APPLICATION OF INDUSTRIAL ECOLOGY IN RECYCLE ECONOMY OF MINING

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ABSTRACT

As one of the world's biggest depositors of mine, China is undergoing rapid industrialization of mining. In this paper, the nature of industrial economy is illustrated based on the theory of recycle economy, and the new discipline of industrial ecology as an amalgam of concepts and techniques is introduced to provide the framework for stage-specific optimization of factors in mining. Conducted by the concept of industrial ecology, construction of recycle economy in typical mining area in Xuzhou city is investigated, and the constraints to mining industrial sustainability have also been analyzed. It shows that the Closed-loop chains and industrial symbiotic webs are the technological key and core of successful initiatives in the application of industrial ecology compared to the traditional technological support methods-cleaning production, waste reuse, pollution control etc. Besides, a higher compatibility of dematerialization, Ecology recovery technology with the industrial system, as studied in industrial ecology, can result in lower resource extraction and reduced waste emission, contributing to a better industrial sustainability. In addition, an effective decision-making tool on material and process substitution is needed in the design process.

Key words: Industrial ecology, Closed-loop chain, Ecology recovery, dematerialization, Mining city.

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INTRODUCTION

The ecological utilization of resource is a new demand to the mining industry for sustainable development which behaves the transition from the mode of spontaneous utilization of resource to that of systematical utilization. For this reason, the ecology utilization of resource is the only approach to sustainable development.

As an important base of energy source in Jiangsu province of China, Xuzhou city is a typical mining area, and its economy is characterized by high investment, increasing consumption of natural resources, low efficiency in the process of production, very high emissions to the environment, and an industrial structure that lacks closed loops and other structural efficiencies. It supplies a lot of energy sources raw and processed materials to society, but also it impacts the environment of the city seriously. Hence, conducted by the concept of industrial ecology, construction of recycle economy in typical mining area in Xuzhou city is investigated, and the constraints to mining industrial sustainability have also been analyzed.

RECYCLE ECONOMY OF MINING

Ecology chain-loop design of mining

The matter of ecology chain-loop design is to set up the industrial production mode both beneficial to ecology and economic profits, which based on the ecology mechanism to systemic configuration of closed-loop chain and the profit mechanism to systemic inducement of that. The concept of closed-loop chain of renewal resource is introduced to the recycle economy of mining, which is unrenewable resource. The theory of ecology closed-loop design changes the traditional mode of “exploitation-coal selection-coal production”, which goes with exclusion of a great number of solid waste such as minestone and peat, mine water, waste-gas and mining-induced subsidence areas, into a ecology mode. The additional loop chain to the closed-loop chain consists of production chain of “minestone-electricity-building materials”, which could also be expanded to the chain of “recirculated cooling water of electricity generating station—livestock breeding in mining-induced subsidence areas—ecotourism”.

Ecology industry

Industrial ecology has been guided by the quest for production and consumption processes that minimize waste generation and, thus, environmental impact (Ruth M., 2006). It is largely driven by engineering approaches to increase material and energy efficiencies of specific processes, and by a systems perspective that calls for shortening or creatively combining process chains so that undesired intermediate pro-ducts can be avoided or used elsewhere in the system. Most research so far has concentrated on accounting tools to trace material and energy flows, to provide life cycle assessments of products and to guide investments and policies to minimize adverse environmental impact. Fig. 1 presents a conceptual framework for industrial ecology applied at different scales of spatial and economic organization, evaluating alternative management options using different types of information, tools for analysis, and criteria for performance evaluation (Diwekar U., 2005).

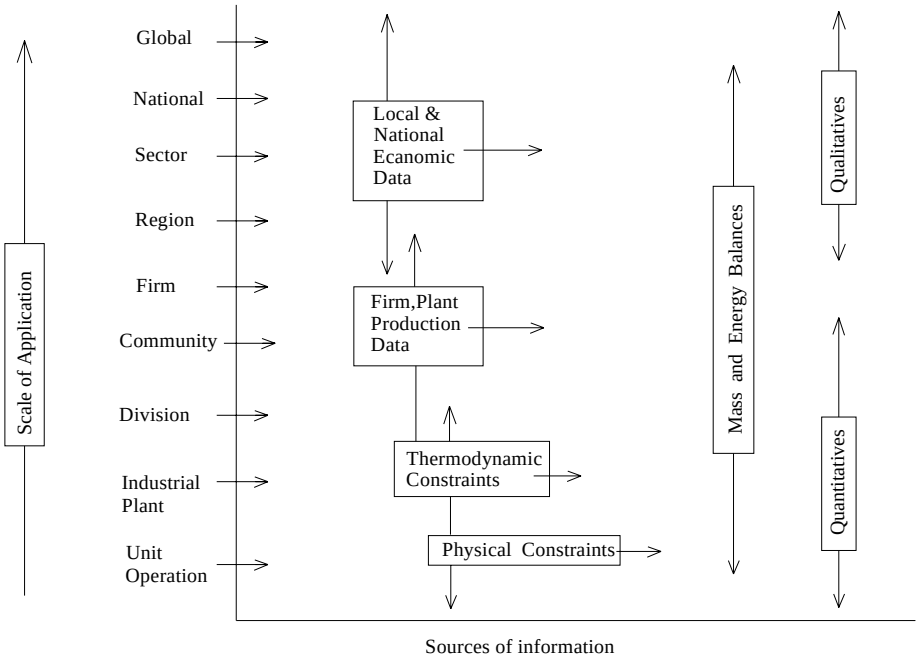

Figure 1.: Conceptual framework for industrial ecology.

TECHNOLOGY AND WAYS TO DEVELOP RECYCLE ECONOMY OF MINING

The construction of recycle economy mode of mining is based on the technology which is harmless or beneficial to environment, which includes the less contaminative and no contaminative technics of waste preventation and the terminal technology of waste control Table 1. lists the main technology and ways to develop recycle economy of mining (Zhou M., Zhu Y.L., Wang L.P, 2006).

Table 1.: Technology and ways to develop recycle economy of mining

Technical classification	Concrete measures	purpose
Clean production technology	Green exploitation, callback of coal, clean coal burning, underground gasification of coal, production of new building material, etc.	Lower resource extraction and reduced waste emission
Waste utilization technology	Reuse of mine drainage water, generating electricity by burning slime, multipurpose utilization of minestone and fly ash, utilization of surplus heat in cement stove, etc.	Utilizing material and energy effectively
Pollution treatment technology	Disposal of mine drainage water, dust removal of furnace gases, flue gas desulfurization, Reclamation of coal mine area, etc.	Pollution control, end-of-pipe waste treatment

Ecological restoration technology	Mine reclamation, ecotourism ,culture construction, etc.	Resuming the ecology function of circumstance
others	Environment information system and monitoring technology, coal chemical technology, etc.	Insuring the actualization of recycle economy

At present, the technology of cleaning production, waste utilization and pollutant management have already matured, and are popularized in the mining successfully. The resumption technology of ecology and others such as soft link technology for matter transfer and so on are necessary to develop for the recycle economy of mining. The key to resume ecology of abandoned mining at present is to achieve the transfer of paying attention to profit excessively to the exploitation of nonmaterial service function. the below ways are used chiefly.

Application of mycorhiza on mine reclamation

Mycorrhizal fungi cover roots and rootlets with a thick mantle of hyphae, effectively enlarging the surface areas of the roots in contact with clay minerals and soil pores that are not accessible to the root hairs. The finest lateral root-lets, which can have a very short life and remain unbranched when not colonized, respond to mycorrhizal infection by growing for a longer period of time and by branching, which is highly metabolism-dependent and partially related to the ion exchange between soil clay particles and roots and thus may enhance mineral nutrient uptake by plant roots. Now, application of mycorhiza on mine reclamation is being widely researched.

The integrative exploitation is carried into execution based on the characteristic of the city, mainly to the mining-induced subsidence areas. For example, the high-grade farmlands, the commercial orchard, the characteristic truck farm, aquafarm and ecotourism park are built after mine reclamation.

Mining travelling culture

The main purpose of industrial ecology is to evaluate and minimize impacts from economic activities. Tourism, as an economic activity, results in a full range of environmental impacts and should be regarded as any other industry. Hence, the application of industrial ecology in tourism was investigated to enhance environmental management of catering (Kuoa N.W., Hsiao T.Y. and Lan C.F., 2005). When the coal mine is facing the problems of drying up or being discarded of, the industrial tour can be exploited to found the ecology journey and mining culture after the equipments of these mine being maintained.

Ecology community of mining

The areas including no resource mountains and fragmentation zones can be planted at large in the mining community by pomiculture; the disused mining can be used as fishponds; the

rest rooms are built for miners in the exquisite and convenient regions where the basic equipments are constructed. Based on this, the compounds of nature, industry and society are built linking to the foundation of city.

PRIMARY MODE OF THE RECYCLE ECONOMY OF MINING

Efficient actualization of cleaning production

Xuzhou Coal Mining Group Corporation is a great public corporation which mines more than 16 million ton coals per year. Since 2001, the cleaning production process has been extended widely and the audit to this has been entirely finished among the main mining. Until 2003, 164 cleaning production projects have been actualized which induce the consumption index and pollution discharge dropped rapidly. The integrative consumption of energy per 10million coal falls 25% during the 10th Five-year Plan period than the 9th Five-year Plan period.

Xuzhou General Iron and Steel Works is a state-owned enterprise aggregating pig iron and coke with 5 pudding blast furnaces and 4 rows of charred furnaces, leading the great energy consumption and heavy pollution. The scruff and slag are discarded 200kt per year and 240kt per year, respectively. In recent years, many measures are adopted to increase integrative utilization to reduce pollution and improve performance. First, a product line of hollow block of 2 million per year is founded to consume 70% of the slag. Second, the thermoelectricity station of the capacity of 120,000kw is built which reclaims the exhaled gas from blast furnace and charred furnace to offer heat for boiler. It radically solves the contaminated gas which discharged to air previously. Third, the scuffs are selected separately, the high iron content of which are reclaimed to the furnace, and others are sold to cement plant.

More than 200kt solid waste per year such as fly ash is used to produce cement and aerated concrete in the Julong Cement Plant. The second chemical engineering factory of Lion Mountain not only utilizes the leavings of the oil factory to produce 4 groups of chemical manufactures containing more than 20 kinds such as fatty acid and so on, but also reclaims glycerin from waste water and distills fat from waste residue produced by process. There are nine resource comprehensive utilization power plants in Xuzhou, which have a power-generating capacity of 16.2 million kw, consuming 807kt minestone, 300 kt coal mud, 0.52 billion cubic metres of coal gas and 80,000ton of castoff such as crop stalks and sawdust. Efforts have been stepped up to save energy and reduce consumption. The capability to treat waste gas, wastewater and industrial residue (the "three wastes") has been enhanced and the comprehensive utilization amount of these materials has been increased. There are 300 enterprises of this type with the comprehensive utilization rate of 3.7 million ton per year. The solid industrial waste is consumed for 65,665,000 ton and the utilization rate reached 92.47% during the year of 2003.

Preliminary design of green closed-loop chains of mining

The Pangzhuang mine of Xuzhou have finished more than 60 comprehensive management items and acquired commercial profit of more than 0.06 billion yuan by preventing waste and utilizing "three wastes" comprehensively. The mine persisted in the integrative utilization of minestones as a key to develop the industry, and successfully uniforms the commercial benefit, society benefit and environment benefit to the way of sustainable development. First, backfill with the minestone. The engineering technology of this foundation engineering has passes the identification of Science and Technology Office of Government. By this technology, more than 2300 kt minestone has been used, with 4 seats of minestone mountains being removed and. 39ha. of mining-induced subsidence areas being backfilled. Second, comprehensively utilize the minestone. The production line of low heat-value coal with the annual output of 200kt has been built which enhanced the commercial benefit of mine. Third, Generate electricity with minestone. A steam supply and power generating plant with a bed combustion boiler (installed capacity of 6000kw) is built to transfer the minestone resources into clean electrical energy on the spot. Furthermore, the coal ash and slag produced by boiler is also fully utilized. Since fly ash particles are flame-resisting, the water after being used for dust removal in boiler which contains fly ash particles, can be used to injected into the mine goaf for fireproofing, instead of using slurry.

Besides, the technology of mine water reuse is developed actively in the Coal Mining Industry Companies. In 2 mines of Datun Coal and Electricity Corporation, 8 mines of Xuzhou Coal Mining Group Corporation and so on, the mine water is widely used for residential use, pure water production, bath, virescence, ash cleaning, recirculating water cooling and so on.

Additional loop design of green closed-loop chains of mining

Recently, the industrialization of waste treatment is developed quickly in Xuzhou city which draw a series of policy measures. Since 1996, 0.4 billion has been ploughed into introducing equipments and technology for more than 50 technological renovation programs. The technology of substituting minestone and fly ash for clay as main material for block masonry wall is popularized. At present, the solid wastes have been gradually given priority to use instead of accumulation. The innocuity, reclamation and merchandizing of solid wastes have been achieved. Especially, the slag, water residue and minestone have been widely applied to the building material and electric power industry. The boiler slag and water residue are sold out well and the price of these gradually rises.

Comprehensive development of the mining-induced subsidence areas

The mining-induced subsidence areas is an inevitable problem of excavating coal which have reached 17,333 ha in Xuzhou city. Since 1998, the integrative item of mining-induced subsidence areas has actualized. Six treating modes have been introduced to adapting the various instances according a series of subsidence areas. This induced the water system in the sinking area dredged, roads checkless, and soil which can't be planted in renewed.

According to statistics, the total reclamation area is 8,666 ha, adding infield 10,000 ha, area of planting foodstuff in the exploitation item 43,333 ha, that of high-quality vegetable 1,333 ha, high-quality woods 10,000 ha, water breed aquatics 10,000 ha and so on which induce the new production value 78million yuan. Five characteristic regions have been built such as zones of high-quality nice and wheat, commercial woods, characteristic vegetables, freshwater breed aquatics and farming for tour as dominant industries in the mining-induced subsidence areas in Xuzhou city.

APPLICATION OF INDUSTRIAL ECOLOGY IN RECYCLE ECONOMY OF MINING

After several years of efforts, the study of multipurpose utilization of resource has been gained success. The mode of recycle economy is progressed by exploration and practice at the micro-level and meso-level. In order to further develop industrial ecology economy, transfer the mode of spontaneous utilization of resource to that of the organized utilization and found the basis of sustainable development of industrial system in the new mining city, the design of ecology closed-loop chains are carried out to develop the recycle economy of mining based on the theory of ecology industry (Wang L.P., Zhao Y.R., Zhou M., et al, 2005). Fig. 2 illustrates the design of industrial ecology in recycle economy of mining in Xuzhou.

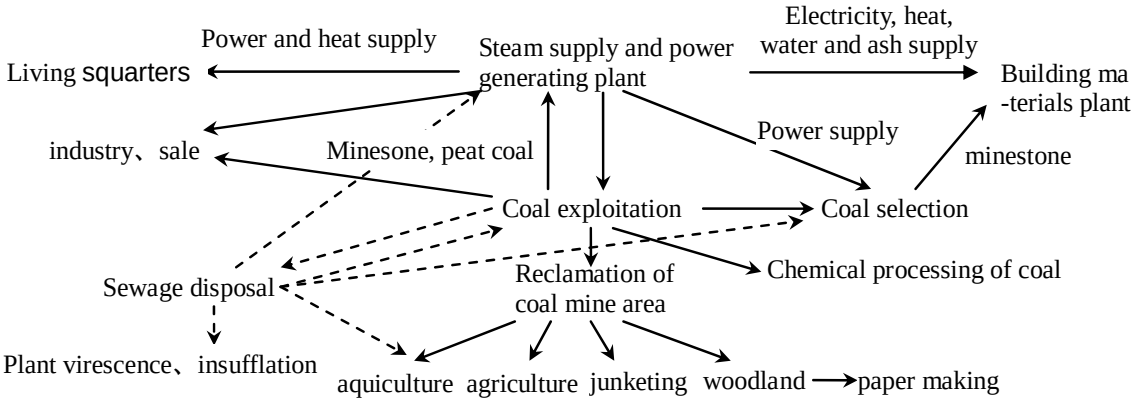

Figure 2.: Design of industrial ecology in recycle economy of mining

The coal mining is a preponderant and conventional industry in Xuzhou city. Recently, the items of high value-added which are Kengkou Power Plant, the depollution of coal, coal chemical processing, coal-water slurry and so on are developed actively. The transportation of electricity instead of coal is one of the important stratagems for adjusting industrial structure. At present, the installed power generating capacity has reached as much as 6,000,000kw. Until the end of the 11th Five-year Plan period it will achieve 10,000,000 to 15,000,000kw. The integration project of coal-electricity-aluminum is carried out to unceasingly prolong closed-loop chain. A series of major energy projects of high value-added such as coal chemical processing is practiced to accelerate development of energy

resources to be efficient and clean. The primary work is processing at present for the chemical engineering item of methanol of 600,000 ton per year in Peixian. The item of high technical and high value-added is processed to further upgrade the predominance of coal mining industry in Xuzhou city.

It is feasible for the integration project of coal-electricity-building material. The mineston, fly ash are widely used to road building, mining-induced subsidence areas reclaiming, electricity generating to heat, building materials and so on. The utilization rate of industrial solid wastes keeps in 90% near these years. The solid wastes have been utilized as one of important measures for reducing production cost in the corporation. It is a self-conscious action. At present, the dregs ratio into cement has reached as much as 30%, and that of new wall material 60~90%.

The National Government will also have to ensure that solid policies are developed to encourage the implementation of the recycle economy. These policies will have to be supported by both economic reformation and incentives. In addition, an effective decision-making tool on material and process substitution is needed in the design process.

CONCLUSIONS

The ecology utilization of resource is an effective way for the sustainable development. It can result in lower resource extraction and reduced waste emission, contributing to a better industrial sustainability. The application of ecology industry to the recycle economy of mine, that is, the research of city industrial ecosystem in the mine, constitutes the design of ecology closed-loop chains and the primary mode of cycle economy in mining city by introducing the concept of ecology closed-loop chains of regeneration resource and dematerialization. The integration project of "coal—electricity—building materials" and "coal—agriculture—Tourism" is developed, changing the simplex mining into the integration of industrial ecology. It offers the feasible precept for the adjustment of industrial structure in mine and the employment problem, and promotes sustainable development of mining city.

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