From the figure it is seen that the sensed current is less than the actual current measured by the system this is due to the non-linearity in the system measurement. The initial interval shows the nonlinear graph. The correction is necessary. The correction factor is employed using software and the corrected current graph is shown in Fig. 5b. After correction the input current and sensed current are linear in nature.

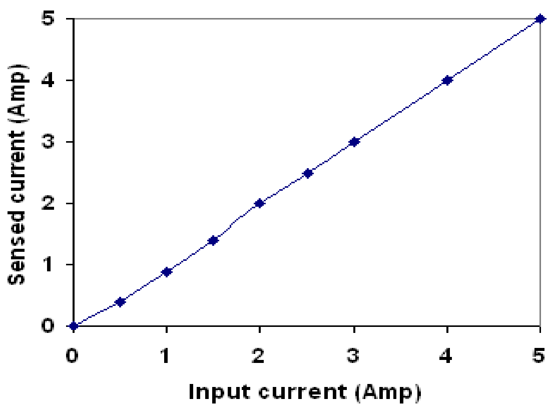


Fig. 5a: Input Current Versus Sensed Current

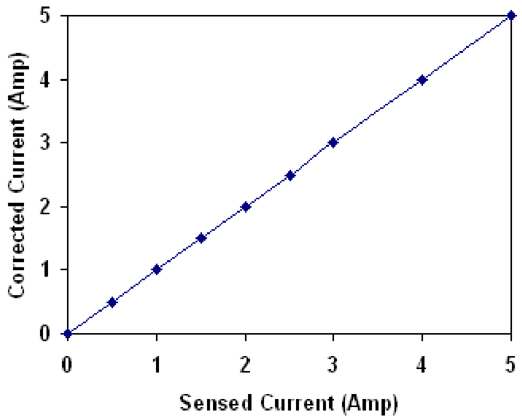


Fig. 5b: Measured Current Versus Sensed Current

The Fig. 6a shows the graph of input voltage versus sensed voltage. For Ac voltage measurement the peak detector circuit is used. The input voltage is reduced proportionally from 12000V to 250 Volt using the step-down transformer. From the figure it is seen that the initial sensed voltage is nonlinear in nature. The initial input and sensed voltage do not follow the linearity so the correction factor is applied using the software to get the actual corrected voltage and scaled proportionally in the range 0-250V and then it is scaled to actual voltage of the system. This is the simple method for the measurement of the voltage of the system.

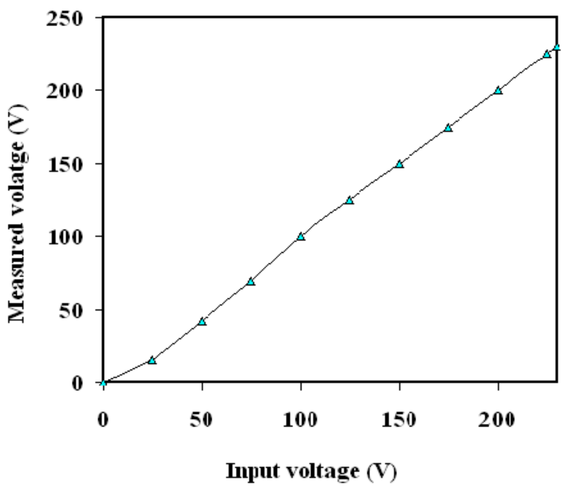


Fig. 6a: Input Voltage versus Sensed Voltage

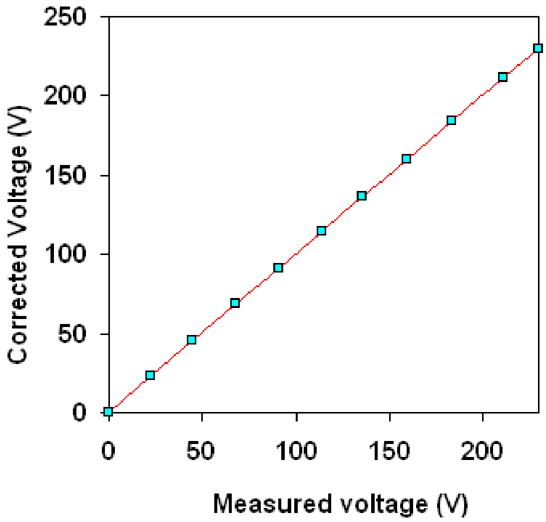


Fig. 6b: Measured Voltage versus Corrected Voltage

4. VOLTAGE DROP COMPENSATION

The devices like Drill machine, AFC, shearers, etc. requires very high starting current (6-8 times full load current) in turn there is significantly voltage drop at the face of long tunnel. To maintain the quality voltage at the tunnel face working transformer is fixed at optimized position. In order to meet the line drop compensation boosting transformer is used which uses the thyristors for fast switching the ON to the load and OFF the load. This change was made due to tap changers which requires very high time as induction motor requires 6 to 8 time the full load current with approximately 2-3 ms. So these electromechanical switches are inadequate and replaced by thyristors which can switch from top to bottom of limit within few μsec. Fig. 7 shows the Voltage drop at the face. This is corrected by using the boosting transformer. The voltage inside the tunnel at the driller position is always maintained nearly constant. The drop in the voltage due to the starting of the driller or cabling or distance in the tunnel is long. This drop is immediately sensed and the thyristorised tapping adds the voltage to boot it or when it is more the tap changer helps to provide the quality voltage at the coal mine.

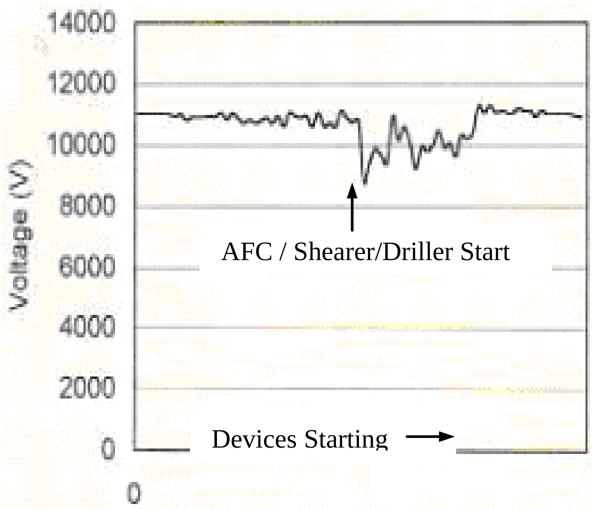


Fig. 7 Graph of Voltage drop with device starting

This keeps the voltage constant during the processing of drilling the tunnel. This avoids the heating and damaging the cable and avoids the dangers in the long tunnel drilling.

The Fig. 8 shows the graph of line voltage after voltage compensation technique. It is observed that almost constant voltage is provided to the machinery used in the tunnel. The quality voltage supply will help to enhance the life of the drive and avoid the various dangers inside the tunnel during drilling.

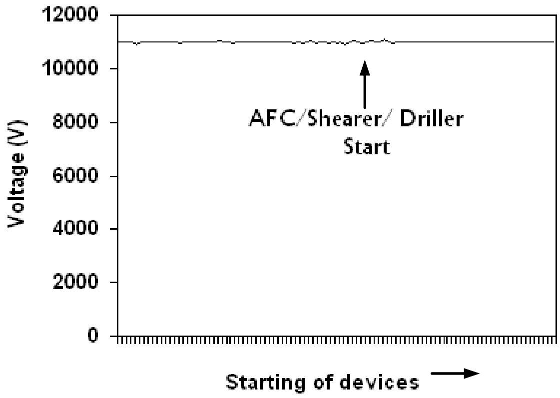


Fig. 8 Graph of voltage after compensation of starting of various devices

5. CONCLUSION

In order to compensate the line drop compensation the optimization of cable size and distance from the coal face must be optimized and starting problem of drill machine, AFC/Shearers must be compensated by providing the boosting transformer with auto thyristor switches instead of mechanical tap changers as the time requires changing the tap changer is very high. This In order to overcome the forthcoming danger, various parameters like current, voltage of the shearer Face conveyors, stage loaded, load conveyor, power pack, face lightening, etc. are measured and compared to the standard data stored in the file which helps to eliminate the early fault or danger. The temperature measurement will help to avoid the danger of fire in the tunnel or mines. The reduced size of the cable will reduce the cost. The quality voltage at the face of the mines will increase the life of the devices used in the drilling purpose. The drop of voltage at the time of the AFC or shearers is compensated and it advised that all the devices should not start at the same time. There is also need to monitor the various parameters of the machines remotely that will reduce the cabling inside the tunnel and hence the complexity, damage of cable and shock hazards will be prevented. The proper management of voltage at the face and inside the tunnel will also reduce the uneven heating and damage of the cables and devices. Further the cable quality and size, for transmission of quality voltage is necessary to modify as per the requirement.

6. FUTURE SCOPE

1. Distance of the transformer feed is also necessary to manage to provide the quality voltage.
2. Need to monitor the various parameters through remote controller helping to reduce the wiring inside the tunnel.
3. Need to develop smaller size cables with less voltage drop with distance.
4. Need to develop the system that will manage the starting of the various devices to compensate the voltage.
5. Auto compensators are necessary to develop the voltage compensation management.

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