MINE WATER UTILIZATION IN THE USSR NATIONAL ECONOMY

G. G. Voznjuk, V. A. Gorshkov

(USSR)

ABSTRACT

The paper briefly describes mine water utilization in the USSR. Mine water has been classified in accordance to it's pH value, degree of mineralization and composition. Water standards are described along with the consumers which require treated and untreated mine water. Usage of mine water in industry, underground coal mining, surface coal mining, coal preparation and agriculture are described. The economical contributions of mine water to the USSR national economy is also given.

INTRODUCTION

Annual volume of mine, quarry and drainage waters pumped out to the surface makes up more than 2 billion m^3, out of which mine water accounts for 70%, quarry water - 12% and drainage water - 18%. Owing to the similar composition and characteristics of mine and quarry waters fields of their utilization are also the same. Suspended solids, mineral salts, salts of heavy metals and also bacterial pollutants and petrochemicals are the main mine water pollution ingredients.

Mine water according to its pH value, degree of mineralization and their composition can be divided into three types :

- neutral fresh (pH 6.5-8.5, total residue up to 1 g/l);
- neutral with increased mineralization degree (total residue more than 1 g/l);
- acid (pH less than 6.5).

Each of the above mentioned type of mine water requires specific treatment before utilization. Water quality requirements of corresponding consumers who in their turn define the treatment degree are the governing factors of mine water utilization.

WATER STANDARDS

Mine water according to the actual standards: (ГОСТ*2874-73) "Potable Water", (ГОСТ 2761-57) "Potable Water Supply Sources" and also "Coal Mining Enterprises Arrangement and Maintenance Sanitary Rules" 1974 cannot be recommended for use as a potable and domestic water supply source. This is mainly explained by the fact that it is impossible to provide a sanitary water protection zone in the areas of active mine workings. After the proper water treatment or without it mine water is used for industrial water supply. Water discharge for the coal mining industrial needs according to the actual "Consolidated Standards of water consumption and diversion during production and processing of coal and shales" can be brought up to 20% out of the whole volume of mine water. Upon this the volume of water used will increase by 1.5 times as compared with achieved results. The rest of the mine water can be used at the adjacent enterprises of other branches of industries for land irrigation, recreational purposes and fish propagation (Fig.1) or can be discharged into the drainage network. Up to now at the coal mining enterprises mine water utilization in the whole volume of water consumption has reached 25%. The main water consumers are as follows: preparation plants - 50%, mines - 36% and quarries - 14%.

Treated and Untreated Mine Water

Drainage water is not contaminated with industrial products as mine water is, and can be regarded as a domestic water supply source without treatment or with water conditioning to get quality appropriate to ГОСТ 2874-73 "Potable Water". In Sub-Moscow coal basin drainage water is used for domestic and industrial water supply. In Kizel coal basin drainage water has found application for dust suppression in underground mining workings and also for potable water supply of settlements. The following general requirements are laid to industrial water utilization: to be harmless for the service staff health, not to possess negative organoleptic properties and corrosive action to metal and concrete, not to call biological growth and salt sedimentation, not to reduce the technico-economical indices of industrial process and not to provide breakdowns. Different consumers make various requirements for the quality of water used. According to the requirements put forward all consumers are divided into two groups. Consumers not laying specific claims to water quality are referred to the first consumer group: coal preparation, hydraulic transport, hydraulic mining, hydraulic stripping, preventive silting, hydraulic filling and others. They use mine water with the exception of acid and highly mineralized waters without any treatment. Consumers laying higher water quality claims are referred to the second group: steam and compressed air generation, conditioning and degasification, dust suppression and others. In this case mine water should undergo treatment.

* ГОСТ - All-Union State Standard

INDUSTRIAL WATER UTILIZATION

Let us consider different types of coal mining enterprises (mines, quarries, coal preparation plants, mechanical repair shops) with regard to industrial mine water utilization.

Various processes and types of production economic activities of mines are connected with potable water consumption D and industrial water consumption T. They have once-through D_p and recirculated D_R water supply systems and are characterized by the following main fields of water discharge :

Dust suppression	D, T - D_p
Hydraulic filling	T - D_R, D_p
Degasification	T - D_R
Air conditioning	T - D_R, D_p
Thermal power production	T - D_R, D_p
Compressed air generation	T - D_R
Preventive silting	T - D_p
Hydraulic coal production	T - D_R

UNDERGROUND MINE WATER UTILIZATION

Mine water utilization volumes mainly depend on fresh water resources in areas of coal mining enterprises location.

Dust suppression :-

Under the conventional technology of subsurface coal excavation dust suppression is one of the processes that needs much water.

In the whole water consumption volume water discharge for dust suppression is about 40%. To provide comfortable and safe operating conditions according to the existing rules and "Instructions for dust control in coal mines" water discharge for various industrial processes is characterized by the data given in Table 1.

Table 1 - Water discharge for dust suppression

Fields of water discharge	Measuring unit(s)	Discharge rate
Water forcing	l/t	25
Irrigation during coal excavation from working faces	l/t	50
Water curtains arrangement during coal excavation and opening driving	l/min	30
Irrigation during preparation works	m^3/m	0.6
Irrigation at the loading points	l/t	10
Irrigation during conveying transportation	l/t	10
Irrigation during coal and rock reloading	l/t	15
Irrigation at the repouring points of the surface complex	l/t	8

Percent water discharge for dust suppression, on the average in coal industry, is presented in Table 2.

For dust suppression in underground conditions potable water should be used in compliance with ГОСТ 2874-73. However in the areas of fresh water shortages utilization of mine water treated to achieve potable water requirements is admitted. Utilization of treated mine water instead of potable water is allowable after the permission of local sanitary authorities has been received.

Table 2 - Water discharge for dust suppression in underground coal mining

Fields of discharge	Discharge, %
Second working	31.8
Preparation works	11.4
Transportation of rock mass	35.9
At the surface complex	9.1
Others	11.8

Donetsk and Karaganda coal basins, deposits in the South Urals are referred to such areas. Thus in Karaganda basin for a complex dust suppression mine water, disinfected and cleaned from suspended solids, is used with a salt content about 9 g/l, in Donetsk basin - 5 g/l and in Chelyabinsk basin - 7 g/l. At some mines water treatment plants like "Don" specially made for treatment of mine water for dust suppression are applied. Surface facilities for treatment of mine

water to remove suspended solids with after-treatment are the main means of treatment. Commercial tests of compact vibrofilter apparatus have been passed and are under preparation for serial production. In future they should substitute for state-of-the-art sedimentation and filter facilities.

Hydraulic steering

In hydrofilling water is a transporting medium, therefore no special requirements are made for its composition with the exception of odor, the amount of which should not exceed 3 and pH 6-8. Water volume needed for the filling of I m^3 of mined-out area is defined by the T:K ratio, ranging from 1:3 to 1:15 and a mined-out area filling factor assuming to be 0.9-0.95.

In recirculated water system, when hydrofilling complexes with water distributors are used, water discharge for the operation of such system is taken as 0.15 out of the once-through discharge.

Fire Fighting

For prophylactic silting to prevent endogenic fires slurry with the T:K ratio 1:3-1:5, depending on the season, is used. Water used is filtered off into mine workings and mixed with mine water. Water provides for self-ignition of coal even in the absence of mineral impurities. Mineral salts or salts of heavy metals contained in water are catalysts or inhibitors of coal self-ignition processes, nevertheless water treatment is not expedient. The limiting indices are odor (no more than 3) and pH (5.5-8.5). These conditions are met with about 90% of raw mine water.

Hydraulic Mining

In hydraulic coal mining separation of rock mass from the massif and transportation it to the surface is carried out with water. For these purposes only mine water is applied. Water supply system is recirculated. Composition of mine water for replenishment of recirculated systems should have the characteristics listed in Table 3.

Table 3 - Water requirements for hydromining

Characteristics	Measuring unit(s)	Value not more
Temperature	°C	26
Suspended solids	g/l	50
Ether soluble matter	g/l	5
Odor	amount	3
pH		5-9.5

MISCELLANEOUS USAGE

At hydromines excess mine water after proper treatment is transferred to other consumers. As a cooling medium mine water is used for degasification stations, conditioners and compressed air generation. Water composition requirements are determined by the structure of heat exchangers. Mine water is subjected to treatment for suspended solids removal and, if necessary, to softening. Mine water used for boiler units during thermal energy production is undergone an appropriate water treatment which depends on the composition of raw water. Water treatment provides for dealkalization, softening, reduction of iron content and total dissolved solids (TDS).

At "Petrovskaya" mine in Donbass brackish mine water desalinated by electrodyalisis has been used for boiler house. In Kuznetsk, Sub-Moscow and Chelyabinsk basins fresh mine water is widely used for thermal energy production.

WATER UTILIZATION IN SURFACE MINE

In surface coal mining mine water is applied to the following main industrial processes: dust suppression, production of thermal energy and compressed air, maintenance of road transport mechanisms and hydromechanization of stripping.

During a year dust suppression in quarries is accomplished periodically, mainly in summer, taking account of coal and rock humidity and duration of precipitation. In excavation zone and repouring points for dust suppression potable water is used while in other sites treated and disinfected mine water.

Hydraulic mechanization of stripping needs much water. Its discharge makes up more than 60% of water used in quarries. Water is a working and transporting medium. Water supply system is recirculated. No special requirements for water composition with the exception of pH value (5.5-8.5) and odor amount (up to 3) are made. Water volume for replenishment of recirculated system reaches 0.5 m^3/m^3 of overburden.

MINE WATER UTILIZATION IN COAL PREPARATION

As it has been already shown wet-milling plants are the main mine water consumers. The most water consuming processes are : technological processes of preparation, thermal energy production and generation of compressed air. Technological processes of wet preparation are accomplished according to water recirculated system. Water is used for replenishment of free losses. Losses of water substantially depend on the class of cleaned coal and the degree of its preparability. Thus in preparation of coal up to the size 0 mm water discharge according as the degree of preparability is ranged from 0.9 to 1.2 m^3/t, but up to the size +13 mm - from 0.15 to 0.4 m^3/t. An average water discharge for preparation of coal and shale makes up 0.4 m^3/t. In technological process of preparation mineralized mine water (of the sulphate class) takes an evident advantage over fresh river water of the bicarbonate class. With the content of sulphates about 5 g/l floatation processes for Donetsk coal are carried out with

fewer expenditures. As a rule, for replenishment of recirculated systems mine water with TDS to 7 g/l and suspended solids content to 5 g/l is used.

MINE WATER UTILIZATION IN AGRICULTURE

In the areas of coal mining operations mine and drainage waters under their proper utilization can serve a perspective source for agricultural crops irrigation. Up to now some experience of mine water utilization for fodder grass, food/bread grains and vegetable irrigation has been gained. Irrigated land areas in Donetsk basin make up about 20 thousand ha. Agricultural lands have been subjected to irrigation in other coal basins too. Mine water utilization with salt content up to 2 g/l mainly gives positive results. In some cases utilization of mine water with increased salt content up to 3 g/l has resulted in land salinization. To determine mine and drainage water utilization possibilities for agricultural crops irrigation, land, irrigational, biological and agrochemical assessments have been carried out. According to them up to 40% of mine water in Donetsk coal basin, 30% in Chelyabinsk coal basin and 70% in Sub-Moscow coal basin can be used for agricultural irrigation.

ECONOMICS OF MINE WATER UTILIZATION

Arrangement of ponds and reservoirs is one of the main ways of mine water complex utilization enlargement. Rain and precipitation water along with mine water will be accumulated, leading to mine water dilution and its quality improvement. Mine water utilization results not only in ecological conditions improvement, but also in a significant economic effect. As it was shown above for a number of technological processes and production in compliance with water quality requirements mine water can be used without any treatment. In such cases the value of water is determined only by costs of sewerage from the place of discharge at the mine to the place of its utilization. Our experience shows that treated and disinfected mine water can substitute for potable water. According to our calculations mine water utilization in Karaganda coal basin gives an economic effect up to 350 thousand roubles annually, and in Donetsk coal basin more than 6 million roubles.

An annual profit of mine water utilization P_{MW} is calculated from the following expression :

$$P_{MW} = [D_1 - (C * \varepsilon_1 K)] Q_a + P_A$$

where P_{MW} = Annual profit from mine water utilization

D_1 = price of 1.0 m³ of potable or service water received from underground or surface sources, roubles

C = cost of 1.0 m³ of mine water used (treated or untreated), roubles

ε_1 = normalized efficiency factor for capital investment

Q_a = Annual volume of mine water used m³

P_A = Annual profit from product realization during mine water treatment

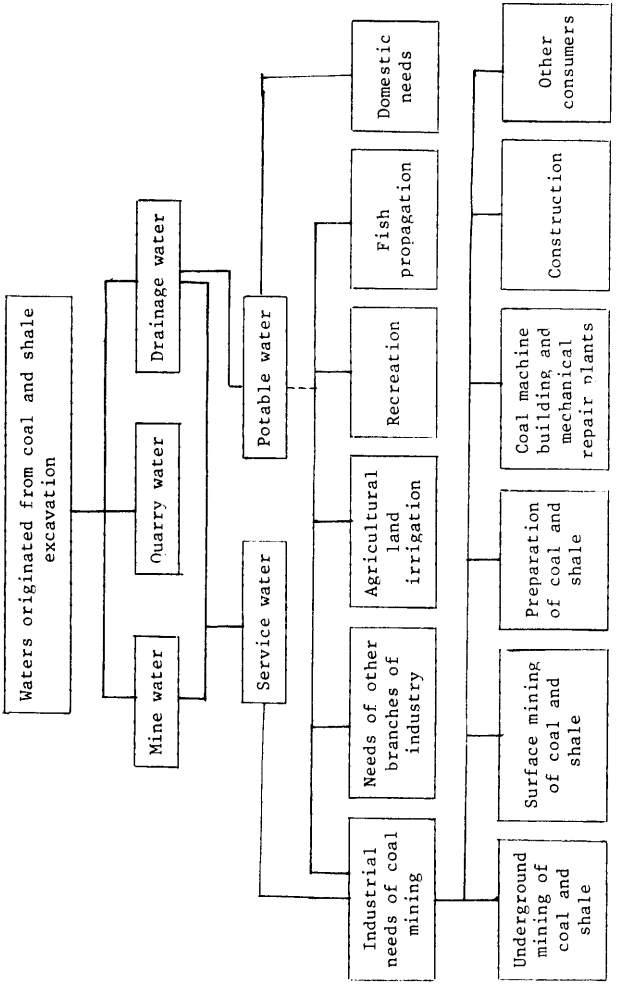

Fig.1. Fields of utilization of waters originated from coal and shale excavation