http://ansinet.com/itj

ITJ

ISSN 1812-5638

INFORMATION TECHNOLOGY JOURNAL

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Information Technology Journal 12 (15): 3436-3441, 2013
ISSN 1812-5638 / DOI: 10.3923/itj.2013.3436.3441

Design and Application of Equipment Selection and Layout for Deep Shaft Drilling Based on Decision Support System

[1]Wang Bang-jun, [2]Zhang Xu-gang and [3]Shi Yun-feng
[1]School of Management, China University of Mining and Technology, Xuzhou of Jiangsu, 221116, China
[2]No 4 Division of China Coal First Construction Co. Ltd. Xuzhou of Jiangsu, 221000, China
[3]Engineering Department, Suzhou Anhui, 234000, China

Abstract: It is a complex task in the construction equipment selection and layout of drilling the over 1km. deep shaft. The designer should consider many factors, i.e. diameter, depth and hydrology, geological data of the shaft and its calculation is also enormous. Therefore, it has great theoretical and practical value that a design system considered for drilling project equipment selection and layout. This study, based on ideas of Decision Support System (DSS), especially aiming at more than over deep shaft's drilling equipment selection and layout, has analyzed theoretical research and practical application of its design system. The system is consisted of three parts, i.e., the dialogue, data and model subsystem, through the design of multi-menu approach controlling parts of the realization of human-computer dialogue in plug-in style and as far as possible dynamic design to improve system flexibility. The system is a new service carrier for deep shaft construction design with applied functions, for example, it can achieve the selection, layout and its optimization of drilling equipment and can also automatically generate the computing manual books, as well as its construction floor plan and section of equipment layout.

Key words: Deep shaft, shaft drilling equipment, decision support systems, selection and layout, designing

INTRODUCTION

Vertical shaft is widely used in coal, metal mines and military engineering. It acts as a key unit project while representing only 3.5-5.0% of the total mine construction engineering quantity, but its construction period often accounts for the whole project construction is 35-40% (CNCA, 1999). Taking the coal mine as an example, the vertical shaft has been used nearly half in new mine development since 2004 (Zhou, 2009). At present, in the deep earth resource exploration mining areas, many Chinese solid mineral exploration mining depth are less than 1000 m, however, some shafts have been excavated from 2,500 meters to 4,000 m in some developed countries' mining industry (Xu, 2008). There is a tendency along with the exploitation of mineral resources and gradually to the deep development trend, the large diameter (over 8 m), deep shaft (more than 1 km) to develop the proportion is increasing gradually in the future.

In general, several factors should been considered in deep shaft sinking when selecting and arrangement of main construction equipment: (i) The design diameter, depth and hydrology, geological data of shaft; (ii) Safety regulations and mine shaft construction in various specifications; (iii) Available to meet the demand of deep shaft requirements of construction equipment and construction provided by the enterprise's existing equipment and construction practices; (iv) The designer of human factors and so on. Therefore, it is a complicated design work which need to consider such factors in the kilometer deep shaft sinking equipment selection and layout. Only one design result is often difficult to reach the requirements of application site and a device changes will cause other parts and all equipment to selection needs to revise through relapsing and modifications. Further, due to a huge workload, it is often only based on the habit and experience of designer in sinking equipment selection and layout optimization. These factors present more optimized difficulties on shaft construction design (Gao *et al*., 2000; Tian *et al*., 2002; Jiang and Tang, 2003). Therefore, if consider adding computer automatic reasoning together with some necessary artificial interference from begin, construction design task will be simplified and reduced gradually.

Decision Support System (DSS), as a intelligent technology, is used widely in many fields in recent years, which is comprehensive of management science, operations research, control theory and behavioral science knowledge, with computer simulation technology as the means and also is a intelligent human-computer

Corresponding Author: Wang Bang-jun, School of Management, China University of Mining and Technology, Xuzhou of Jiangsu, China

interaction decision systems (Gao, 2009). DSS can provide required data, related information and background materials for decision-maker, which can help setting decision objectives and problem identification, establish or modify decision model. It can also provide a variety of options and various program evaluation and optimization, through man-machine interacted on function analysis, comparison and judgment, making designer with more decision efficiency, enhance decision-makers in-sightly and also provide necessary support for the process of decision-making (Jiang *et al.*,2003). Therefore, for realizing the equipment selection and optimization of deep shaft sinking, this study has taken the systems engineering theory as the guidance, combined the technology of decision-making support system, selected and designed the appropriate type of construction equipment in deep shaft sinking equipment layout and optimization, automatic generation of computing task book and equipment level, profiles and other functions and thus the new service tool for sinking task based on DSS.

ORGANIZATIONAL STRUCTURE AND WORK FLOW OF SHAFT SINKING EQUIPMENT SELECTION AND LAYOUT SYSTEM

Based on the DSS, sinking equipment selection and layout design system of deep shaft construction is consisted of three subsystems, i.e., dialogue, data and model subsystem. Its systematic structure is the orgamic combination of the three subsystems. Its system model structure is shown in Fig. 1.

Among them: (1) Dialogue subsystem: it is a man-machine interactive system and is also a interface between DSS and its user. The user inputs basic information and personalized requirements through DSS to the system, at the same time, system can provide the operation status and the final result for user through the man-machine interaction system.

Data subsystem: It includes the data collection and management system. The database is used to store large amounts of sinking equipment data and data management system for the management and maintenance of the database.

Model subsystem: It includes the model base and its management system. Model database is used to store the decision model which rules are based on management system library.

Dialogue subsystem: It is the interface for user to input data, as shown in Fig. 2.

The input data of subsystem mainly includes two parts, one part is the basic data of shaft which can not change, such as the net diameter, yield of shaft; another is the user's individual choosing data according to its own conditions, such as construction monthly schedule, construction technology and work mode, et al. User can

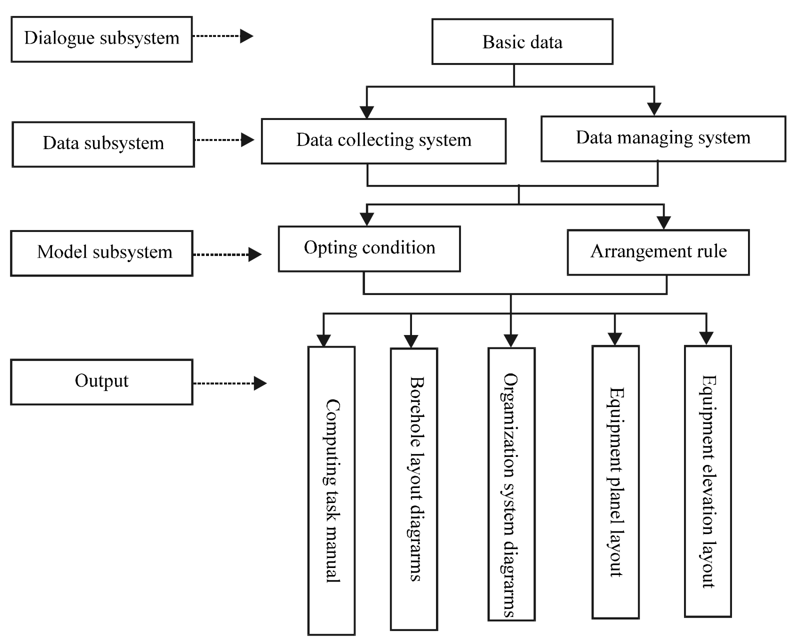

Fig. 1: Systematic model structure of deep shaft sinking equipment selection and arrangement

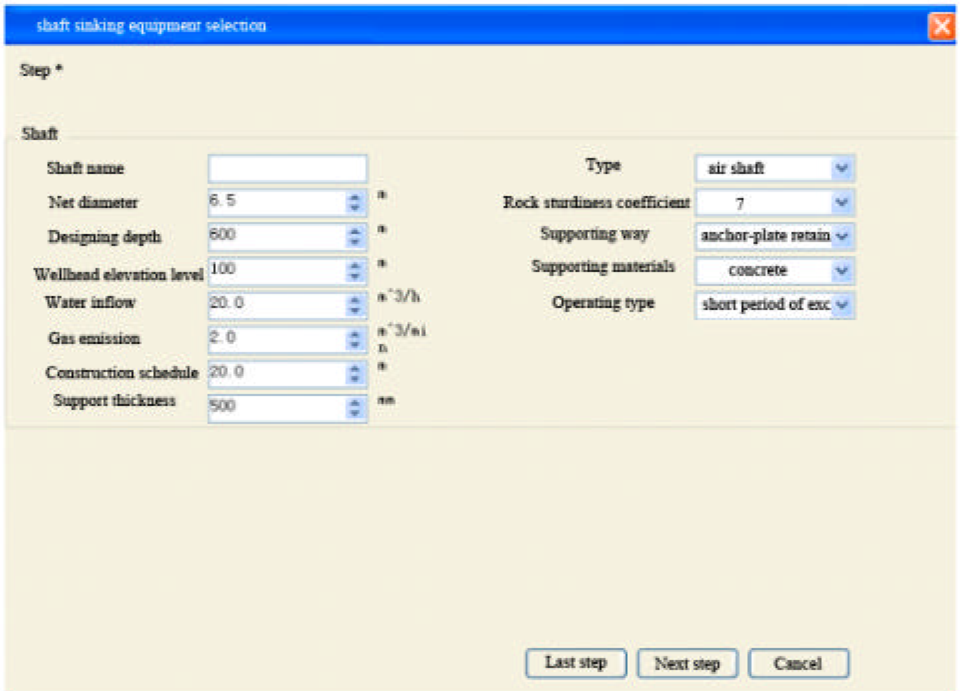

Fig. 2: Interface of system for user inputting

choose the system default data, or with his own requirements when inputting basic data. DSS can create a dynamic database which information provided by user through man-machine interactive system automatically.

Data subsystem: Data subsystem has the function of data collection and its management. Its database is used to store data and data management system is for the management and maintenance of that database. The design of data in the system can be divided into two categories: the static and dynamic data base. The static database refers to the established database, mainly by the shaft sinking equipment selection and layout database components, which includes derrick crane, hoisting bucket, pump, drill umbrella frame and all kinds equipment library of rock drilling machine, rock-seizing machine, hoisting machine, wire rope, template, head sheave, blasting data. It also contains the most current advanced sinking equipment, such as: the new VI type of umbrella drill derrick, hydraulic, HZ-1.0 central rotated rock-seizing machine, walking type hydraulic template, etc.

Dynamic database system is to establish and with the operation and change database in the running process, obtaining the required knowledge and decision making after the completion of data and its results are stored in the database, such as various individual requirements of user for shaft sinking equipment selecting.

Based on the Microsoft Corp's Access database, the system is formatting VB, •NET and internal database can convenient to the object operation. As a relational database, Microsoft Access consists of a table composed of a series of row and column and each row and column is served as a record. Each field is set to have individual name in the table and also formed by .mdb document.

Model subsystem: Model base includes two parts: One part is the layout condition, the other is selection condition.The knowledge and design rules of that two parts accordance with the current regulations, such as CSAWS (2010), coal mine roadway engineering construction standard (CCAC, 2005) and concise and shaft construction engineering handbook (Cui, 2010).

The three subsystems are independent mutually, interrelated and influence in the process of designing. They are completed in phases, such as database can be established before the choosing the frame, then it can be completed by the other two components, specific database later filled, so as to ensure the system efficiency, greatly simplifies on the design complexity of the sinking design system.

On the basis of these steps, the final results are output which include calculating task manual book, hole

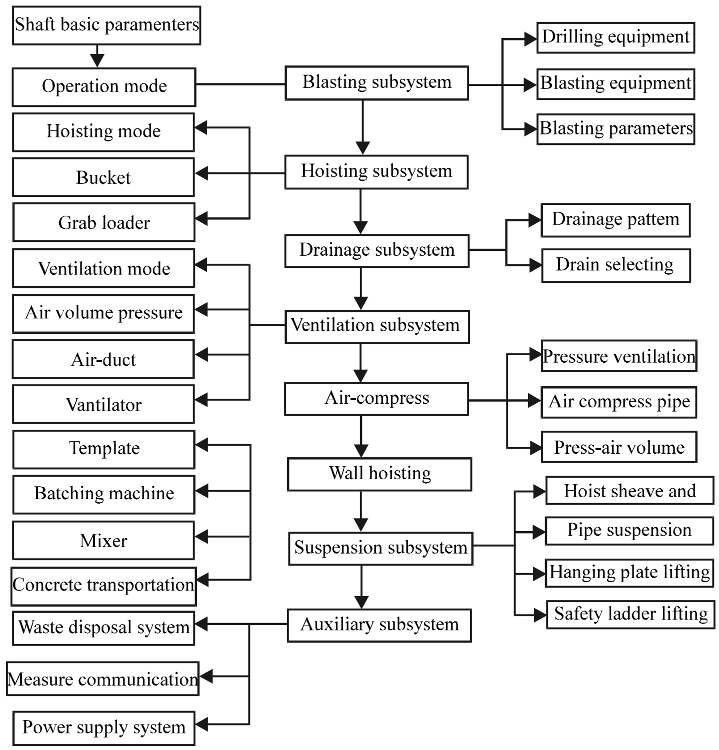

Fig. 3: Function subsystem of deep shaft sinking equipment selection and arrangement

arrangement, construction progress chart, sinking equipment layout plan, sinking equipment layout profile diagram, *et al*.

SYSTEM'S MAIN FUNCTION MODULE AND ITS TECHNOLOGY PRINCIPLE

Shaft sinking equipment selection and layout system is mainly used VB.net, Auto CAD, word development tools and it also use the researcher's own design platform which concludes program developing tools of vertical shaft construction equipment selection and arrangement. The system realizes human-computer dialogue through the design of multilayer menu control method for each part. It also served as plug-in management as far as possible on dynamic design.

The system's total menus include the file, menu view, shaft construction data and tools, gallery and help menus. All levels of the main menu functions as follows:

- **File menu:** It realizes function of set a new file, open, save, save, exit, et al.
- **View menu:** It is the main part of the display device properties, window scale, system background
- **Shaft construction menu:** It includes equipment selection guide and calculation task book, shaft stability plan and layout, twisted flat profile generation figures
- **Data menu:** The selection and arrangement of data operation functions are also included
- **Library menu:**. It is for equipment layout of equipment graphics library. For example, round shaft, generally rectangular shape of grab and lifting pump and steady vehicle based
- **Tools menu:**. User can define the data scope of selection and arrangement with it
- **Help menu:** It is mainly to provide user with some useful detailed information of the system

According to the commonly used steps on equipment selection method, the input strategy of the system is from the primary and secondary. The first step requires the user input the most basic data of the shaft, which including design and build diameter, depth of well level, strength coefficient of rocks, water inflow, absolute gas emission, wall material, plan construction monthly schedule of shaft, etc.

Secondly, when basic data has been determined, each subsystem can be used stepwise to selection required equipment. The subsystem order is followed as operating mode selection, blasting, hoisting, drainage subsystem, ventilation, air-compressed, wall hoisting and auxiliary subsystem. The subsystem specific distribution are shown in Fig. 3.

APPLICATION EXAMPLE

The coal mine of Shao Zhai belongs to Gansu Huaneng energy development limited company and its annual designing production capacity is 1.8 million tons and total investment is 15.71 billion yuan. Its auxiliary shaft depth is 878 m and the net diameter 8 m, shaft lining thickness is from 600 to 900 mm, concrete and reinforced concrete structure and its construction method is ordinary. Its expected normal gushing water is 35 m^3 h^{-1}, maximum in 71.3 m^3 h^{-1}, quaternary and bedrock weathering zone water is from 23.3 to 41.8 m^3 h^{-1}. The main characteristic parameters are shown in Table 1.

The user, at first, inputs basic parameters, then operates DSS on shaft sinking equipment selection and layout, so the calculation task book, lifting, suspension system equipment selection table which shown in Table 2 and borehole layout shown in Fig. 4. The ground stability cutter layout, flat profile can also be drawn automatically.

Table 1: Main technical characteristics of auxiliary shaft in coal mine of Shao Zhai

Name		Auxiliary shaft	Unit
Shaft	X	3874830.0	m
coordinate	Y	36484330.0	m
Shaft elevation		+1293	m
Net diameter		φ8.0	m
Net cross-section area		50.3	m^2
Shaft depth		878	m
Topsoil depth		288.7	m

CONCLUSION AND DISCUSSION

As shaft sinking equipment selection and layout is a complex design work, its design involves in many complicated factors that should be considered and its modifying is also a huge amount work. Therefore, a design system integrated sinking equipment selection and layout has many useful values. Based on the DSS, a set of practical drilling engineering equipment selection and layout system has been developed in the study, in order to realization of drilling equipment selection, layout and optimization, computational task book and shaft stability, twisted flat, sectional layout and the automatic generation of function, sinking equipment selection and layout of the new service tool thereby.

The design of the deep shaft sinking construction of DSS in the study is composed of three parts, i.e. the dialogue, data and model subsystem. Through the design of multilayer menu control method for each part, the realization of human-computer dialogue, the system uses plug-in management and as far as possible on dynamic design and it has very high scientific and flexibility that can be very good to the requirements in the construction of more than 1km. deep shaft.

At present, in the construction process of vertical shaft, it is often ready for the depth of below 1 km. and diameters less than 8 m in the choosing and designing construction equipments. In the future, there is a obvious tendency that large diameter (more than 8 m), deep shaft (over 1 km) to develop in the deep exploitation of resources increasingly. Therefore, it is necessary for

Table 2: Hoist and suspension system selection table of auxiliary shaft of Shao Zhai

Equipment name	Unit weight of wire rope (kg m^{-1})	Calculated height (m)	Wire rope mode	Safety coefficient Standard	Safety coefficient Calculating results	Model of winch	Wire rope length (m)	Quantity
Main hoist (4 m^3)	5.63	908	18×7+FC-38-1770	7.5	7.505	JK-3.5/20	1060	1
Auxiliary hoist (4/3 m^3 each one)	5.05	908	18×7+FC-36-1870	7.5	7.845	2JK-3.5/20	1060	1
Plate hanging rope (guide rope)	5.05	908	18×7+FC-36-1670	6.0	6.580	JZ-16/800	1000	7
Template suspension rope	3.51	908	18×7+FC-30-1670	5.0	5.220	JZ-16/800	1000	4
Umbrella drill hanging rope (grab loader)	3.99	908	18×7+FC-32-1670	6.0	6.190	JZ-16/800	1000	1
Drainage pipe hanging rope	6.24	908	18×7+FC-40-1670	6.0	6.300	2JZ-25/1300	1000	2
Air-duct suspension rope	1.26	908	18×7+FC-18-1670	5.0	6.000	/	1000	2
Safety ladder hanging rope	2.64	908	18×7+FC-24-1670	9.0	9.550	JZA-5/1000	1000	1

Additional description: Air-compressed and water pipes are fixed on shaft wall, Concrete is transported by bottom discharge bucket and (iii) Air-duct is suspended under shaft cover breakthrough in shaft construction, which including the key technology innovation in equipment and construction and its organization mode, used reasonably of sinking equipment selection and arrangement of shaft construction system based on DSS. So, it will improve the safety, stability and speed of the shaft construction.

REFERENCES

CCAC, 2005. Code for design of mine of coal industry (GB50215-2005). Coal Construction Association of China, Beijing.

CNCA, 1999. China Coal Society of Professional Committee of Mine Construction: Construction Technology of Shaft Sinking Technology for 50 Years in China. China Coal Industry Publishing House, Beijing.

CSAWS, 2010. Coal Mine Safety Regulations. China Coal Industry Publishing House, Beijing.

Cui, Y.L., 2010. A Concise well Construction Engineering Handbook. China Coal Industry Publishing House, Beijing.

Gao, H.S., 2009. Theory and Method of Decision Support System. 4th Edn., Qinghua University Press, Peiking.

Gao, Y.B., X. Zhao and Z.H. Zhu, 2000. The vertical shaft equipment selection expert system layout. J. Taiyuan Univ. Technol., 31: 447-450.

Jiang, Y.S. and R.S. Tang, 2003. On expert system design in shaft construction equipment selection. Nonferrous Metals, 55: 35-37.

Tian, H., W.J. Hu and Y.B. Gao, 2002. Sinking equipment layout system based on expert system. J. Baotou Iron Steel Inst., 21: 350-353.

Xu, H.N., 2008. Large diameter deep shaft construction technology optimization. Dissertation of Tongji University, China.

Zhou, X.W., 2009. Mine construction engineering technology. Proceeding of the National Mine Construction Conference, January 1, 2009, Hefei.