

# **Timeliness objective function construction method of pump scheduling in mine water disaster**

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## **Abstract:**

Water disaster, only next to gas outburst, has bad influence on the production of coal mine. Water pump is an important emergency resource to mine water disaster in coal mine. Regarding downhole air supply, food delivery and perforation and other actions in accidents as exogenous variables, this research focuses on the influence of the schedule of pump on timeliness.

Most current research describes emergency resource scheduling as a multi-objective optimization problem. Actually, a comprehensive effect that approaches reality should be observed under conditions of mutual matching and combined roles of objectives. This study combines two scheduling objectives, i.e., time and resource satisfaction, into a timeliness objective. Also considers the different contributions of pump arriving at different time for timeliness. And then constructs the timeliness function of pump scheduling. To make the timeliness function satisfy the qualitative understanding and quantitative relationship, the paper get some data more close to the reality by simulating mine water leaks and emergency mechanism. Based on these data, the paper search for and construct suitable function of pump scheduling timeliness.

### **1. Mechanism analysis of emergency response of mine water disaster**

Mine water disaster only happens when there are the source, channel and sufficient strength of water filling. The source of water filling mines include surface water, underground water and abandoned mine water; channels of supplying water link the source of water filling mines and coal mine. With different source of water filling mines, the development of water damage accident has different features. The abandoned mine water is strong but short; while the underground water is abundant and exist for a longer time; the surface water is relevant to precipitation intensity, time of duration and some ground conditions, such as river and lake and so on. In addition, the development of mine water disaster is also influenced by many other factors.

#### **(1) Three threats miners trapped underground will face because of mine water disaster**

Miners are often trapped in places of higher terrain underground and out of danger provisionally. However, if the water level goes up as to submerge the place where miners are trapped, they would be drowned to death; if the mine remains without air ventilation for a long time (miners are often trapped in a confined space), miners could be choked to death; if the water flux is of high quantity or deposited seriously, and thus cause delay the rescuing time, miners would be starved to death.

#### **(2) Rescuing actions for three threats**

The three threats correspond to the three time windows of opportunity, respectively are pumping water, providing oxygen and supplying food. Exceeding any one of the three time windows of opportunity will deprive the trapped miners' lives. The current rescuing actions are often taken by evaluating the three time windows of opportunity. With different speeds of water release and trapped places, the three time windows of opportunity will be ordered differently.

Taking action not only can extend time windows of opportunity, but also can change the order of the three time windows of opportunity.

(3) Factors influencing rescuing actions

a) Actions taken to extend the time window of opportunity for pumping water includes water pumping, water blocking, punching and artificial rain reduction.

b) Actions taken to extend the time window of opportunity to provide oxygen include compressing air downhole and perforating a hole and so on.

c) Actions taken to extend the time window of opportunity to supply food are to deliver milk and other liquid foods often through channel or by perforating a hole.

Whether the above-mentioned actions are taken effectively is influenced by the supply of needed resources (the quality, quantity of personnel and supplies and when they are delivered) as well as by on-the-spot command, among which the quality refers to work efficiency and the quality of personnel is mainly reflected on technological capacity. The arrival of the resources is also relevant to notification and collection of the resources. If the relevant units can be informed as soon as possible and the relevant personnel and goods and materials can reach at an early time, thus the three time windows of opportunity will be further extended.

2. Simulation of pump scheduling in mine water disaster

There is little relatively detailed data on the practice of emergency management. Therefore, we try to acquire some relatively practical data by using the method of simulation, based on analysis of water damage and its emergency response. The research will realize the simulation of water level underground which is influenced by the permeation rate and pumping:

(1) The permeation rate may vary, for example, the speed of incidentally excavated abandoned mine water is relatively larger in the beginning, but smaller later on.

(2) The speed of pumping may vary. Water pump is few at the beginning of the accident with low rate of work and slow speed. As more pumps are installed, the speed of pumping will accelerate. In addition, pump disorder (such as blocked pump), adjusting water pump, the position of water pipes, the size of position of installable water pump and structural complexity all can influence the speed of pumping.

When water level underground goes down to some extent, We can go to rescue people; when water level goes up, density of oxygen reduces or food is in short supply to some extent, the trapped miners' lives are at risk. Accordingly, we can know whether and when miners can be saved.

3. Structure of the objective function of timeliness of pump scheduling of mine water disaster

Find a proper function (such as Sigmoid function); construct a function through the combination, transformation and recursion of function; reflect quantitative relations between the timeliness of pump schedule and the time, quality and quantity of pumps. Specifically speaking, the following three aspects are needed: (1) In part I, based on the mechanism analysis, we tease out the emergency response procedure, factors influencing the timeliness of pump scheduling and some quantitative understanding; (2) In part II, we get some simulation data; (3) Based on many years of experience and knowledge of mine structure and features of water damage, the local mining experts have estimated various needs for resources in light of flow of water and environment when accidents happened.

**Keywords:** emergency management, emergency resource scheduling, mine water disaster, pump scheduling, timeliness objective function