Computer Simulation of Truck/Shovel System at Tuncbilek Coal Mine Using GPSS/H

N.Cetin, ICErarslan & A.Okuducu
Dumlupinar University, Department of Mining Engineering, Kutahya, Turkey

ABSRACT: In this study, the materia] handling system at Tuncbilek surface coaJ mine operated by Garp Lignite Enterprise (G.L.I.) is simulated. In the district, material handling is performed as a truck/shovel operation. The simulation model is developed using a well-known simulation language, GPSS/H. The goal of the study is to determine the optimum number of trucks to have in the mine using probabilistic cycle times. The input data is collected by observation of actual system operation and analyzed by using Goodness of Fit Test with Minitab statistical software package. To find the optimum number of trucks, the developed simulation model is run by changing the number of trucks for maximum shovel productivity.

1 INTRODUCTION

Computer simulation is now an ever-increasingly used design tool by engineers in many scientific disciplines. It enables them to solve or evaluate a wide variety of technical problems rapidly and inexpensively without even actually changing the system under consideration. That is, through simulation, various operating policies which are impractical to experiment can be tested before they are implemented in reality. It has been used extensively for automotive designs, design of large factories and production lines in industrial applications. In fact, most situations in which the effect of changes in the operating system policy are to be evaluated can be considered as simulation opportunities. In its broadest sense, computer simulation is the process of designing a mathematical/logical model of a real system and conducting experiments with this model on a computer for the purpose of either understanding its behavior or evaluating various strategies for its operation (Law and Kelton, 1991).

The present paper presents the results of using the GPSS leuguage for simulation of truck/shovel system performance at G.L.I. (Garp Lignite Enterprise) Tuncbilek Coal Mine located in western part of Turkey. The model is used for optimizing the number of trucks using probabilistic cycles times taken from an actual operating mine site.

2 DESCRIPTION OF THE MINE

Tuncbilek Lignite Reserve operated by Garp Lignite Enterprise (G.L.I.) is located at western part of Turkey and is one of the most important lignite deposits being in production since 1940*s. The property has an area of 13,477 hectares, with mineable open pit reserve of over 70 million tons and an underground mine reserve of about 265 million tons. Annual amount of waste stripping İs 60 million m^3 and surface mine coal production of around 9 millions tons/year. The waste stripping is done with a mixed fleet of 65-ton and 85-ton trucks and 10,17 and 20 cu-yd capacity shovels.

3 DETERMINATION OF OPTIMUM NUMBER OF TRUCKS

Simulation can readily identify the point at which the shovels are over-trucked. This involves a trade-off between truck idle time and shovel idle time. The identification of this point determines the optimum number of trucks required to maintain the operational goals of the mine.

A computer program was written in the GPSS/H language to simulate the load, haul, dump and return cycles. By changing the number of trucks on the haulage run, the optimal number of trucks to be used for maximum shovel utilization is determined.

4 INPUT DATA USED IN THE SIMULATION MODEL

For the purpose of simulating an actual truck/ shovel operation, it is important to obtain data mat closely describe reality. The input data are often very difficult to gather because many surface mines operate with a mixed fleet of trucks and shovels. Thus, data collection and analysis İs one of the most important aspects in the implementation of any simulation model since any simulator is as good as the input data it receives (i.e.: "Garbage-In Garbage-Out")(Banks et al. 1984).

In time studies, İt is very important to clearly define die duration of each element of the operation. In order to simulate the truck/shovel production system, the times required to load the truck, haul the coal, dump the coal and return to the shovel have to be known. These times were determined from actual measurements using a stopwatch. An analysis of these time study data using goodness of fit test with Minitab software package have resulted in the statistical distributions which will be used as input data into the simulation program. Goodness of Fit Tests showed that the cycle times from actual mine data collected can reasonably be well modeled by normal distributions for all load, haul and dump times (Rasche and Sturgul, 1991). The mean and standard deviations of these times were needed in the simulation model. However, GPSS/H simulation language can easily handle any statistical distributions. Table 1 shows the mean and standard deviations of mese times in seconds.
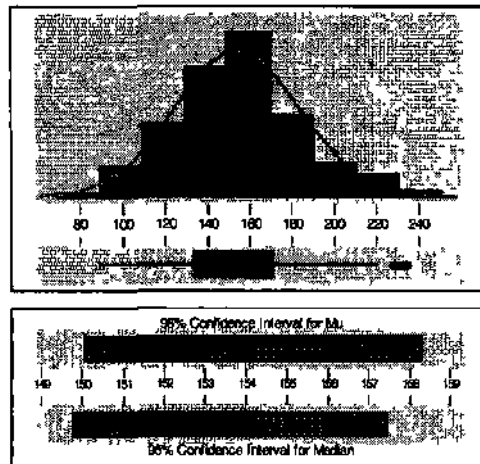
One of the primary problems when dealing with operational data obtained from time studies is that of outliers, which are defined as those points that do not belong to the same population as the bulk of observed data. There is no hard and fast rule to determine which observed values are outliers. As a rule thumb, Tu and Hucka (1985) suggest that all data points should lie within 3.5 tunes standard deviations of the mean and this rule İs also applied in this study.

Table 1 Time Study Data Used in Simulation Model (Seconds)

	Mean	Std. Dev.
Truck Loading Time	155	30
Truck Dumping Time	55	10
Truck Hauling Time	265	45
Truck Return Time	165	30

By running the simulation program with the number of trucks currently used on the haulage route for the mine, a comparison was made between the actual number of loads and the predicted number from the simulation model. The difference was within a few percentage points and it was felt that the simulation model would accurately represent the mine for other possible combinations of trucks and haul routes.

Descriptive Statistics

Variable, load

Andersen-Darting Nonnaiity Test

A-Squarect	0555
p-vakje	0150
Maan	15*177
SM Dev	29 560
Variance	873 804
SteWiesa	0265
Kurtoete	0049
n of data	200000
Mnlmum	89310
IslCUartite	134 329
Mâdan	152.633
MQuartie	171050
MDdmum	233 446

95% Confidence Interval lor Mi
150055   158298

95% ConfidBrce Irtervat for Sigma
26.919   32 780

95% Confidence Interval for Maian
149 829   157 432

Figure I Density/Histogram Plot For Truck Loading Time
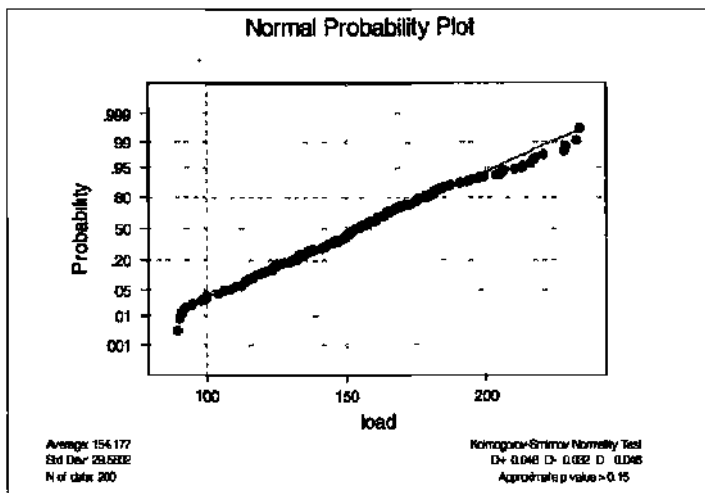
Normal Probability Plot

Figure 2 Normal Probability Plot For Truck Loading Time (Sec)

5 RESULTS OF SIMULATION

Table 2 summarizes the most important results and statistics of the simulation runs performed for the mine haulage. The optimal number of trucks to be used is clearly lunited by the best possible utilization of the loading unit. The output from GPSS/H program supplies the engineer with all relevant statistical information and assist in forming the correct decision as to how many trucks should be matched to the loader.

From analysis of figures 3,4 and 5, and table 2, it is seen that the best operating policy for this shovel location is to utilize a fleet of 5 trucks in regard to shovel productivity. A more objective analysis could be performed by using cost-per-ton figures obtained by dividing the total equipment costs by total tons hauled (Cross and Williamson 1969).
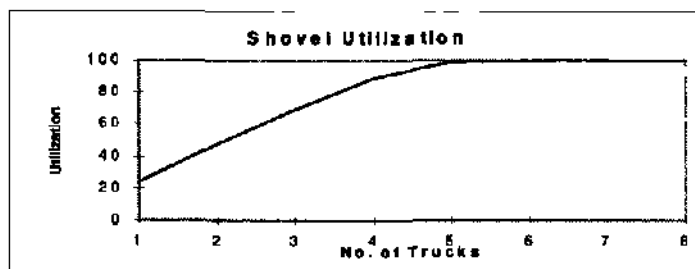

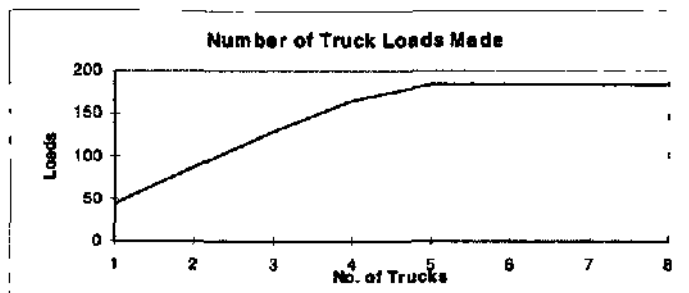Figure 3 Shovel Utilization vs. Number of Trucks

Figure 4. Truck Loads vs Number of Trucks
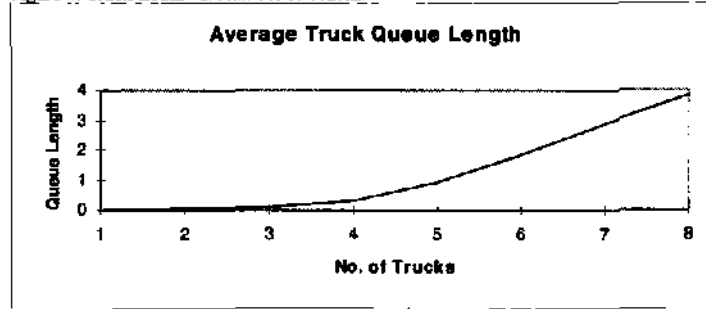
717

Figure 4. Truck Loads vs. Number of Trucks.

Figure 5. Average Truck Queue Length vs. Number of Trucks.

Table 2. Results of Simulations (Average of 100 Replications).

F Trucks	Shovel Utilization (%)	Truck Loads	Average Queue Length
1	24.2	44	0.00
2	47.8	88	0.03
3	69.8	130	0.10
4	89.5	166	0.29
5	99.3	184	0.90
6	100.0	185	1.86
7	100.0	185	2.86
8	100.0	185	3.86

6 CONCLUSIONS

The use of GPSS/H computer simulation language at a typical surface coal mine in Turkey was presented. It was used to evaluate the current performance of truck fleet at G.L.I. Tuncbilek coal mine. Simulations were performed to find the optimal number of trucks for the haulage routes.

REFERENCES

Banks, J., Carson, J.S. and Nelson, B.L. 1984. Discrete-Event System Simulation , Prentice Hall, Upper Saddle River, NJ, USA.

Law, A-M. and Kelton, W.D. 1991. Simulation modeling and analysis. McGraw-Hill Inc. USA.

Cross, B. and Williamson, G. 1969. Digital Simulation of an open pit truck haulage system. APCOM, Salt Lake City, USA: 384^100.

Rasche, T. and Sturgul, J.R. 1991. A simulation to assist a small mine: A case study. International Journal of Surface Mining and Reclamations : 123-128.

Tu, H. and Hucka, V. J. 1985. Analysis of open - pit truck haulage system by use of a computer model. CIM Bulletin ,78(879): 53-59.

Schriber, J. Thomas, 1991. An introduction to simulation using GPSS/ H. John Wiley & Sons., NY, USA.

718