DEVELOPMENT OF COMPUTER BASED EQUIPMENT PERFORMANCE MONITORING SYSTEM IN OPENCAST MINES

A THESIS SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF

Bachelor of Technology

In

MINING ENGINEERING

By

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&

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CERTIFICATE

This is to certify that the thesis entitled, "Development of Computer Based Equipment Performance Monitoring Systems in Open Cast Mines" submitted by **Sri Sidharth Das** & **Sri Suman Chakraborty** in partial fulfillment of the requirements for the award of Bachelor of Technology Degree in Mining Engineering at the National Institute of Technology, Rourkela (Deemed University) is an authentic work carried out by him under my supervision and guidance.

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other University / Institute for the award of any Degree or Diploma.

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It is our pleasure to refer Microsoft word 2003 of which the compilation of this report would have been impossible.

An assemblage of this nature could never have been attempted without reference to and inspiration from the works of others whose details are mentioned in reference section. We acknowledge my indebtedness to all of them.

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ABSTRACT

Truck haulage is the most common means used for moving ore/waste in open-pit mining operations, but it is usually the most expensive unit operation in a truck shovel mining system. The state-of-the-art in computing technology has advanced to a point where there are several truck dispatching systems which offer the potential of improving truck-shovel productivity and subsequent savings. Introducing a dispatching system in a mine can achieve operational gains by reducing waiting times and obtain other benefits through better monitoring, optimal routing and grade control. Efficiency of the employed truck-shovel fleet depends on the dispatching strategy in use, the complexity of the truck-shovel system and a variety of other variables. It is a common situation in mining that considerable analysis of the available strategies is undertaken before dispatching is adopted. In most cases, computer simulation is the most applicable and effective method of comparing the alternative dispatching strategies.

To develop a computer based equipment performance monitoring systems in open cast mines. We have made a choice to make it on the shovel dumper combination using GPS.

The computer monitors the location and status (full or empty, heading, and velocity) of each vehicle in the fleet. The system analyzes production statistics, such as haul routes, historic data about drive time to a specific shovel location, and cycle time how long it takes to make a round trip from the shovel to the dump site and back.

The system then correlates these data to most efficiently route all the vehicles. The computer based equipment performance monitoring of equipments of open cast coal mine on an offline monitoring basis. This system starts from the counting of the number of trips dumpers. It has very good features such as it is easy to learn, very good user interface capability. The success of the system is totally dependent on the availability and incorporation of the data into the system .If the data will no be available then the system cannot provide good result. The data which has been incorporated into the system also should be correct, other wise it will provide wrong information to the management. There is a huge scope for further development of this kind of system such as incorporation of other equipment such as dragline, dozer, etc. It can also be used for equipment maintenance system and also for inventory control.

The program written in C compiler has been written on the basis of GPS data of the time, loading, unloading points in the mine. It gives us the availability, utilization, idle time and breakdown time for the shovel dumper system. The data taken is on the basis of the data selected for a whole shift.

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INTRODUCTION

1.1 OVERVIEW

Truck haulage is the most common means used for moving ore/waste in open-pit mining operations, but it is usually the most expensive unit operation in a truck shovel mining system. The state-of-the-art in computing technology has advanced to a point where there are several truck dispatching systems which offer the potential of improving truck-shovel productivity and subsequent savings. Introducing a dispatching system in a mine can achieve operational gains by reducing waiting times and obtain other benefits through better monitoring, optimal routing and grade control. Efficiency of the employed truck-shovel fleet depends on the dispatching strategy in use, the complexity of the truck-shovel system and a variety of other variables. It is a common situation in mining that considerable analysis of the available strategies is undertaken before dispatching is adopted. In most cases, computer simulation is the most applicable and effective method of comparing the alternative dispatching strategies.

When designing dispatching systems, it is natural to attempt to design the best possible system relative to some performance criteria, but subject to mining and resources constraints. If the number of alternative system designs is not too large, the standard approaches for solving optimization problems are used: ranking and selection, and multiple comparisons with the best. Ranking and selection procedures yield one decision, i.e., which system design has maximum expected performance, while multiple comparisons with the best provide estimates, i.e., the difference between the expected performance of each system design and the best of the other system designs. However, this theory is not extensively used in practice.

A mine's computer system stores huge volumes of information used by mining equipment in the field. By building systems right into mining equipment, vast amounts of data can be collected and processed in real time to control drills, shovels, dumpers and other equipment in response to that data.

1.2 OBJECTIVES:

To develop a computer based equipment performance monitoring systems in open cast mines. We have made a choice to make it on the shovel dumper combination using GPS. The computer monitors the location and status (full or empty, heading, and velocity) of each vehicle in the fleet. The system analyzes production statistics, such as haul routes, historic data about drive time to a specific shovel location, and cycle time how long it takes to make a round trip from the shovel to the dump site and back. The system then correlates these data to most efficiently route all the vehicles.

By having real-time access to each vehicle’s position, the dispatch system can determine if several trucks are waiting at one shovel and, if so, route them to a different shovel. This helps prevent bottlenecks and keeps operations moving freely. The dispatch computer can also determine the most efficient location for the truck to dump its load at any given time.

Historically, open-pit mining operations were run with each truck assigned to a given shovel. With modern computer monitoring and control, the usual strategy is to dispatch the trucks to whichever shovel will contribute the most to the short-term production objectives. Marty dispatching methods can be used, both heuristic and pseudo-optimal.

For shovel dumper combination system the main objectives are to increase the productivity and to reduce the time of operation. These are done by:

Minimizing shovel wait time (MSWT): The empty truck in this criterion is assigned to the shovel which has been waiting for a truck the longest time, or is expected to be idle next.

Minimizing truck cycle time (MTCT): The goal of this strategy is to assign an available empty truck to the shovel which will provide the minimum value for completion of the expected truck cycle time to maximize either total tons or ton-miles per unit of time.

Minimizing truck waiting time (MTWT): The objective of this criterion is to assign an empty truck to the shovel where the truck loading operation will be initiated first.

Minimizing shovel saturation (MSS): The goal of this rule is to assign the trucks to the shovel at equal time intervals to keep a shovel operating without waiting for trucks. The truck is assigned to the shovel which has the lowest ratio of the current coverage against desired coverage.

Chapter 2

Indian surface mining status

Mines where computer based equipment performance monitoring system is used outside India

Mines where computer based equipment performance monitoring system is used inside India

2.1 INDIAN SURFACE MINING STATUS:

Predominance of surface mining in the Indian coal industry with a share of over 80% and 54% respectively of total production in Coal India Limited and SCCL, calls for insightful analysis of the means and methods for upgrading the production and performance of surface mining systems in the 21st century. Even if there are surface mining systems of variegated sizes and sophistication, there is no doubt whatsoever that surface mining systems from small scale to medium scale and mega-sized mines, would call for significant inputs of new technology to be cost effective, environmentally friendly and meet the production requirements. In striving for new levels of performance in the competitive environment of the 21st century, technology will be the principal lever for change, where information technology (IT) will play a key role.

Benchmarking of surface mining operations world-wide reveal a yawning gap between the performance capability of the best of the mines and the worst of the mines and there exists an imperative need to bridge this gap. Since, the scale of operations in opencast coal mines in India has grown by leaps and bounds; the conventional methods of surveying, planning and operating the mines would have to be upgraded to meet the requirements. A whole host of leading edge technology products and systems for effective management of surface mines have evolved in the past decade.

2.2 MINES WHERE COMPUTER EQUIPMENT PERFORMANCE MONITRING IS BEING USED OUTSIDE INDIA

Some of the prominent mines where the system is being used:-

1. The Century Zinc Mine, operated by Zinifex in northern Queensland has been using high precision GPS supplied by APS on two excavators for three years. The ore zone is hosted in grey shale. Identification of ore and waste is difficult. Century also operates GPS systems on their Bucyrus 495B shovels used for overburden stripping.

2. The Collinsville Coal Mine, owned by Xstrata Coal and operated by Thies Contractors is a mixed coking and thermal surface coal mine in northern Queensland. Overburden stripping is accomplished by a dragline, dedicated stripping dozers and excavator and

truck fleets. The mine has two Liebherr 994 excavators and two Liebherr 995s equipped with high precision guidance from GPS.

3. The ore body at asarco's mission mine at Arizona, the mine uses a high-speed computer system to track each truck and shovel and calculate when a shovel will need a truck to load and which truck will be nearby. This reduces the waiting time for both the shovel and truck. The dispatch system also monitors the trucks' vital signs like oil pressure and temperature, to help prevent breakdowns.

4. U.S. Borax's mine in California's Mojave Desert is the source of nearly half the world's supply of refined borates. Developed a high-precision global positioning system (GPS) for machine guidance. This helps shovel operators navigate safely in potentially hazardous areas. In addition to protecting people and equipment, the GPS system has also improved the mine's productivity.

5. In the case of the Chuquicamata mine in Russia, about 130 haul trucks are employed along with the GPS truck dispatch system to increase the productivity.

2.3 MINES WHERE COMPUTER EQUIPMENT PERFORMANCE MONITRING IS BEING USED INSIDE INDIA

1. The Northern Coalfields Ltd (NCL), Jayant open cast mine management has recorded an overall increase of seven per cent in the productivity of capital-intensive mining equipment like excavators and trucks with the use of dynamine.

2. Tata Steels application of a Truck Dispatch System at the Opencast Coal Mines located in West Bokaro (in Hazaribagh District of Jhakhand State of India)

3. Truck dispatch sytems at Nalco,Damonjodi using the sytems of GPS by an Australian company.

Chapter 3

Introduction to global positioning system

INTRODUCTION TO GLOBAL POSTIONING SYTEMS

It has been more than 25 years since the introduction of the Global Positioning System (GPS). Uses and applications have grown rapidly and the technology is now well established and reliable. Almost all mines now use GPS for surveying. A single surveyor can now accomplish in a few hours what once took a team of people days of tedious field and office work. GPS has also been employed directly on mining machinery. GPS guidance systems allow the operator to complete complex earthmoving designs without the need for field staking. More advanced systems allow for accurate real time productivity monitoring and the automatic generation of “as-builts” in the form of Digital Terrain Maps (DTMs). Before we get onto the core issue , let us try to recap as to when and where GPS started. The first one called NAVSTAR GPS (Navigation Satellite Timing and Ranging Global Positioning System) was (and still is) a satellite-based radio navigation and surveying system providing precise three dimensional position, navigation and time information to suitably equipped users everywhere on a continuous basis.

Opencast coal-mines operate with periodic blasting and then excavations which in turn is followed by removal of Over Burden (OB) and retrieval of the coal. In the process of coal mining, two main sub processes viz. removal of OB and retrieval of coal are predominant. But most of the effort goes in the removal of OB and this has a dominant influence on the productivity. In the process of OB removal, two of the equipment viz. Rear Dumper and Excavator play a leading role. After the schedule of blasting in an specific zone of the mine has been prepared, the Excavator loads the OB into RD and each RD goes practically through four different machine states i.e. Waiting (near Loading zone), Loading, Full and Empty (at Dumping zone). This sequence of machine states of a RD constitutes one trip. Now it may be understood that to monitor the productivity automatically, one has to monitor the movement of RDs around the corresponding Excavator i.e. Loading zone to Dumping zone and back to Loading zone. Using the facility of GPS Receivers, it is possible to find out the absolute co-ordinates of any mobile equipment. In addition the system incorporates load sensors, limit switches, RF Telemetry etc.

The system consists of 24 satellites including three active spares, placed in near circular orbits in six orbital planes of 55 o inclination at height of about 20,200 km. There are often more than 24 operational satellites as new ones are launched to replace older satellites. The orbit altitude is such that the satellites repeat the same track and configuration over any point approximately every 24 hours. The satellites have 12-hour periods so that atleast 4 satellites are available for observations for positioning on ground, sea and air at any time throughout the year anywhere in the world. GPS provides specially coded satellite signals that can be processed in a GPS receiver, enabling the receiver to compute position, velocity and time. Signals from four satellites are required to compute the four dimensions of X, Y, Z (position) and Time at any point on Earth.

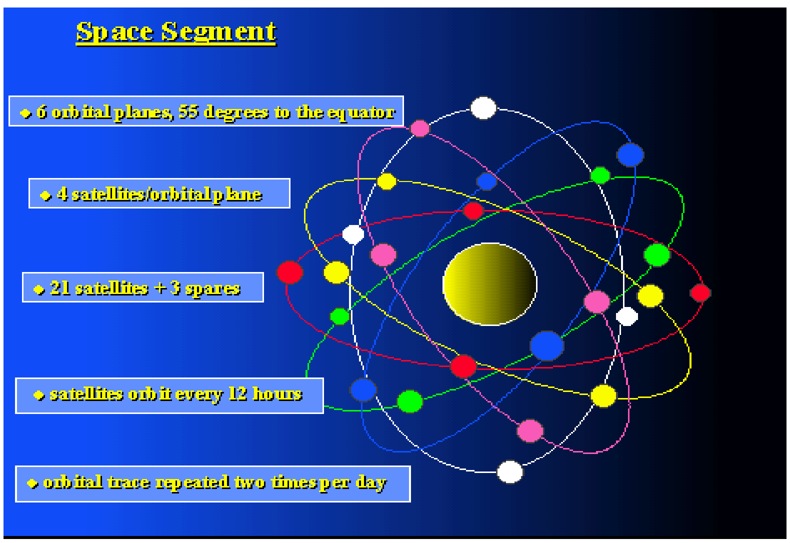


FIG: 3.1: GPS 24 SATELLITES CIRCLING THE EARTH

The GPS system can tell the location anywhere on or above the Earth to within about 300 feet. Even greater accuracy, usually within less than three feet, can be obtained with corrections calculated by a GPS receiver at a known fixed location. The principle behind GPS is the measurement of distance (or "range") between the receiver and the satellites. The satellites also tell exactly where they are in their orbits above the Earth. It works something like this: If we know our exact distance from a satellite in space, we know we are somewhere on the surface of an imaginary sphere with radius equal to the distance to the satellite radius. If we know our exact distance from two satellites, we know that we are located somewhere on the line where the two spheres intersect. And, if we take a third measurement, there are only two possible points where we could be located. One of these is usually impossible, and the GPS receivers have mathematical methods of eliminating the impossible location. For the system to work, the receiver has to know exactly where the satellites are and the satellites have to be able to keep reliabletime.

ANTENNA PLACEMENT

GPS instruments determine the latitude, longitude and elevation of the GPS antenna. Ideally to determine the position of the bucket, the antenna would be placed right on it. However the antenna would not survive in this location, and moreover would be frequently shielded from the sky and thus not receiving satellite signals.

On top of the machinery house is a better solution. The GPS determines the position of the antenna, but a functional system requires the system to determine the orientation of the machine. Since shovels and excavators typically stay in one position for some time and rotate in order to move material from the bank to trucks, it is possible to use one antenna offset from the centre of rotation. As the machine rotates the successive positions from the antenna can be used to calculate the position of the centre of rotation. Once knowing the rotation, the orientation of the machine can be calculated as the GPS antenna moves. However this scheme has the disadvantage that the machine must be rotated through at least 120 degrees every time the machine changes position. Using two GPS antennas and two receivers is more expensive, but gives a faster more accurate result. The preferred locations are the back corners of the centre of rotation, machinery house.

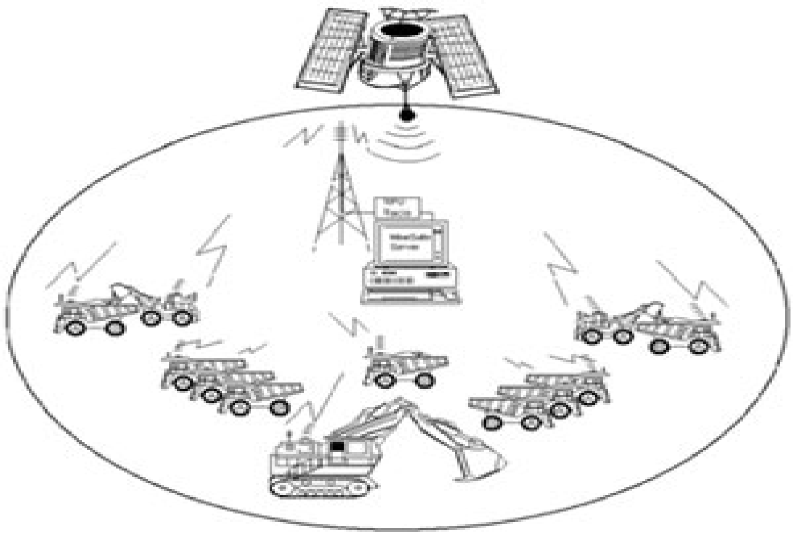


FIG:3.2: Showing the GPS action

ROTATION PLANE

Knowing the orientation and position of the machinery house enables the position of the boom to be calculated. However the result will be in error if the machine is not rotating in a plane parallel to the earth's geoid. It is necessary to measure the pitch and roll of the machine to correct the result for rotation in an angled plane.

BOOM COMPONENTS

Knowing the position of the machinery house does not get us the position of the bucket. To do that, we need to know the movements of the ropes or beams connecting the bucket to the machinery house. This can be accomplished with a variety of instruments-:

1. Tilt sensors
2. Rotation encoders on rope drums
3. Wire reel sensors on hydraulic cylinders
4. Measurement of fluid flow through hydraulic cylinders

Tilt sensors and encoders have proven to be the most reliable and robust solutions.

TILT SENSORS

Many commercially available sensors work with fluid vials. These have variable sensitivities and limited ranges, and many reports in only one axis. However so called nano technology has opened up the possibility of tilt sensors based on other physical effects, such as the movement of minute gas bubbles. A tilt sensor developed for the task of tracking mining equipment must demonstrate a number of capabilities:

1. Rapid response – reporting at a rate of at least 10 times per second.
2. Accuracy – performance to within 0.1 degrees is essential in order to achieve centimetre level precision on mining scale equipment.
3. Resistance to vibration – the sensor must be capable of filtering out vibration effects.
4. Resistance to overshoot – fluid sensors tend to "slosh".
5. With large Resistance to shock loading – the unit must be capable of withstanding the high g forces associated rocks landing on the boom.
6. Low maintenance requirements.

7. Easy calibration when installed in different orientations
8. Long life – at least 3 years is desirable.

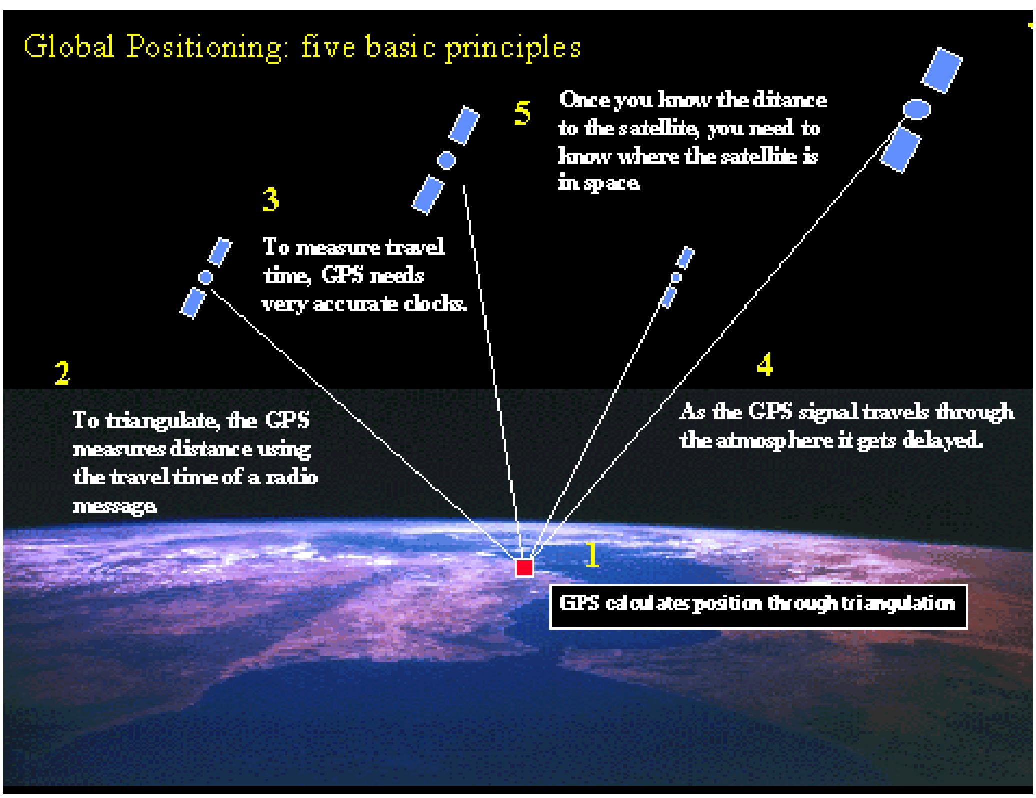


FIG: 3.3: Showing triangulation by GPS

INITIALIZATION

High precision GPS requires the GPS receivers to measure phase differences on both code signals (L1 and L2) from each satellite and the carrier wave itself. Because the wavelength of the carrier wave signal is shorter than the resolution of the code phase, the GPS receiver must resolve the ambiguity in whole wavelengths. This requires at least five satellites and may take some time. For the user this means that after turning on the equipment there will be a delay before the equipment can define a precise position (reaches "lock"). If the delay is lengthy this can be a source of irritation. Some manufacturers' algorithms are more efficient than others and hence require less time to achieve "lock". The more satellites that are available, the shorter the time necessary to achieve "lock".

COMPUTERS

Computers used on board mining equipment must contend with difficult environmental conditions. When the machines are unattended in the field the temperatures can range from the very cold to the very hot. When the machine is in operation, it is subjected to vibration and sometimes to relatively high dust levels. To be useful to the operator it must be easy to use and be visible under varying ambient light conditions. Rotating hard disks have a short life in this application and must be replaced by solid state memory. At least 2 GB of non volatile memory is necessary to hold the operating system, system software and complex designs. The computer should have a touch screen for easy operation. It must be fast enough to compute bucket positions and update screen backgrounds in a production situation.

Fig: 3.4: COMPUTER SCREEN SHOWING THE MOVEMENT OF MACHINES

TELEMETRY

. Radio telemetry systems are needed to transmit GPS correction signals, to download designs to the machines and to upload as built DTMs when the job is finished. Many GPS survey units use VHF signals for GPS corrections. These radios are good for coverage but have inadequate bandwidth to transmit complex designs. UHF radios operating at 400 to 900 MHz provide enough bandwidth to transmit designs. Wireless LAN radios operating at 2.4 GHz allow machines to be connected into the mine's intranet system, or even into the internet for remote connection. Wireless LAN systems have great bandwidth but are limited to line of sight communication and distances up to 2 kilometres. Some of the limitations of wireless LAN can be overcome by meshed systems in which each machine is a repeater. Alternatively a dual system can be installed with UHF or VHF for the mission critical GPS correction factors and other data cached until the LAN connection is established.

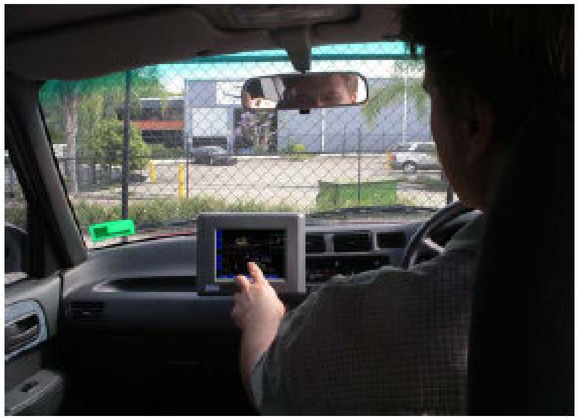


FIG:3.5: Foreman's vehicle system equipped with wireless LAN to duplicate Shovel operators view.

When machines are connected to the intranet, downloading designs is a simple drag and drop process. Intranet connection also allows supervisors and engineers to log in and see exactly the screen that the operator is seeing, and thus answer any questions or concerns. Intranet connections for this purpose can be installed on supervisors' vehicles. Internet connections allow remote trouble shooting.

3.1 GPS Applications in Mining Industry

GPS entered the Mining Industry as a fast and cost-effective instrument for survey. A shifting landscape is the very nature of mining operations; as shovels and dozers remove coal and ore, they reshape the mine's surface. Real-time GPS allows mining operations to keep on top of these constant changes and provide updated operating instructions to heavy equipment operators. In addition, GPS systems provide a fast and accurate solution for replacing and maintaining control points and calculating the volume of material moved.

Moving mining assets, including dozers, shovels, graders and draglines, are managed and guided using advanced GPS technology. Advanced GPS systems also track and monitor the status and location of dump trucks, providing reports to their heading and velocity as well as the size of the truck's load. Live GPS is becoming commonplace for monitoring and dispatching haul trucks or drills and for providing grade control on shovels. These data can also be tied to a GIS to monitor the location of all equipment, in real-time.

GPS being an all-weather real time, continuously available, economic and very precise positioning technique, would have wide range of applications in Indian mining industry. The potential areas for usage of GPS in Indian coal industry includes –

3.1.1 Surveying

Several modern surveying techniques like Satellite Remote Sensing, Photogrammetric, Field surveying procedures using digital theodolites, short and long range EDM instruments like Total Station etc., are available today. However, the advantages of using the satellite based GPS techniques for surveying are:

- GPS measurements do not require inter-visibility between points whereas the conventional surveying tools require line of sight for measurements.
- GPS technique provides a three dimensional position for the point. That is in one go, we get the horizontal and vertical position of the point, unlike in conventional surveying where we need two operations viz., horizontal traverse for planimetric control and a level loop for height control.
- A very high accuracy measurement can be made in a relatively short time for baseline lengths of a few hundred meters to few hundred kilometers and can provide the same accuracy anywhere on earth, in almost any weather condition and at any time of the day.

GPS offers many advantages compared with conventional survey methods. Because there is no need for a rod person, each surveyor can work alone when necessary. GPS also requires much less setup time than did traditional surveying equipment, so the crew can use its time more efficiently. It can also keep a much more flexible schedule and move from one area to the next or one pit to another as needed.

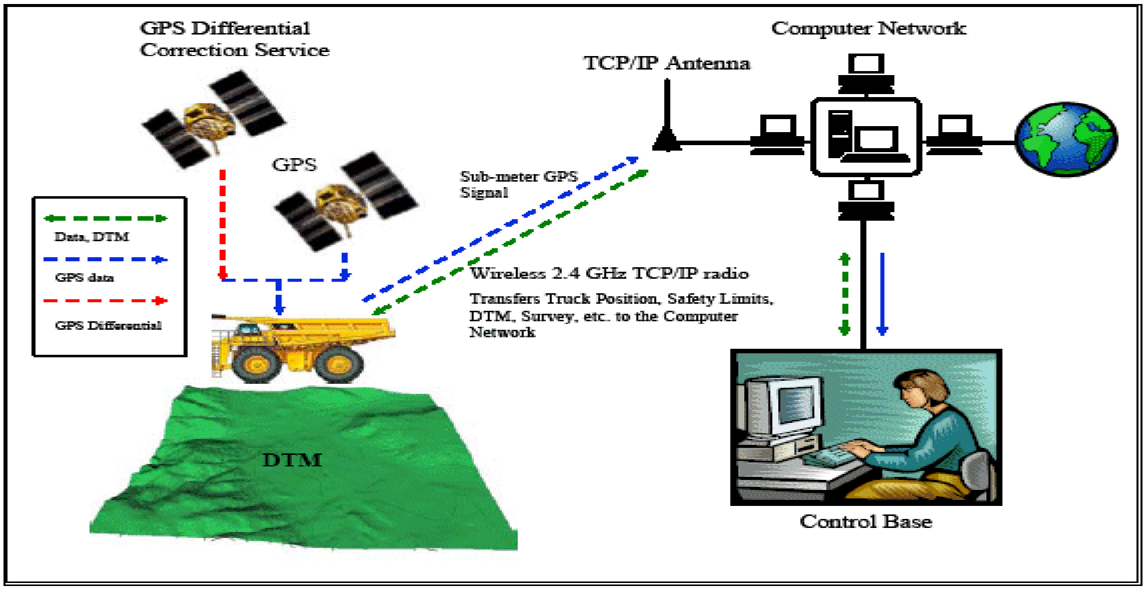
Chapter 4

CASE STUDIES

4.1 Truck disptach system at West Bokaro collieries

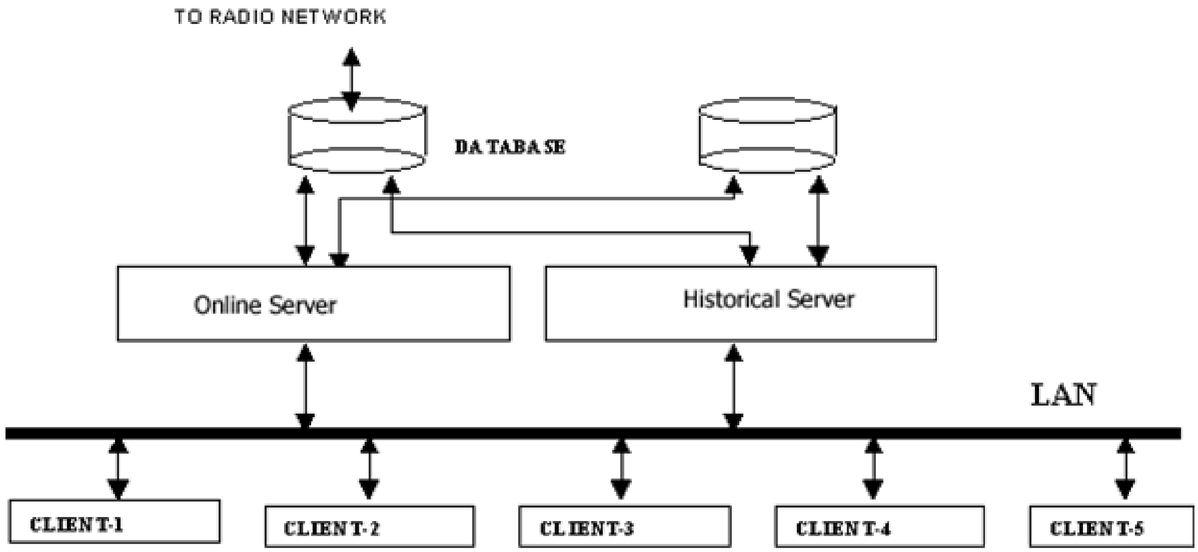
The HEMM capital equipment are mobile, and operate over a large area. They comprise a fleet of Dumpers and Excavators. It is essential to coordinate the activities from a central location. An efficient and reliable on-line Tracking and Production Monitoring system is essential for efficient operation. This describes Tata Steels application of a Truck Dispatch System at the Opencast Coal Mines located in West Bokaro (in Hazaribagh District of Jhakhand State of India). Truck Dispatch System is based on the GPS technology. Being an opencast mine, GPS was the ideal solution to track location of each Dumper & Excavator inside the pit. Real time location (latitude / longitude) of each mobile equipment is transmitted periodically over UHF Telemetry Data Link from mobile equipment to the On-line Server situated at the Quarry Control Room. Since there are two different quarries, this means in effect that there are two different mines, which are geographically separated viz. Quarry AB & Quarry E. For all practical purposes, operation of both these quarries are independent of each other, therefore there are independent Radio Network, Quarry Control Rooms, Server / Applications / Database and Reporting but it is planned to integrate both these TDS Systems with the help of Wireless LAN to achieve composite reporting and the proposed system is capable of easy integration and future expandability. Besides this, the implementation of the TDS has improved operations so that, the HEMM Operator are capable of having better interaction with real time mining process and provide more value added information which in turn assists better production monitoring system.

Fig:4.1



Schematic representation of the configuration used to monitor a remote truck from the central office.

Tata Steel's West Bokaro colliery is at present divided into 2 (two) Quarries viz. Quarry AB and Quarry E . Operation and Maintenance of both these Quarries are independent of each other. There is a total fleet of 70 Nos. of Mobile Equipment, out of which 14 are Excavators and balance are the Rear Dumpers. The whole fleet is almost equally divided into two; one for Quarry AB and other for Quarry E. Since the functionality of both these quarries are independent, separate Central Control Rooms have been set-up for each quarry viz: TDS Control Room for Quarry AB and TDS Control Room for Quarry E. Each Mobile Equipment has got its specific ID burnt in the firmware of its TDS Hardware installed on-board and this TDS on-board hardware comprises of an Intelligent RPU, GPS Receiver, Telemetry equipment and Graphical Touch Screen (GTS) on-board is used as the Operator's interface, keying in delays / logins and viewing their assignments & productivity.



TDS Control System Architecture

FIG:4.2

4.1.1 Radio Network

For the data transfer between the mobile equipment and the base server a radio network is installed. Prior to the radio-network design, a thorough radio survey was done to achieve a good understanding of potential bad coverage areas. There were several areas like at the wall of the cut or behind spoil piles and reject dumps. As landscape within a mine is dynamic and therefore it is planned that the radio coverage will be checked regularly. The performance of the system depends heavily on the successful data transmission from both sides i.e. data from the mobile equipment to the base station and from the base station to the mobile equipment. A poor radio coverage can lead to loss of data, which cannot be compromised.

Within the West Bokaro Mine two completely separate Radio networks have been installed one for quarry AB and one for Quarry E. To decide the height of antenna and place of antenna a radio survey was performed for both Quarries AB and E. After the survey it was decided that the base antenna for quarry AB will be mounted on top of the tower next to the control room and the base antenna for the quarry E will be mounted on top of the tower outside the control room.

The following diagram shows the radio network design and indicates the GPS system. The GPS system is described in detail in an earlier section. This is the link for determining the equipment position and sending this information to the base. The on-board processor communicates with the GPS receiver and sends the equipment position via the radio network to the base. In the case of an excavator, this information is also required by the trucks, and the information is directly routed to them.

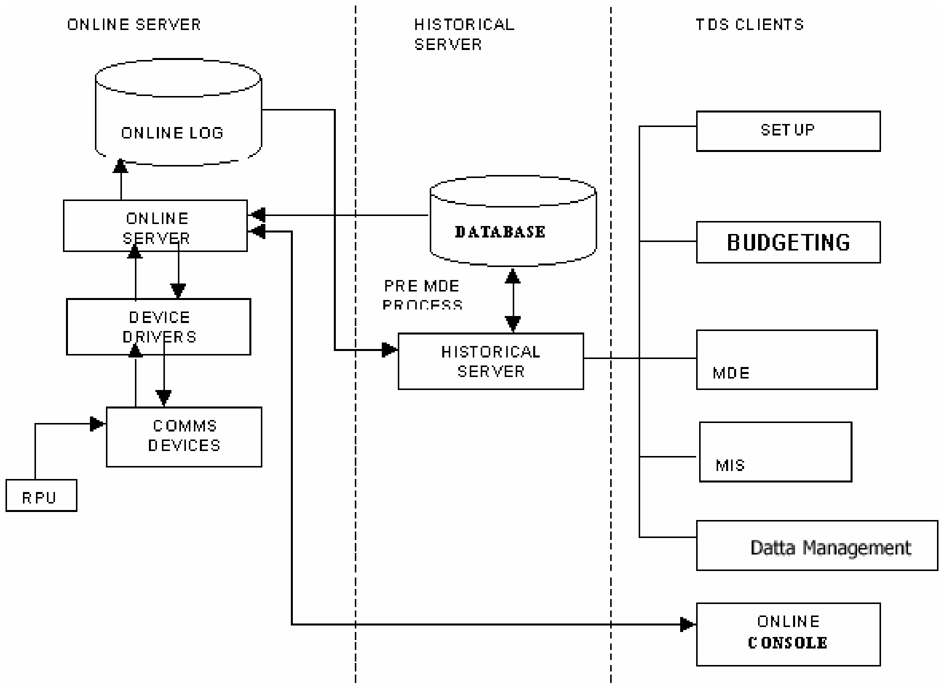


FIG:4.3: TDS Application Architecture

4.1.2 Tier Architecture

3-Tier architecture consists of the following components.

a) **Data Base** :- Data base is where all the data coming from the On-line Server and also manually entered data by Clients is stored. In present case SQL Server 2000 is used as data base. Each Quarry is having its own database. However for generating composite reports both databases are accessed.

b) **Off-Line or Historical Server** - Off-line server is the program, which interfaces database with clients. So all queries from Clients are directed to Database through off-line Server. Thus database is not directly accessible to Client. This secures database from unwanted alterations.

c) **Client Application**:- This is the application, which is distributed to all the Clients. This application consists of GUI, Reporting Module, Online monitoring Module, System Configuration Module and Manual Data Entry Module. GUI is the Map of the mine on which positions (Longitudes, Latitudes) as well different parameters of different on-line monitored HEMM's are shown and updated as per actual movement of the HEMM's. Reporting Module is used for generating different reports regarding performance of equipments. The system provides wizard as well SQL editor for making Report templates, which can be run at any time by entering criteria like date etc.

On-line Monitoring module is functionally similar to GUI except it does not show pictorial representation of the HEMM's. In this module on-line data coming from field devices is represented in tabular form. System Configuration module takes care of various configurations as per the functionality required. This module is used only by System Engineers and all other users are not given access to this module. Data Entry Module is for entering data for non-monitored HEMM's. So database contains information for all the HEMM's. As a result reports coming out of system contain complete information of all the Mine Machines.

4.1.3 Network Architecture

Although both On-line and Off-line Server Application can be on one machine (PC), but that makes system slow and also slow response to On-line Monitored HEMM's whose speed is crucial. So for optimum performance of the hardware and software ,system (refer Fig. 6) contains two server, Off-line Server (Hardware) and On-line Server (Hardware). Since On-line server gets information from field devices, so to ensure that data is not lost and response to On-line Monitored HEMM's is sufficiently fast , this machine(PC) is generally of good configuration (RAM and Processor). Database also lies on this machine. The off-line server handles Clients, so that the client quarries can be answered, without becoming slow. The Off-line server has high RAM. Any Client Machine on the network can run the Client application interfaces, TDS Online Console, TDS manual entry of data for non-monitored equipment and the TDS free format reporting system.

Hence, the system maintains data integrity, while simultaneously permitting a wide range of user interactions and quarries.

4.2 Jayant Opencast Coal Mine, Northern Coalfields Ltd

4.2.1 DynaMine: Truck dispatch system

A global positioning system (GPS)-based, operator-independent truck dispatch system (OITDS) suitable for open cast mines.

The Jayant mine handles 30 million cubic metres of mine overburden (the waste product generated during mining operations) and around 10 million tonnes of coal in a year. It has a fleet of 15 excavators with a capacity ranging from eight to 14 cubic metres, 50 trucks of 85-tonne capacity and 30 trucks of 120-tonne capacity. The OITDS system covers the entire fleet of excavators and trucks. This system was conceptualised in 1999 and was implemented in September 2002.

4.2.2 DYNAMINE

DynaMine is a global positioning system (GPS) based truck despatch system suitable for open-cast mines. All its components have been designed to remain operational in the harsh environmental condition of mines.

Its main components are:

- An Intel / Risc-based application-cum-database server
- A GPS-based onboard instrument called Nirdeshak, for monitoring the vital signs of vehicles, voice / data communication and tracking the location of equipment.
- An application package, which is the heart of the system

- Other communication-related infrastructure like a mast, repeaters and LAN-related infrastructure

DynaMine modules include:

Display:

- Real-time display of mining operations

- Real-time display of instantly generated warning messages / messages sent by the operator to the control room from heavy earth moving machinery (HEMM)

- A scrolling display of critical production parameters in real-time

- Activates voice communication with HEMM operators

- Production / availability / utilization / status details of any HEMM in real-time, on double-clicking the icon of the particular HEMM.

Allocator:

- Dynamic allocation of trucks to excavators

- Opens and closes various dumps

- Displays equipment and operator performance as well as various critical production parameters in real-time on client machines, and also on large displays installed at the mines office

Survey:

- Edits and updates mine map, based on data from mine planning software or from surveying instruments
- Defines blasting zones with blast timings, to generate automatic warning messages in real-time, in case of any HEMM entering the area during those times
- Defines and edits profile of dump-points
- Replays the past movement of any particular HEMM, in a user-selected time period, with user-controllable speeds for analysis

Maintenance:

- Records breakdown details of HEMMs
- Records the preventive maintenance activities of HEMMs
- Maintains a breakdown history of HEMMs, to help in breakdown analysis
- Automatically generates a preventive maintenance schedule for HEMMs
- Monitors critical components of HEMMs, through its interface with the vital signs monitoring system

Administration:

- Administers radio communications between the server and HEMMs
- Configures communication parameters for voice communications with HEMMs
- Configures communication parameters for data communication with HEMMs

- Configures parameters for the vital signs monitoring hardware

- Real-time displays of the status of critical communication equipment like network controllers, communication servers, terminal servers, etc.

- Configures Nirdeshak, network controllers and terminal servers

- Receives and displays status-related data from network controllers and terminal servers

- Creates and maintains users' access rights to various modules

Reports:

- Achieved production
- Allocation reports
- Equipment availability and utilization reports
- Breakdown analysis reports, etc.

Dynamine application server:

- Positional interpreter analyses HEMM position and status continuously to take dynamic allocation decisions and generate critical warning messages

- Generates real-time data for feeding to the server for queries about the production data and equipment status on phone through the interactive voice response system

- Manages to and fro communication with Nirdeshak units fitted in HEMMs

- Manages user connections from client machines

Chapter 5

MONITORING PROCESS INVOVLVED

IMPORTANCE OF EQUIPMENT IN OPEN CAST MINES

5.1 PERFORMANCE MONITORING OF EQUIPMENTS

The entire opencast mine earthmoving process can be monitored and enhanced by GPS equipped heavy earth mining machinery (HEMM). Computerized mine operations management system would include tracking of mining equipment, maintenance, monitoring and diagnostic systems, transmission of loading instructions to dumpers etc for better control.

The equipments are very vital tools for any productive organization in the age of modernization. The better performance of the equipment enhances the production as well as productivity. More over the equipments used in the Open Cast Coal Mines are robust in size and cost. Some hours of break down or idleness will cost lakhs of rupees. Hence performance monitoring of the equipments is very important and essential. The terms PERFORMANCE, here means higher utilization and availability of the equipments, economic fuel/power/lubricants consumption, higher production as well as productivity etc. And the term MONITORING means uninterrupted vigil over the system to keep the Utilization of Equipments and performance of the equipments, the monitoring process can be presented by the following diagram:-

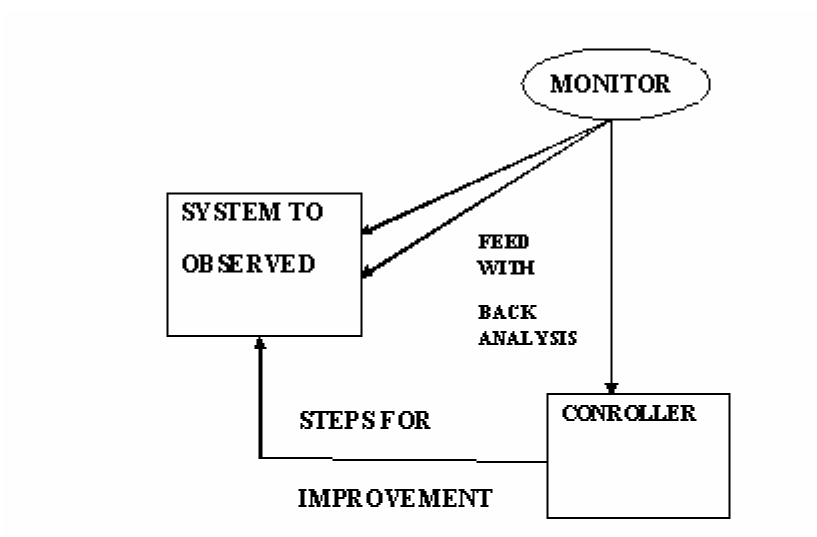


Fig:5.1: MONITORING PROCESS INVOVLVED

There are two way of performance monitoring of equipments in an Open Cast Coal Mine. First one is On-Line Performance monitoring system where the real time motoring is possible with the direct involvement of computer. Another one is Off-line or Indirect involvements of computer where the performances are monitored by analyzing the existing data of the equipments and then take the corrective action. Both the performance monitoring system has some advantages and also disadvantages. For the purpose of dissertation work, off—line Computer based monitoring system have been developed due to easiness of implementation of system.

The system which has been developed is a very powerful tool for performance monitoring of equipments of open cast coal mines on offline monitoring basis. It is an integrated system related to all equipments in an open cast coal mine for performance monitoring.

5.2 IMPORTANCE OF EQUIPMENT IN OPEN CAST MINES

Equipments are very vital tools of any Productive Organization in the age of modernization. It increases the capacity of production or in other word it is responsible for growth of any Organization. If the past record of any productive organization can be examined then it will he found that by increasing the population of equipments the production as well as productivity can be extensively increased. The past record of Coal India Ltd. shows that huge increase in production was only possible due to introduction of sophisticated mining equipments.

DESCRIPTION	1975	1999
PRODUCTION	88.90	256.5
MANPOWER (in Lakhs)	6.05	6.44
EQUIPMENTS (Nos)	600	6500
PRODUCTIVITY(Output/ton/manshift)	0.66	1.99

The above statistics chows that the production as well as productivity is increased three folds here as the manpower remain almost constant. So introduction of equipment has boost up the production/productivity. The introduction of large no of equipments was mainly in Open Cast Mines.

And from Investment point of view or cost contribution point of view all the equipment in the Open cast project takes the major contribution. Cost of one shovel ranges from Rs 3 crores to Rs 10 crores in India and Dumper cost range from Rs 0.5 crores to 3 crores in India. Hence one hour downtime of equipments will cost lakhs of rupees in term of depreciation, consumption of fuel and manpower, interest on investment etc. so the equipment utilization and performance monitoring of equipment i.e production/hour, fuel consumption/ unit of production, spare parts consumption etc play role for growth of any mines.

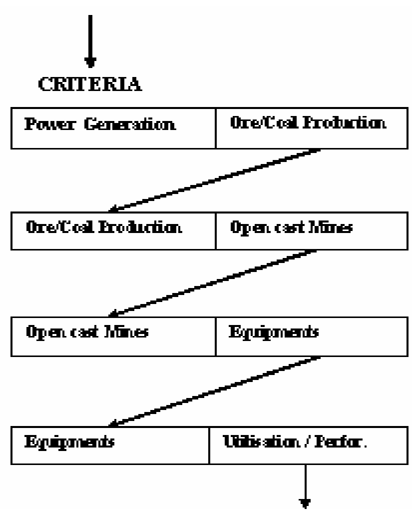


Fig:5.2: Equipment utilization diagram

<u>SO EQUIPMENT UTILISATION AND PERFORMANCE MONITORING PLAY A VERY IMPORTANT ROLE FOR GROWTH OF ANY ORGANISATION</u>

Chapter 6

SYSTEM AND SYSTEM ANALYSIS

SYSTEM ANALYSIS OF COMPUTER BASED EQUIPMENT PERFORMANCE MONITORING SYSTEM

6.1 SYSTEM AND SYSTEM ANALYSIS

SYSTEM is a term which is used in such a wide variety of ways that it is very difficult to produce a definition. However a SYSTEM can be defined as an aggregation or assemblage of objects joined in some regular interaction or interdependence to achieve certain objectives.

System analysis is a coordinated set of procedures, which addresses the fundamental issues of design and management that of specifying how man, money and material should he combined to achieve a larger purpose.

Before designing any system it is very essential to perform the system analysis to make the system efficient and accurate.

Fundamental characteristics of the use of System Analysis are:-

1. It makes the designer's aware about his objectives.
2. It seeks mechanism for predicting the future deniand on a system.
3. It establishes procedures for generating a large number of possible solutions and for determining efficient methods to search through them.
4. It assembles optimization techniques to find out favorable alternatives.
5. It suggests strategies of decision making, which can he used to select among possible alternatives.

The Basic Steps of System Analysis are as follows:-

1) **DEFINITION OF OBJECTIVES:-** The main step of system analysis is the identification and clarification of issues. All analysis is based on some set of objective of the system.

A major part of the analyst job is to challenge loosely stated goals defined by clients for identifying the fundamental purpose of the system.

2. **FORMULATION OF MEASURE OF EFFECTIVENESS: -** The choice of measure of effectiveness is essential because it determines the final design of the system. This

measure of effectiveness is used to determine the relative effectiveness of the selected alternatives for meeting the objective of the system. Therefore measure of effectiveness must be designed and it also must be quantitative.

3. **GENERATION OF ALTERNATIVES: -** The overall purpose of analysis is the discovery of the preferred solutions. In order to achieve this the wide range of possible solution must he generated. The analysis should he proceed to a detailed examination of the design option according to the following principal.

1. The major analytical effort should be developed to those alternatives which have shown to be most productive.
2. The total effort spent on the analysis should not exceed its expected benefits.

4. **EVALUATION OF ALTERNATIVES: -** It is useful to distinguish carefully before the evaluation of the effects of each alternatives and the selection of the particular solution. The evaluation of alternatives consists in associating each alternative system with it's effect : costs ,benefits ,impact on the community.

6. **SELECTION:** - final steps of the system analysis are selection of alternatives .after evaluation of the alternatives value judgment is applied to select the best alternatives which satisfies the objectives and fulfils all the criteria.

6.2 SYSTEM ANALYSIS OF COMPUTER BASED EQUIPMENT PERFORMANCE MONITORING SYSTEM

The Basic Steps for SYSTEM ANALYSIS OF ***"COMPUTER BASED EQUIPMENTS PERFORMANCE MONITORING SYSTEM "***are given below:-

DEFINITION OF OBJECTIVES:- The main objective of this system analysis is to develop an efficient system which can monitor the performance of the equipments efficiently and effectively. The developed system should also be cost effective and simple in operation. Here the performance means availability/ utilization of the equipment, productivity, fuel consumption aspects, spares parts etc.

6.2.1 FORMULATION OF MEASURES OF EFFECTIVENESS:- The measures of effectiveness for this system are :

I. It should be cost
II. Easy to handle
III. Less number of personnel to be involved.
IV. It should be accepted by all.

GENERATION OF ALTERNATIVES :- The use of computer in the system may be

1. On line/ real time/ direct involvement
2. Off line /indirect involvement

The computer can be used directly in the system as real time operation or indirectly to improve the utilization or performance of the equipments. In the direct involvement the computer will be attached to the production line directly and will analyze the performance and give the feedback to the controller or manager who will take some corrective action.

6.3 ONLINE INVOLVEMENT OF COMPUTER

In the past ten to fifteen years this technology has progressed rapidly as the advances in information technology. Sometimes it is called as Global Positioning System and this technology provides an accurate, systematic and cost effective way to collect and control equipment fleet.

The real time operating control of fleet of fleet of equipment using computerized system has two important tasks.

1. The first task is the dispatching the control of whole fleet. The main purpose of the dispatch control is to reduce each dumpers queue time to optimize its effective utilization.
2. The second task is concern with collecting and recording detailed performance data on the dumper fleet operation.

There are basic components of this method controlling are as shown below:-

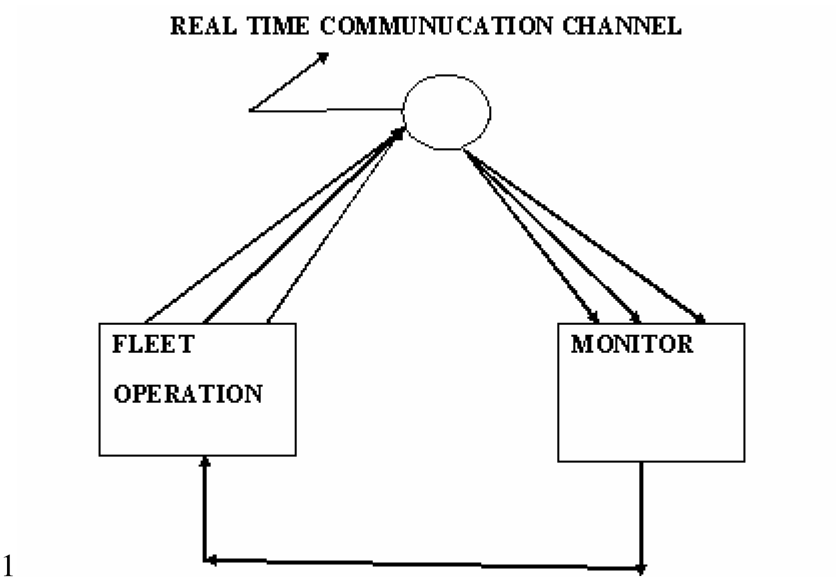


Fig:6.1

The FLEET operation component

From where the actuation of operation is started. Different sensing devices are used to sense the action and then send the signal to the monitor.

Communication Channel

These components are used to transfer the information or signal to the monitor controller.

Monitor

This is the most important component where the computers are deployed to control and analyze the action send by the fleet component. The components include hardware as well as software to suit with the system.

By this way of controlling each and every action of the operator / equipment can be seen instantaneously on the screen of the computer and if there is some problem in any equipment then corrective action can be taken immediately such as sending the maintenance personnel to the spot if there are any breakdown of equipment etc. or say some shovels are under the breakdown then the dumpers can be shifted to another shovel immediately. All these extend the equipments utilization by reducing the idle time of the equipment.

6.4 INDIRECT/OFFLINE INVOLVEMENT OF COMPUTERS IN EQUIPMENT PERFORMANCE MONITORING

This method basically includes the analysis of database or the use of computer simulation. In this way of involvement, it provides a comprehensive approach to accurately calculate the highest achievable performance of individual equipments under some operating environment. By using computer a performance monitoring model of the equipment can be developed or by some other study a standard performance can be established. Then comparative analysis of the standard performance and the actual performance can be carried out and if any significant differences are observed then corrective action can be taken.

6.4.1 EVALUATION OF ALTERNATIVES

Advantage of DIRECT/REAL TIME INVOLVEMENT OF COMPUTER:

- This method of working is very efficient way of controlling
- Instantaneous Decision can be taken

Disadvantages DIRECT /REAL TIME INVOLVEMENT OF COMPUTERS

1. Strong opposition from worker may be arise during implementation of this system
2. Very high cost is involved for installation of this system
3. The performance of the system is totally depended on communication channel. If it fails then the total system will fail

Advantages of OFF-LINE /INDIRECT INVOLVEMENT OF COMPUTER

1. Initial investment is less compared to direct involvement
2. System is very simple with less number of components and hence easy to implement.

Disadvantage of OFF-LINE/INDIRECT INVOLVEMENT OF COMPUTER

- The accuracy of the analysis is wholly dependent on available data if it is wrong then assessment will also be wrong.
- For analysis all types of data have to be included which is time consuming and hence decision may be late.

6.5 SELECTION

On the basis of the above discussion it is found that the OFF-LINE INVOLVEMENTOF COMPUTER is best suited for the purpose. Hence the OFF-LINE INVOLVEMENT OF COMPUTER in "COMPUTER BASED EQUIPMENTS PERFORMANCE MONITORING SYSTEM "has been selected for development.

EQUIPMENT DIVISION:-

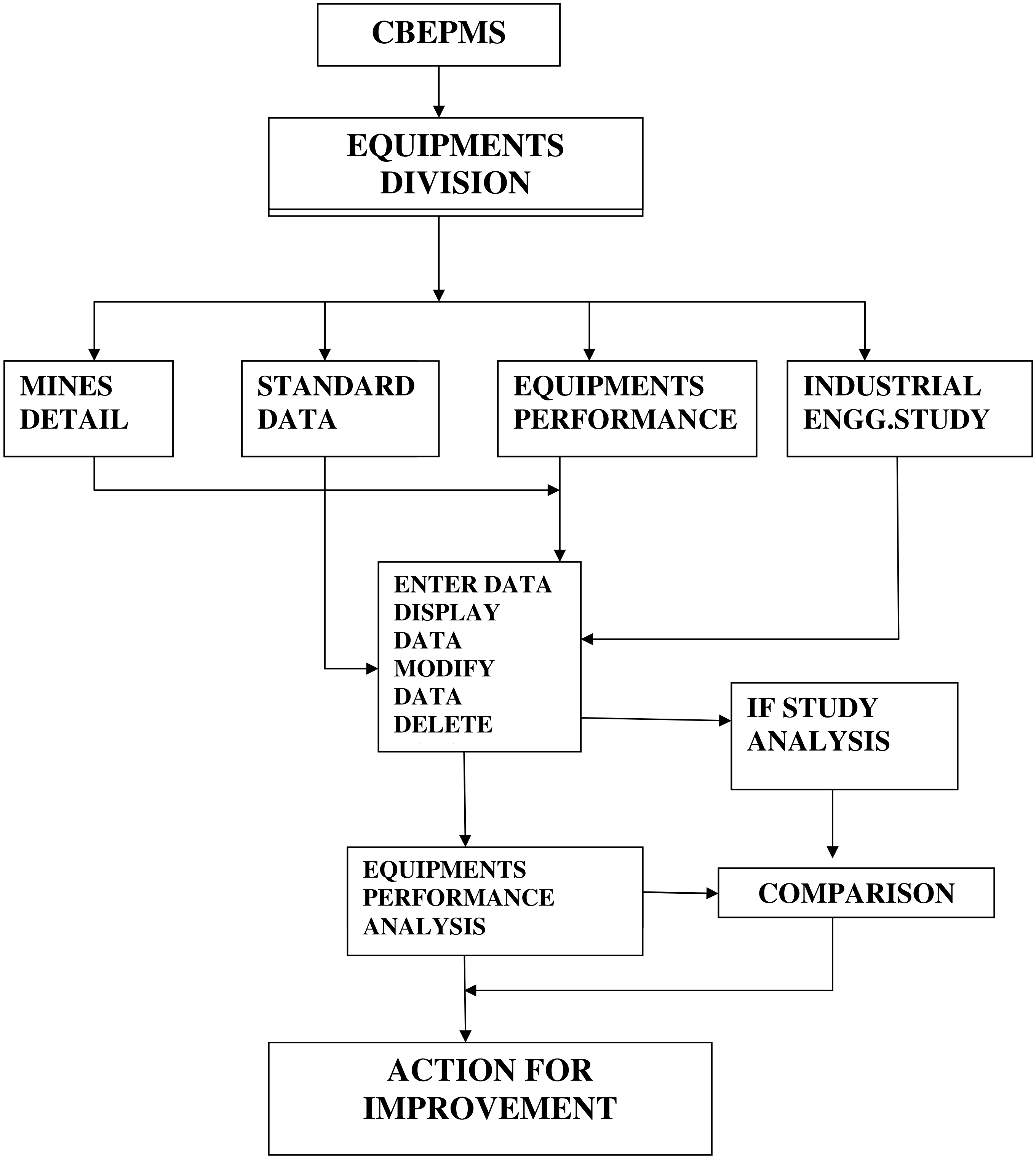


Fig:6.2: Showing component of equipment division

The Computer Based Equipment Performance Monitoring System is a very powerful tool for performance monitoring of equipments of open cast mines on offline monitoring basis. It is an integrated system related to all equipments in a opencast mine for performance monitoring. This system starts from the counting of the number of dumpers/production to spare parts consumption/maintenance performance.

1. Enter all the equipment detail under the heading of standard data in the main menu.
2. Enter the mine's detail such as shift hour duration, production etc in the mine details under the heading of standard data in the main menu.
3. Enter the daily performance in data entry under the heading equipments performance in the main menu.
4. Execute the utilization analysis of equipment under data analysis under the heading of equipment performance.
5. Execute the industrial engineering analysis by analysis under the heading of industrial engineering of standard data in the main menu. This will show the actual performance and comparision with industrial engineering study result.

Chapter 7

APPENDIX

ALGORITHM

step 1:The program deals with automization of machines with computers
step 2:Divide the total machine time into breakdown time, idle time, usage, maintainence
step 3:We also calculate the availability, utilization, capacity, by keeping track of time by counter
step 4:If the computer is unable to read or write data the process terminates automatically.
step 5:The computer reads the data
step 6:If Current location!=Previous location and Vehicle is at unload point it increments the counter by one
step 7:If Current location==Previous location and Vehicle at load point it increment idle counter by one else if Vehicle at unload point then vehicle lies anywhere else and breakdown counter is incremented by one
step 8:The availability time is calculated as follows: **totaltime-breakdown-maintain /total time**.
step 9:The utilization time is calculated as follows: **totaltime-breakdown-maintain-idle/total time**
step 10:Usage=capacity*count
step 11: Print availability ,usage,idle ,breakdown time
step 12:stop

PROGRAM

```
#include <stdio.h>
#include <math.h>
FILE *IN,*OUT;
```

```
int main()
{
    int totaltime,capacity,maintain,breakdown,idle,count,usage,time;
    float availability,utilisation;
    int px,py,cx,cy,lx,ly,ux,uy;
    int i;
    IN=fopen("input.txt","r");
    if(IN==NULL)
    {
        printf("\nUnable to read input data.Terminating...");
        exit(0);
    }
    OUT=fopen("output.txt","w");
    if(OUT==NULL)
    {
        printf("\nUnable to write output data.Terminating...");
        exit(0);
    }
    breakdown=0;
    idle=0;
    count=0;
    px=0;
    py=0;

fscanf(IN,"%d%d%d%d%d%d%d",&totaltime,&capacity,&maintain,&lx,&ly,&ux,&uy);
    for(i=0;i<totaltime;i++)
    {
       fscanf(IN,"%d%d%d",&time,&cx,&cy);      //Reading Data
       if((px!=cx)||(py!=cy))                  //Current location!=Previous location
       {
          if((cx==ux)&&(cy==uy))              //Vehicle at unload point
```

```
        count++;
    }
    if((px==cx)&&(py==cy))                //Current location==Previous location
    {
      if((cx==lx)&&(cy==ly))              //Vehicle at load point
        idle++;
      else
      {
        if((cx==ux)&&(cy==uy))
          idle++;                   //Vehicle at unload point
        else
          breakdown++;              //Vehicle vehicle lies anywhere else
      }

    }
    px=cx;
    py=cy;
}

availability=(float)((float)(totaltime-breakdown-maintain)/(float)(totaltime));
utilisation=(float)((float)(totaltime-breakdown-maintain-idle)/(float)(totaltime));
usage=capacity*count;
fprintf(OUT,"Availability = %f",availability);
fprintf(OUT,"\nUtilisation = %f",utilisation);
fprintf(OUT,"\nUsage = %d",usage);
fprintf(OUT,"\nIdle time = %d minute(s)",idle);
fprintf(OUT,"\nBreakdown time = %d minute(s)",breakdown);
return 0;
```

Chapter 8

GENERAL CRITERIA FOR COMPUTER MONITORING SYSTEM

8.1 ADVANTAGES OF THE COMPUTER BASED EQUIPMENT PERFORMANCE MONITORING SYSTEM:-

MODULARITY:- A complex system may be divided into simpler pieces called modules. A system that is composed of modules is called modular. There are many advantages to divide the system into modules. Modules are easy to handle in terms of error handling or debugging, testing etc.

ANTICIPATION OF CHANGE:- The software undergoes changes constantly. changes are due both to the need for supporting evolution of the application as new requirements arise or old requirements changes.

In CBPEMS is so designed that there is a huge scope of changes. The CBEPMS designed in modular form . If somebody want to insert /delete/modify one item in the system it will be very easy to modify.

SEPARATION OF CONCERNS:- Separation of concern allows us to deal with different individual aspects of a problem, so that we can concentrate on each separately. More over the equipments division are also divided into different type of equipments such as Dumpers, Dozers, Shovels, Drills, etc.

INCREMENTALITY:- This is the concern with the software quality. Instrumentality characterized a process that proceeds in stepwise fashion, in increments. The desired goal is reached by successively closer approximation to it. Each approximation is reached by increment of previous one.

SPEED OF USE:- The speed of use of user interface is determined by the amount of time and effort required on the part of the user to initiate and execute different commands. It is morepver simple to use.

ERROR RATE:- A good user interface allows to minimize the scope of commiting error while initiating different commands. As because all the instructions are given step by step clearly , there is very less chance of committing errors during the execution of the program.

8.2SOFTWARE QUALITY :- A quality product is defined in terms of it's fitness purpose . software is said to be qualitative , if it will perform as per the system requirement specification . it has the following features from quality point of view.

- Portability:- A software product is said to be portable if it can easily made to work in different operating system environments in different machines. With other software product etc . The "COMPUTER BASED EQUIPMENT PERFORMANCE MONITORING SYSTEM" has been developed in c compiler and exe file has been developed. Hence it will work irrespective of the machine and operating system.

- USABILITY:- A software product has a good usability if different categories of user can easily invoke functions of the product.

- REUSABILTY:- A software product has rood reusability if different modules of the product can be reused.

- MAINTAINABILITY:- A software product is maintainable , if errors can be easily corrected as when they show up, if new functions are added to the product and if the functionalities of the product can be easily be modified. Very good comment lines have been incorporated in the program for easy error detection and rectification is very easy.

8.3HARDWARE AND SOFTWARE REQUIREMENT OF THE COMPUTER BASED EQUIPMENT PERFORMANCE MONITORING SYSTEM

The computer system where the system has been developed has the following hardware features:

1. Hard disc: 40 GB

2. Pentium III processor
3. 128 MB RAM (Minimum)
4. Floppy drive 1.44 MB and CD ROM

Operating system : Window 98

Language used: Turbo C

For the execution and implementation of the CBEPMS following minimum hardware is required :-

- Hard Disc: 15 to 20 MB free space will be sufficient to rum the program
- Processor: 386 may be used but higher version of the processor will speed up the program
- Miminum 8 MB RAM is required
- Mouse: this is very essential because the CBEPMS has the mouse driven menu program

Chapter 9

CONCLUSION

CONCLUSION

The Computer Based Equipments Performance Monitoring System(CBEPMS) powerful tool for performance monitoring of equipments of open cast coal offline monitoring basis. It is an integrated system related to all equipment of open cast coal mine for performance monitoring. This system starts form the Counting of trips of dumpers production to spares parts consumption / maintenance performance.

The CBEPMS very effective and accurate for the purpose of equipment performance monitoring in an open cast coal mines. The CBEPMS has a very good features such as it is easy to learn, very good interface capability, lesser chance of committing errors, error recovery is also possible and it is consistent.

The CBEPMS can be used by different category of users and the system has a good quality of portability, reusability and maintainability There is huge scope of development in the CBEPMS. The CBEPMS will provide a very good result in terms of performance monitoring in open cast coal mine. After getting the analysis result the management can take the decision instantaneously, may be related to equipments.

This system has been developed for the dumper system only.

9.1LIMITATION OF THE COMPTER BASED EQUIPMENT PERFORMANCE MONITORING SYSTEM:-

1. The CBEPMS has been developed for only performance monitoring of dumpers and shovel. The other equipment can be included such as draglines ,drill, dozers are not included due to time constraints.
2. The success of the system is totally dependent on the availability and incorporation of data into the system . if the data will not be available then the system cannot provide good results.
3. The data which has been incorporated into the system also should be correct

otherwise it would provide wrong information to the management.

9.2SCOPE OF FURTHER WORK

The computer based equipment performance monitoring system has very good features of maintainability, reusability, portability that are discussed above. There are a lot of scope of further development in the system. They are given below:-

- At present it is designed for dumpers. other equipment such as dozers ,drills ,draglines can also be incorporated with some little effort.
- The CBEPMS can also be used for equipment maintenance system. Such as simulation of maintenance of sub assemblies, assemblies can be developed.
- This can also be used in multiple user system by some little modification
- This can also be used for online monitoring.

CHAPTER 10

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Development of Computer Based Equipment Monitoring System in Open Cast Mines

SUMMARY

ABSTRACT: The state-of-the-art in computing technology has advanced to a point where there are several truck dispatching systems which offer the potential of improving truck-shovel productivity and subsequent savings. Introducing a dispatching system in a mine can achieve operational gains by reducing waiting times and obtain other benefits through better monitoring, optimal routing and grade control. Efficiency of the employed truck-shovel fleet depends on the dispatching strategy in use, the complexity of the truck-shovel system and a variety of other variables. It is a common situation in mining that considerable analysis of the available strategies is undertaken before dispatching is adopted. In most cases, computer simulation is the most applicable and effective method of comparing the alternative dispatching strategies. The computer monitors the location and status (full or empty, heading, and velocity) of each vehicle in the fleet. The system analyzes production statistics, such as haul routes, historic data about drive time to a specific shovel location, and cycle time how long it takes to make a round trip from the shovel to the dump site and back.

INTRODUCTION: The state-of-the-art in computing technology has advanced to a point where there are several truck dispatching systems which offer the potential of improving truck-shovel productivity and subsequent savings. If the number of alternative system designs is not too large, the standard approaches for solving optimization problems are used ranking and selection, and multiple comparisons with the best. Ranking and selection procedures yield one decision, i.e., which system design has maximum expected performance, while multiple comparisons with the best provide estimates, i.e., the difference between the expected performance of each system design and the best of the other system designs. However, this theory is not extensively used in practice.

OBJECTIVES: To develop a computer based equipment performance monitoring systems in open cast mines we have made a choice to make it on the shovel dumper combination using GPS. The computer monitors the location and status (full or empty, heading, and velocity) of each vehicle in the fleet. The system analyzes production statistics, such as haul routes, historic data about drive time to a specific shovel location, and cycle time how long it takes to make a round trip from the shovel to the dump site and back.

GLOBAL POSTIONING SYTEMS: GPS can employ directly on mining machinery. GPS guidance systems allow the operator to complete complex earthmoving designs without the need for field staking. More advanced systems allow for accurate real time productivity monitoring and the automatic generation of "as-builts" in the form of Digital Terrain Maps (DTMs).

SYSTEM ANALYSIS OF COMPUTER BASED EQUIPMENT PERFORMANCE MONITORING SYSTEM:

- **Online involvement of computers:** The first task is the dispatching the control of whole fleet. The main purpose of the dispatch control is to reduce each dumpers queue time to optimize its effective utilization.
- The second task is concern with collecting and recording detailed performance data on the dumper fleet operation.

Indirect involvement of computers: This method basically includes the analysis of database or the use of computer simulation. In this way of involvement, it provides a comprehensive approach to accurately calculate the highest achievable performance of individual equipments under some operating environment. By using computer a performance monitoring model of the equipment can be developed or by some other study a standard performance can be established.

CONCLUSION: The CBEPMS very effective and accurate for the purpose of equipment performance monitoring in an open cast coal mines. The CBEPMS has a very good feature such as it is easy to learn, very good interface capability, lesser chance of committing errors, error recovery is also possible and it is consistent. The CBEPMS can be used by different category of users and the system has a good quality of portability, reusability and maintainability. There is huge scope of development of the CBEPMS. The CBEPMS will provide a very good result in terms of performance monitoring in open cast mine.