

## SHOVEL AND DUMPER COMBINATION

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### **Abstract:**

The most common transportation method in surface mining is the shovel-dumper combination. This operation accounts for approximately 50-60% of the total operating cost in surface mining. Efficient utilization of this combination is crucial for improving the economy in the mining sector. Various techniques are available to analyze and optimize the combination. Mining is a capital-intensive industry, and it is well-known that equipment utilization and accurate estimation are vital. In India, about 70-80% of the production of minerals comes from surface mines. The material handling system in surface mining operations includes loading, hauling, and dumping, with the shovel-dumper combination being the most commonly used method in open-cast mining. The most important factor in its operation is profitability.

**Keywords:** Surface Mining, Shovel-Dumper Combination, Operating Cost, Equipment Utilization, Mineral Production

### **1.Introduction**

Due to rapid growth in demand for minerals, the mining industry is now facing a great challenge for rapid production of different minerals to compete with the market. For this mechanization of is obvious. Different types of mining machineries are now being used in the mining industry. In the planning stage, the application of advanced computer techniques is being used. In large opencast mines, the areas where the application of computer techniques are using are determination of production schedule, the breakdown maintenance schedule of the equipments for preventive maintenance and replacement policies, determination of optimal production schedule, optimum design of open pit, optimal blends and ore body modeling, selection of machineries and matching factor with production. The present study is based on application of Monte-Carlo Simulation technique on production optimization and simulation of break-down of mining machineries for their preventive maintenance for maintaining a steady state production. During production planning, it is required to have production target on a fixed time schedule, i.e. on yearly basis or monthly basis or on day-to-day basis. After having the production target it is very important to decide the requirement of exact number of machinery to achieve the target. Because of high rate of the machineries (i.e. initial investments), considering their spare parts and high level of maintenance, profitability, suitability for the mines, feasibility study of the machines are very important to minimize their breakdown frequency. So, it will be helpful, if the selection of machineries is done in a mathematical manner using computer programming with the help of Monte-Carlo Simulation technique. However this study is limited only in cost estimation of shovel-dumper transport system and the number of machineries best fit to the system from the available field data. An important

aspect of long-term production planning is maintaining a steady-state production with target achievement. For that which needed is subdivided the period into medium-term which is 1-5 years, provided that long-term production planning is generally 25-30 years. So, for the sub-divided period is to fix the rate of production from the mine.

### **Scope Of Work**

The scope of research includes an in-depth investigation on the performance of surface miners operating in different ore opencast mines of India under varied geo-mining conditions, both in empty travel back and turn back methods, covering the following aspects:

- Development of a drum design methodology for surface miners for producing a given chip size and production with cutting drums located in the centre.
- Parametric analysis of shovels and dumpers parameters, surface miner design and operational parameters and key performance indicators (KPI), i.e., chip size, production, diesel consumption, pick consumption, and development of a suitable prediction model.

### **2.Literature Review**

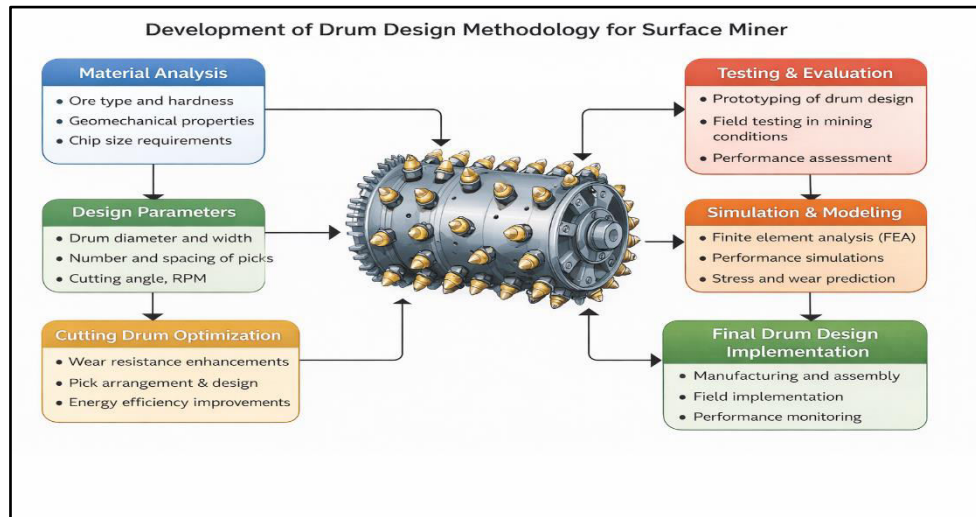
The shovel and dumper combination is one of the most commonly used systems in surface mining operations, particularly in open-pit mining. This combination is crucial for the efficient handling of large quantities of materials, as it involves the excavation of material by shovels, which are then transported by dumpers to different locations. The efficiency of this combination is vital, as it accounts for a significant portion of the operational costs in surface mining, often ranging between 50-60%. In terms of production capacity, the shovel and dumper combination's performance depends heavily on the selection and coordination of both components. Shovels are responsible for digging and loading the material, while dumpers transport the material to stockpiles or crushers. A well-optimized combination ensures that both the loading and hauling processes operate in sync, minimizing downtime and maximizing throughput. According to studies by authors like Rathi et al. (2016), effective utilization of this combination directly influences the overall productivity of mining operations. Shovel and dumper performance optimization involves various factors such as cycle time, the capacity of equipment, fuel consumption, and the impact of maintenance strategies. Researchers like Mishra et al. (2017) and Prasad and Praveen (2015) have suggested that efficient equipment maintenance schedules and machine replacement policies can drastically reduce operating costs. Moreover, the integration of modern technologies like real-time monitoring systems helps in dynamically adjusting the operation based on shifting mining conditions. The choice of the appropriate shovel-dumper combination also depends on the terrain, the type of material being extracted, and the distance over which the material must be transported. The appropriate matching of shovels and dumpers not only increases operational efficiency but also contributes significantly to the profitability of the mine. Moreover, as the mining industry faces increasing pressure to improve sustainability, innovations such as electric dumpers and autonomous systems are being explored to further enhance the efficiency and reduce the carbon footprint of shovel-dumper combinations (Kumar et al., 2020).

### **3.Methodology**

The methodology for this study involves a comprehensive approach to optimizing the shovel and dumper combination system for surface mining operations. The study applies advanced techniques for production optimization, equipment selection, and simulation of the operational efficiency of mining systems under various geo-mining conditions. The methodology can be divided into the following key stages:

### Development of Drum Design Methodology for Surface Miner:

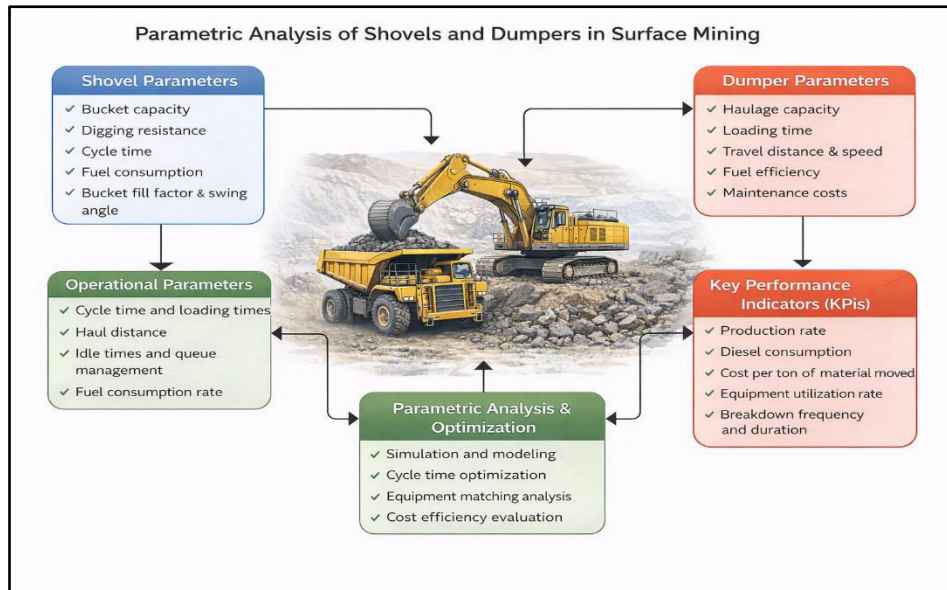
The first stage focuses on the development of a drum design methodology tailored to the needs of surface miners. The design will be aimed at producing a specific chip size and achieving optimal production levels, with particular attention to the cutting drums located at the center of the machine. The methodology will incorporate factors such as the ore type, hardness, and required output, ensuring the machine is designed to meet specific mining targets efficiently. A detailed analysis will be conducted on the design parameters of cutting drums, with emphasis on their material strength, wear-resistance, and ability to maximize production while maintaining optimal chip size.



**Figure 1:** Development of Drum Design Methodology for Surface Miner

### Parametric Analysis of Shovels and Dumpers:

A parametric analysis of various shovel and dumper configurations will be performed. This includes analyzing key parameters such as loading capacity, cycle time, fuel consumption, maintenance schedules, and operating costs. The relationship between shovel capacity and dumper size will be examined to optimize the match between the loading and transport systems. The surface miner design will be correlated with the shovel and dumper parameters to ensure that the equipment is well-matched for efficient material transport. Key Performance Indicators (KPIs) such as chip size, production rate, and diesel consumption will be closely monitored and assessed. Operational parameters, including travel time, loading times, and haul distances, will be evaluated to ensure that the shovel-dumper system works at maximum efficiency.



**Figure 2: Parametric Analysis of Shovels and Dumpers**

### **Monte Carlo Simulation for Production Optimization and Breakdown Simulation:**

- A Monte Carlo simulation will be applied to model the stochastic nature of the mining process, including uncertainties in equipment performance and breakdown events. This simulation technique will help in optimizing production schedules by accounting for the variability in mining conditions and equipment efficiency.
- The breakdown of mining machinery will be simulated to identify the impacts of equipment downtime on production and to develop strategies for preventive maintenance to ensure steady-state production.
- The model will incorporate historical data on equipment breakdown frequencies, maintenance schedules, and spare parts availability to predict the future performance and optimize maintenance strategies.

### **2. Development of Prediction Model for Equipment Maintenance:**

- A mathematical model will be developed to predict the optimal number of machines required to achieve the target production. The model will account for the capacity of each machine, fuel consumption, and maintenance costs. The objective is to minimize downtime and maximize throughput while maintaining cost-effective operations.
- A predictive maintenance model will be integrated into the simulation, allowing real-time adjustments to maintenance schedules based on performance data and breakdown predictions. The model will help identify potential equipment failures before they occur and provide insights into the optimal replacement and maintenance schedules.

### **3. Evaluation of Long-Term Production Planning:**

- Long-term production planning will be based on the optimization of equipment usage and performance metrics. This will involve breaking down the long-term target into medium-term goals (1-5 years) and ensuring that the system maintains a steady production level over time.

- The study will explore the viability of using new technologies and automation tools to improve the long-term production process. This will include the use of remote monitoring systems, automated machines, and predictive analytics to ensure sustained efficiency over the years.

#### **4. Cost Estimation and Economic Analysis**

The cost estimation and economic analysis of the shovel-dumper transport system are critical for evaluating the financial feasibility and operational efficiency of surface mining operations. The primary goal of this analysis is to assess both initial and ongoing costs involved in the operation of shovels and dumpers used in mining. It begins with estimating the initial investment for acquiring the machinery, which includes the purchase price of shovels and dumpers, along with associated costs for auxiliary equipment, installation, and setup. In addition to the upfront investment, operating costs such as fuel consumption, labor, and maintenance expenses must be considered, as these typically account for a significant portion of the total operating budget. Fuel efficiency and the frequency of equipment maintenance play a large role in shaping these operational costs.

The breakdown costs, caused by equipment failures and resulting downtime, are another key aspect of the analysis. Downtime can lead to lost production and higher maintenance costs, making it essential to include the maintenance schedules and spare parts management as part of the cost estimation. Furthermore, the cost per ton of ore transported will be calculated to determine the efficiency of the shovel-dumper combination. This metric allows operators to assess the financial viability of different equipment configurations and optimize for the best cost-to-output ratio.

The economic analysis incorporates several financial metrics to evaluate the long-term profitability of the operation. Key indicators such as return on investment (ROI), net present value (NPV), and internal rate of return (IRR) will be used to assess the project's financial health. A positive NPV and IRR greater than the cost of capital indicate that the operation is financially viable, while a long payback period suggests that the investment may take longer to recover. Sensitivity analysis will be employed to understand the impact of fluctuating variables, such as fuel prices and labor costs, on the overall profitability. The findings from this comprehensive analysis will enable mining operators to make informed decisions, ensuring that equipment selection, operational planning, and maintenance strategies align with both financial and operational goals for sustainable and profitable mining.

#### **Conclusions**

The combination of shovels and dumpers are very useful for the transportation of ore. The use of smaller and simpler machines to load and transport ore increases the number of production faces for a given output and thus makes the quality of ROM ore more uniform. A trend of increased use of this equipment for the opencast ore mining is likely to continue because of its obvious advantages. Another incidental advantage of using several feeder breakers distributed at many places in the mine is that such a system avoids concentration of ore dust at one point and, thus, becomes environment-friendly. It has been experienced that in India, opencast mines that are deeper than 70m take acute problems of maintaining dumpers. With the growth in the world's demand for resources expected to continue for some time, mine operators are looking for further efficiency improvements. In addition to developing machinery that reduces the burden on the environment while also improving performance and reliability and reducing running costs, growth in mining methods.

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