Go Back

The Application of System Dynamics Theory to the Checking and Ratifying of Mine Production Capacity

Feng Xiwen,
College of Resource and Environment Engineering
Shandong University of Science and Technology
Taian, Shandong 271019, PRC

Abstract: The cause and effect analysis of main factors which affect mine capacity is made，by means of System Dynamics Theory. Based on this analysis, the feedback cycle and flow chart result. In the actual situation， the simulated model of system dynamics is established to check and ratify the mine capacity effectively.

Key words: mine production capacity, system dynamics, check and ratify

It is common sense that coal mine production system is a complex system. Mine production is influenced by lots of random factors that keep changing with the time. Mine production capacity enhances the veracity of checking and ratifying, it is necessary to consider the influence of time on production capacity, that is, to check and ratify the mine production capacity using dynamic methods.

System Dynamics (SD hereafter) is a new comprehensive subject of learning which deals with such large systems as society, economics, ecology and biology, etc. with high non-lineal, high order，multiple variable, multiple feedback and complex alternation with time [1]. The SD method is one that combines nature and amount determination by systemic, analytic, comprehensive and inference methods. The model simulation is a kind of structure (function simulation) to adopt albefaction technology and improve the structure as much as possible. Although the SD technology has been initially used in some coal-fields recently, it is only limited to the macro-fields, for instance, middle and long term programming in coal mine; nevertheless, its application to micro-field is still on the exploratory stage.

I. The cause and effect analysis of factors which affect mine capacity

With the present technological equipment and under the production conditions, the main factors [2] which restrict and affect mine production capacity are such capacities as of the working face production, the mining area production, the main conveying system underground, the main shaft hoisting , the ventilation and drainage. These factors are changed along with time, affected by mine geological conditions (deposit and its moving tension, thickness and number of coal seams, surrounding rock character, mining depth, etc.), technological feasibility of extraction operation, reliability of working face equipment. This paper deals only with checking and ratifying the mine production capacity, and the investment effective index, economical effective index from the point of qualitative determination, but it does not establish the state equation to have the quantitative analysis. Through the analysis of factors which affect the mine production capacity, we have established a cause-effect relationship, and then built the feedback loop of cause-effect. (Fig. 1)

The main feedback circuit of model is: mine production capacity • hoisting capacity of

main shaft • conveying capacity of main conveying system under ground • working face production capacity • mining area production capacity • mine production capacity.

The main feedback circuit of model with regard to the coal market is: mine production capacity • marketing capacity • surface conveying capacity • surface storage capacity • hoisting capacity of main shaft • conveying capacity of main conveying system under ground • working face production capacity • mining area production capacity • mine production capacity.

II. The establishment of SD model for checking and ratifying mine production capacity

The system flow chart of this model is established on the basis of analysis of the above cause-effect relation. (Fig. 2). Through on-the-spot data analysis, the establishment of systemic feedback mechanism, using model building theory and method of system dynamics, we determine the equation of each factor's speed, state, etc. , and establish the SD simulated model for checking and ratifying mine production capacity with the help of system dynamics simulated language (vensim-language) [3]. The operational state of each sub-system in the model was indicated by the effective grade of system and equipment mainly by

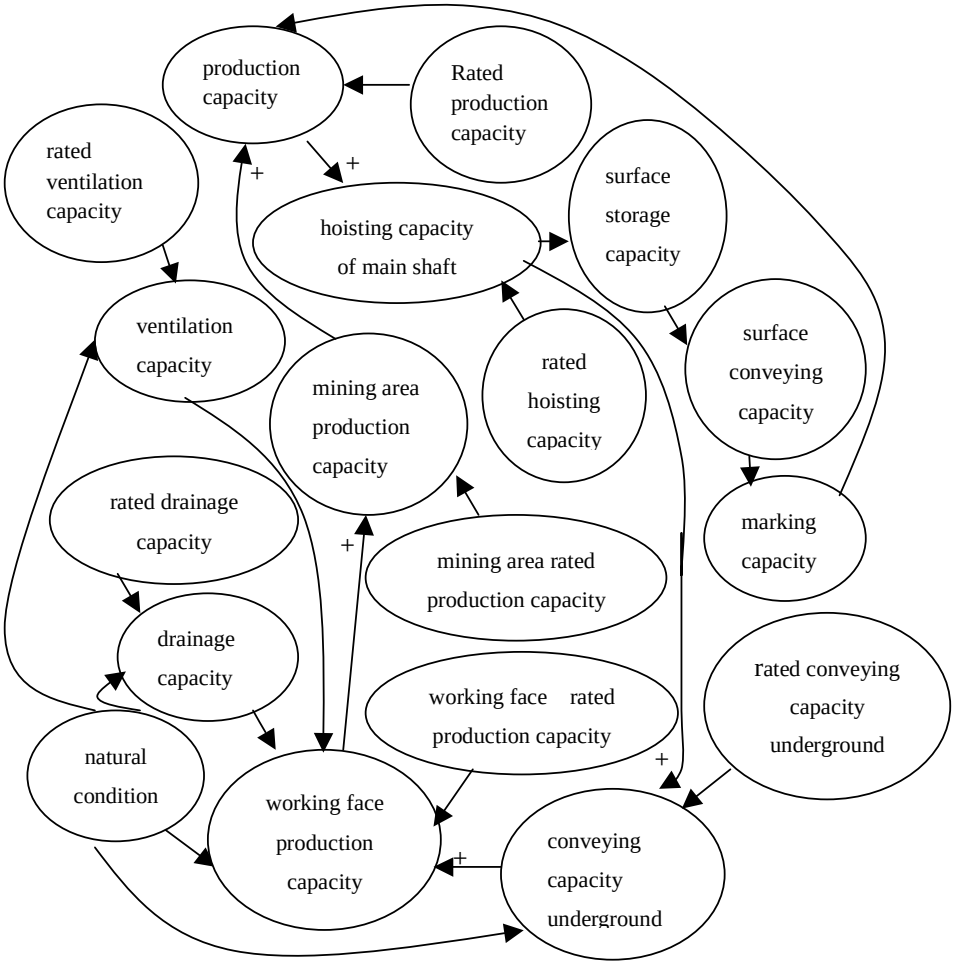

Fig.1 Feedback Loop of Cause-effect Relation

means of reliable theory and statistical data analysis method.

III. The realization of checking and ratifying mine production capacity

The simulated model for checking and ratifying mine production capacity is a simulated

laboratory. It is realized by means of conversation between person and machine under the situation of various kinds of policy and decision parameters, etc.. First of all, we input to the computer the relative data of every link and factor such as the effective grade and ability coming from each equipment or sub-system of coal mine production system, make simulated analysis according to the actual data, and combine it with the on-the-spot situation, and test and verify the model availability. Secondly, according to the operating situation of the mine production system, we check and ratify the production capacity for the present coal mine production system, determine the rated production capacity under conditions of the present production system and equipment, then, analyze and determine the weak link which affects mine production capacity according to simulated results. According to the capacity and reliability level of each link of the present production system, we reasonably determine the production capacity of the mine. Finally, combining with the on-the-spot situation, we determine the effective measures which may improve the mine production system and enhance the production capacity. Whether to improve the production system or to simulate the analysis of the production system thereafter, depends on SD switch function .

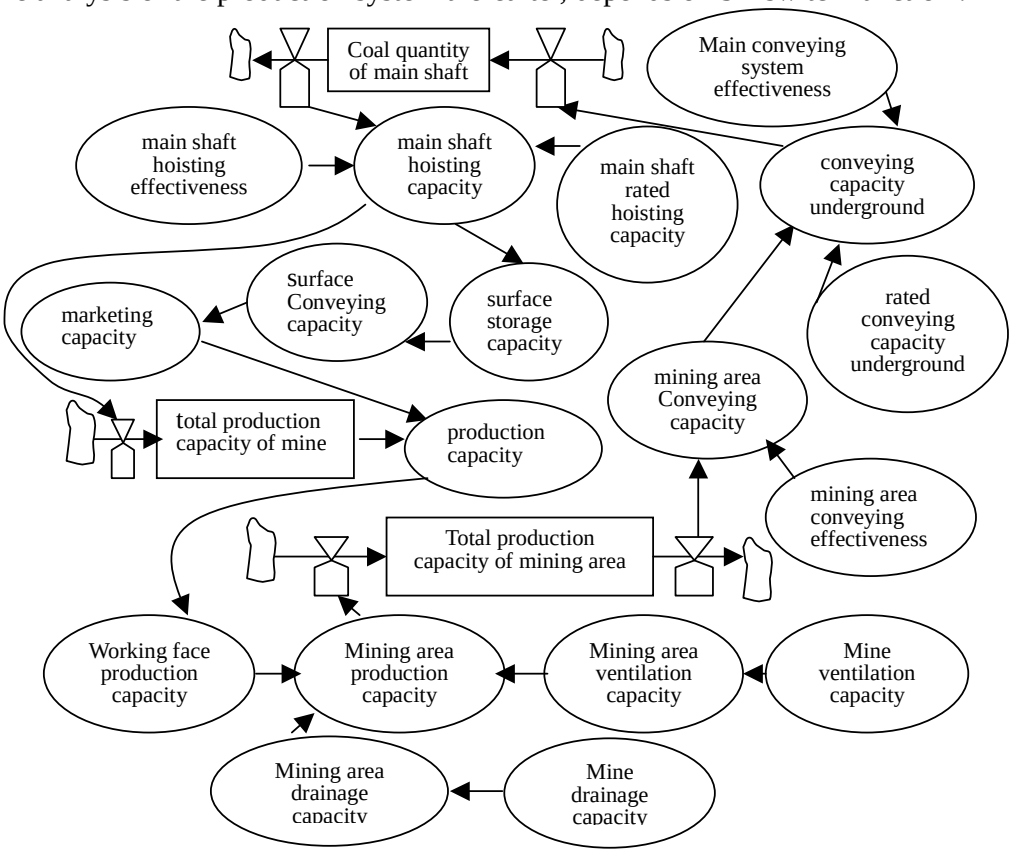

Fig. 2 The System Flow Chart of Emulating Model

IV. Example analysis

We conducted a simulated test in one mine in Shandong Province using the model. The designed production capacity of this mine is 0.45 million tons per year. 4-ton skip multiple -rope friction wheel is used in the main shaft for hoisting, and its designed hoisting capacity is 0.63 million tones per year. 1-ton double-bank cage for hoisting is used in the auxiliary

shaft whose designed capacity is 0.45 million tons. Central-boundary ventilation system is used and its ventilation quantity is 2550m^3/min. 4 pumps are used for drainage, 2 pumps are prepared. Flexible flight conveyors and cable-belt conveyors are used for the mining area conveying. Trolley locomotives (totally 4 sets are used alternatively) are used in the main roadway for loading.

According to on-the-spot data observation and analysis, after the simulated demonstration using the model, we check and ratify the production capacity of this mine is 0.88 million tons per year with the present technological equipment. At present, the actual production capacity of this mine is 0.85 million tons per year, the main factors which restrict this mine's production capacity is the shortage of hoisting capacity of the main shaft and mine ventilation capacity. The only way to increase the production capacity to 0.88 million tons per year, is to improve the hoisting capacity of the main shaft and mine ventilation capacity. According to the on-the-spot situation and analysis of simulated result, it is unnecessary to change the hoisting equipment of the main shaft, but to enhance the hoisting speed from 8 m/s to 9.6 m/s, which is feasible through on-the-spot implementation, so the hoisting capacity can be enhanced to 0.88 million tons per year from its designed capacity of 0.63 million tons per year, and it is also unnecessary to have new investment; It is needed to improve the ventilation capacity, and the total input air quantity should be increased from 2550 m^3/min to 3000 m^3/min. This conclusion has provided the useful basis for managers to make decisions over middle and long term programming and reconstruction, and reduce the repeated investment and unnecessary financial loss.

V. The conclusion

The simulated result basically accords with the on-the-spot situation with the help of the SD model for checking and ratifying the production capacity of the mine, which is established by means of SD theory, and this model has a certain feasibility and effectiveness. Using this model we can analyze and determine the main factors which restrict the mine production capacity, and check and ratify the mine production capacity. It provides the basis for mine reconstruction, enhancement of the mine production capacity, new mine optimum design, planning of effective production, and managers' decision-making .

The conducted research has a certain social and economic effectiveness for further inquiring into the application of system dynamics theory in coal mines, exploring effective ways for checking and ratifying mine production capacity.

Reference

[1] Wang Qifan，"System Dynamics", Beijing, Qinghua University Press, page 151-200, 1988.

[2] Feng Xiwen, "System Dynamics Model of Production Control on Fully-mechanized Working Face ", Journal of Northeast University, 1994

[3] Wang Qifan，"Dynamic Analysis of Social economy Complex System", Shanghai, Fudan University Press, page 80-200, 1992.