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Environmental Impact Analysis Based on Life Cycle Energy Analysis Extended Two New Viscosity Reduction Technology

Li Dan, Guo Jixiang, Zou Lele

***Abstract*— Doped thin viscosity reduction technology is the traditional heavy oil viscosity reduction technology, the complex viscosity, oil soluble viscosity reduction technology are two new types of heavy oil viscosity-reducing technique. Different production process is accompanied by a certain environmental emission, in order to identify key emission process, find the fundamental way to reduce emissions, and to reduce the environmental pollution of the application of the viscosity reducing technology is an important issue. With two new visbreaking technology as the research object, based on life cycle method, combined with resource consumption and environmental emissions in the process of the heavy oil exploitation, study on the contribution of different production processes to global warming potential (GWP) and (AP) acidification potential, photochemical smog and other types of environmental impact. The results show that underground oil production process is the most influential process, the contribution rate of the underground oil production process to GWP is more than 80%.the contribution rate of AP and photochemical smog are more than 90%. Reducing the energy consumption of key emission link, improving the energy utilization rate and updating the nitrogen and sulfide purification facilities are significant for realizing the environmental friendly production of viscosity technology.**

***Index Terms*— complex viscosity reduction, oil soluble viscosity reduction, environmental effect, life cycle approach**

1. INTRODUCTION

China[1] is rich in heavy oil reserves, the proven reserves reached 16×10^8 tons., which can be mainly distributed in Xinjiang, Shengli, Liaohe, Henan and other oilfields. Land resources of heavy oil in China accounted for about 20% of the total resources of oil above. Heavy oil exploitation is an important issue, mixed thin viscosity technology is widely used on the thick oil mining field currently. Composite viscosity reduction technology and high efficiency oil soluble viscosity reduction technology are two new types of chemical viscosity reduction technology, Blending light viscosity oil production is injected through the tubing or casing annulus to the bottom of the thin oil wells, so heavy and light oil formations mixed output, thereby reducing its viscosity and heavy oil and heavy oil column pressure. Mixed thin viscosity technology is injected through the tubing or casing annulus to the bottom of the thin oil wells, the light oil and heavy oil from stratum are fully mixed, thereby reducing the viscosity of heavy oil and heavy oil column pressure and flow resistance, increasing production bottomhole pressure, so that restore the spray oil production or to achieve the purpose of mechanical oil extraction, as in [1]. Complex viscosity reduction is to combine highly effective composite reducer with wellbore lift technology effectively to achieve ultra-heavy oil which is difficult to extract successfully lifting to the ground from the well bottom. Oil soluble viscosity technology is a new type of technology of viscosity reduction which is developed on the basis of flow agent technology, the research and development of effective oil soluble agent overcome many disadvantages of previous traditional oil-soluble viscosity agent, alleviate the light oil resources tensions. The field application of oil soluble viscosity reducer is successful developed by He Xiaoqing, as in [2]. Combined with heavy oil recovery technology, the scope of application of oil soluble viscosity reduction will be more widespread.

While heavy oil exploitation promoting local economic growth, a certain degree of environmental pollution and ecological destruction arised. Ensure the environmental effects of heavy oil mining technology is an important premise and guarantee for oil and gas field development and construction. With the development of oil prominent environmental problems, many scholars have carried out a survey on the environmental impacts of petroleum exploitation. Yi Yong has analyzed the ecological environment effect in the exploitation of Daqing oil field, as in [3]. Put forward the principles and objectives of ecological planning. The atmospheric, ecological, soil and water environment in the development and construction of Liaohe oil field were analyzed by Zhang Changnan, as in [4], and the suggestions for strengthening the pollution control and environmental protection in the development of oil fields were put forward. At present, there are almost all the research on the environmental impact of oil production process, and lack of the environmental impact assessment of the various links in the application of heavy oil viscosity reduction technology; Environmental impact type is mainly for the direct impact of the groundwater, soil, atmosphere and so on, such as global warming, acid rain, photochemical smog environmental impact analysis are relatively less.

In this research, with typicality and universality of M oilfield as a case study, which is rich in oil reserves and the exploitation of heavy oil technology is relatively mature. Based on the life cycle method, we analyse and evaluate the

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environmental impact of the composite technology and the high efficiency oil soluble viscosity reduction technology. Life cycle assessment (LCA) is a environmental assessment methods with comprehensive range and wide application field, which can make up the deficiencies of traditional "pressure - state - response" (PSR) framework model without combining qualitative and quantitative evaluation together, as in [5] ,overcome the disadvantages of the single factor method that the evaluation process is too simple, as in [6]. There is no similar report on the study of the environmental impact of the LCA on viscosity reducing technology. Therefore, this paper uses LCA method to take a complete environmental impact analysis on the new viscosity reduction technology, calculate environmental emission inventory of viscosity reduction technology, then get the contribution situation of the of each main process on the environmental types such as global warming (GWP), acidification (AP), photochemical smog and so on. Find the main reason for environmental pollution, provide basis and suggestion for the green application of viscosity reduction technology from the source.

2. RESEARCH METHODS AND DATA PROCESSING

A. Life Cycle Assessment Model Description

Life Cycle Assessment(LCA) is a process about evaluation of the product, technological process or activity from the collection and processing of raw materials, transportation, sales, use, recycling, conservation, recycling and final disposal of environmental load related to the entire life system[7].

With the continuous progress and improvement of LCA, environmental impact assessment essentially consists of four interrelated components, including goal and scope definition, life cycle inventory(LCI), life cycle impact assessment(LCIA) and life cycle interpretation. The evaluation process[8] as is shown in Fig.1

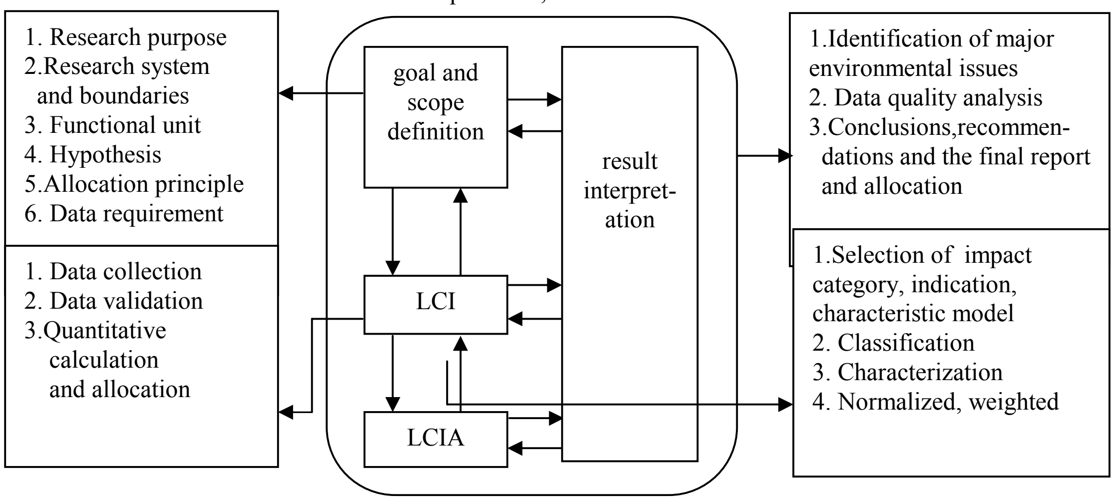

Fig.1 The framework and technical content of life cycle assessment

In order to better illustrate the impact of greenhouse gases and atmospheric pollutants on the environment which produced by energy consumption in the mining process of oil and gas, life cycle energy analysis (LCEA) becomes a good choice as a simplified method of LCA. LCEA is a original four-step method based on LCA, but LCEA regards the energy consumption and carbon emissions along with generating as the only measure objects of environmental impact [9]. Similar to traditional LCA, inventory analysis and impact assessment are the key to LCEA, in which inventory analysis is to define and quantify the energy flow under the system boundary framework, impact assessment can convert the data of Energy use into the GHG emissions. In this study, LCEA can evaluate not only CO_2 emissions in the energy use, but also other pollutants at the same time, in order to more fully reflect the overall impact of oil and gas production on environments.

B. Determination of Goal and Scope

The aim of this study is to quantitatively analyze the environmental emissions from the part of the life cycle of M oil field, which is the composite viscosity reduction technology, the high efficiency oil soluble viscosity reduction technology and the traditional light oil blending technology ,including the energy consumption in the process of heavy oil recovery and gathering, the direct emission from processes, the emission of the related industrial boiler, the emission of the transportation process and the life cycle consumption and emission of primary fuel. Related environmental emissions including liquid pollutants, solid waste, CO_2 , SO_2, NO_x, CH_4, CO, smoke and other gas emissions.

There are some differences between the processes of composite viscosity reduction technology, high efficiency oil soluble viscosity reduction technology and traditional blending technology. The composite viscosity reduction technology composite viscosity reduction technology includes four main parts, including wellhead filling, underground oil production, produced oil transported to the joint stations and joint stations processing. The high efficiency oil soluble viscosity reduction technology and the traditional blending technology includes three main parts, including underground oil production, produced oil transported to the joint stations and joint stations processing. Compared with the processes of composite viscosity reduction technology, lack of wellhead filling operation, namely a process that transport composite viscosity reducer from liquid mixing station to the wellhead.

Considering the environmental impact of the process or activity directly related to the functional unit in the system boundary, without consideration of the environmental impacts of such activities as the construction of the plant infrastructure and the life of the workers. The daily energy consumption and environmental emissions of heavy oil exploitation are defined as data acquisition cycle, daily environmental emissions from the oil recovery process is defined as a function unit. According to the research goal, the boundary of the three kinds viscosity reduction technology system is shown in Fig.2.

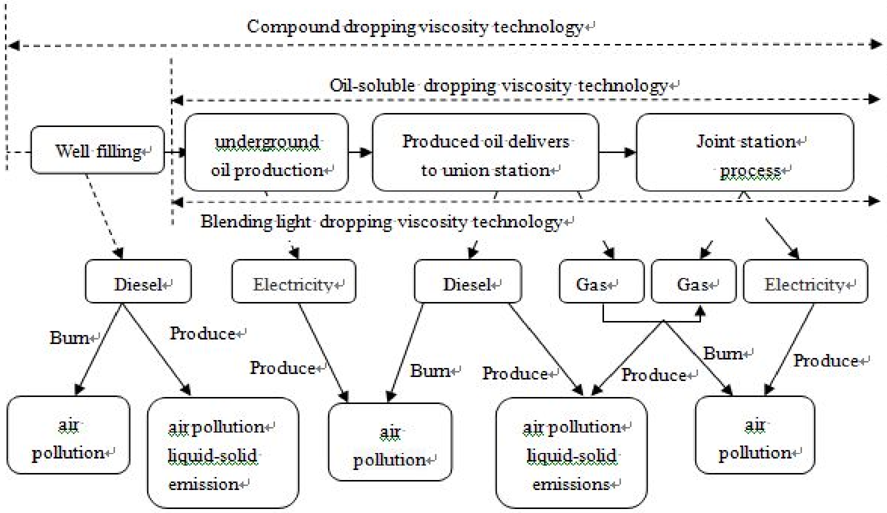

Fig.2 system boundary of oil production process by viscosity reduction technique

We mainly consider the different links of electricity, diesel, natural gas and other energy consumption in the viscosity reduction technology system boundary, the energy production and consumption process accompanied by the emission of pollutants, mainly including CO_2, SO_2, CH_4, CO, NO_x, smoke dust, liquid pollutants and solid waste.

C. The Energy Consumption Input Data of Life Cycle Assessment

In this study, adapting the date of mixing light production and environmental emission of M oil field production factory and according to the change data of heavy oil production which the composite viscosity reduction technology and the high efficiency oil soluble viscosity reduction technology substitute for the traditional light oil blending technology in order to calculate the data on production and environmental emission of the two new technologies. Emissions of different pollutants from different links are calculated according to pollutant emissions from different fuels and different processes.

There are 418 production wells in M oil field production factory, among which, blending light oil viscosity reduction producing wells are 310 wells, the daily oil output of mixing light, composite, oil soluble viscosity reduction technology is 5739 ton, 6204ton, 6264.59ton, respectively. The solid waste emissions per day directly followed by 1ton/day, 1.08t/d, 1.09t/d, mainly include oil sludge, etc. After the relevant treatment, no direct discharge of solid waste; after correlation processing, part of qualified liquid waste undergoing recycling, the remain qualified liquid injected to formation energy supply, liquid has no waste ultimately.

In different production process, energy consumption is different. Mainly including:

Diesel: (1) Transport vehicle driven when viscosity reducer is delivered to the wellhead during wellhead filling link; (2) Transport vehicle driven during the process of the produced oil delivered from wellhead to joint station;

Power: (1) Power driven of underground oil production ; (2) Power driven of pump group in joint station treatment.

Natural gas: (1) Pipeline heating during process of produced oil being transported to the joint station. (2)Energy supply of the heating furnace in the joint station.

The energy consumption list of tons of oil production in different processes of composite viscosity reduction technology and oil soluble viscosity reduction technology in M oil field production factory is shown in table □and table □.

Table□ Daily energy consumption inventory of tons of oil production stages by composite viscosity reduction technology

Energy	Well filling	Underground oil production	Produced oil delivered to joint station	Joint station process	Total
Diesel kg	1.103×10^{-3}	--	8.269×10^{-3}		9.372×10^{-3}
Electricity kWh	--	21.115	--	0.753	21.868
Natural gas m^3	--	--	0.523	3.485	4.008

Table□ Daily energy consumption inventory of tons of oil production stages by oil-soluble viscosity reduction technology

Energy	Underground oil production	Produced oil delivered to joint station	Joint station process	Total
Diesel kg	--	8.189×10^{-3}	--	8.189×10^{-3}
Electricity kWh	21.119	--	0.753	21.872
Natural gas m^3	--	0.523	3.485	4.008

3. Lifecycle Environmental Impact Assessment of Viscosity Reduction Technology

In the process of oil production, the direct and indirect environmental emissions are accompanied with the heavy oil viscosity reduction technology. Considered emissions include: liquid pollutants, solid waste, CO_2 and SO_2, NO_x, CH_4, CO, smoke dust and other gas emissions.

Direct emissions refer to the environmental emissions generated by the direct combustion of different kinds of energy in the system boundary. Including: diesel fuel combustion in the wellhead filling, diesel fuel combustion using diesel as the transport driven, natural gas combustion for the tube heating and natural gas combustion for the joint station boiler heating.

Indirect emissions refer to the emissions generated during production of different types of energy within the boundaries of the project. Including: emissions from diesel production, emissions from natural gas production and emissions from electricity production process.

A. Direct Emission Calculations

In the direct emissions of the environment, the environmental emission of the electric power is very small, this study is to neglect the calculation. We only consider the diesel transport process and natural gas combustion process. In the oil production process by composite viscosity reduction technology, daily transport diesel vehicles mileage is 170km, among which, transport mileage in wellhead filling process is 20km, distance that produced oil transported to joint station is 150 km. Only the process that produced oil being transported to joint station needs diesel vehicle transportion by the oil soluble viscosity reduction technology, and the distance is 150 km.

(1)Emissions of CO_2 and air pollutants in the transport process by IV diesel vehicles

$$D_i = VKT \times BEF_i \qquad (1)$$

In the equation, i mainly including CO_2, CO, CH_4, CO, NO_x, soot; wherein, D_i is the emissions of gas i, measured in kg; VKT is vehicle mileage, measured in km; BEF_i is comprehensive reference emission coefficient for diesel combustion gas[10,11].

SO_2 emissions calculated by reference 10 in section 4.4, the formula is as follows:

$$D_{SO_2} = 2.0 \times 10^{-6} \times (F_d \times \alpha_d) \qquad \square 2\square$$

In the equation, D_{SO2} is the emissions of SO_2 for motor vehicle diesel combustion, measured in kg; F_d is diesel oil consumption, measured in kg; α_d is average sulfur content for diesel oil, measured in ppm, as in[12].

(2) CO_2 and air pollutant emissions for natural gas combustion

CO_2 emissions are calculated as follows:

$$G_{CO_2} = C_{gas} \times Q_{gas} \times \varepsilon \times 10^{-9} \qquad (3)$$

In the equation, G_{CO2} is CO_2 emissions for natural gas combustion; measured in kg; C_{gas} is the consumption of natural gas, measured in m3; Q_{gas} is the heat of natural gas[13], measured in KJ/m^3; ε is CO_2 emission coefficient of natural gas combustion[14], measured in kgCO_2/TJ.

Gas pollutant emissions are calculated as follows:

$$G_k = C_{gas} \times \omega_k \times 10^{-4} \qquad (4)$$

In the equation, k on behalf of SO_2, NO_x, CO, CH_4, smoke and other pollutants; G_k is pollutant emissions of k, measured in kg; C_{gas} is natural gas consumption in heavy oil recovery process, measured in m^3; ω_k is pollutant emission coefficients of k[15,16], measured in kg/million m^3.

B. Indirect Emission Calculations

(1) Emissions of CO_2 and various pollutants in the production process of diesel oil

The calculation formula of CO_2 and pollutant emission in diesel oil production are as follows:

$$D_j = C_{diesel} \times \delta_j \qquad (5)$$

In the equation, D_j is diesel emissions of production processes j, measured in kg; j represents CO_2, SO_2, NO_x, CO, CH_4, soot and other environmental emissions; C_{diesel} represents consumption of diesel fuel, measured in kg; δ_j is pollutant emission coefficients for production unit of diesel j[17], measured in kg/kg.

(2) Emissions of CO_2 and various pollutants in the production process of natural gas

The calculation formula of natural gas and pollutant emission in diesel oil production are as follows:

$$G_j = C_{gas} \times \theta_j \qquad (6)$$

In the equation, G_j is emissions of CO_2 and other pollutants in natural gas production process , measured in kg; C_{gas} is consumption of natural gas, measured in m3; θ_j is emission intensity of production unit of gas j[17,18], measured in kg/m^3.

(3) Production process of electricity

The calculation formula for pollutant emissions are as follows:

$$E_j = C_{elec} \times \gamma_j \qquad (7)$$

In the equation, Ej is power production process in CO_2 emissions of air pollutants, measured in kg; C_{elec} is power consumption, measured in KWh; γ_j denotes the emission factors of greenhouse gases and other atmospheric pollutants in power production process, measured in kg/kWh. Greenhouse gases CH_4, CO_2 and NO_X emission factors selected in Xinjiang power grid data of 2010[19].Reference for calculation, SO_2 emission factor refer to the research content of Li Qian[20], emission factors of smoke refer to Zhang Xuan[21]. Due to the lack of the latest statistics, CO emission factors refer to Di Xianghua[22].The environmental emission coefficients of each process for direct and indirect emissions are shown in table □.

Table □ Emission coefficient of pollutants

	diesel combustion (g/km)	diesel oil production (kg/kg)	natural gas combustion (kg/million m^3)	natural gas production kg/m^3	electric power production (kg/kWh)
CO_2	1066	0.175	2.184×10^{4}	0.13	0.849
SO_2	50ppm	1.47×10^{-3}	0.096	1.06×10^{-3}	5.958×10^{-3}
CO	2.2	2.11×10^{-3}	2.72	1.57×10^{-3}	1.55×10^{-3}
CH_4	0.129	9.89×10^{-6}	0.48	7.36×10^{-6}	0.92×10^{-5}
NO_X	5.554	4.16×10^{-4}	27.83	2.67×10^{-4}	1.28×10^{-5}
Smoke dust	0.291	5.06×10^{-4}	2.4	3.26×10^{-4}	1.06×10^{-3}
Liquid waste	--	0.76	--	0.57	--
solid waste	--	7.7×10^{-3}	--	5.76×10^{-3}	--
data source	literature 10~12	literature 17 18	literature 14~16	literature 17 18	literature 19~22

Note: Emission factors of CO, CH_4, CO_2, NO_x, smoke in the diesel combustion process come from literature 10; emission factor of CO_2 during diesel combustion process come from literature 11; National IV diesel sulfur content is 50ppm, derived from the literature 12; Calorific value of natural gas derived from the literature 13; emission coefficient of CO_2 in the combustion of natural gas derived from literature 14.

According to energy consumption data and environmental emission calculation formula of the two kinds viscosity reduction technology of each process, with the exploitation of tons of oil environment emissions as the evaluating criteria, according to the definition of the boundary of the system, the composite viscosity reduction technology considers 4 main links, and the environmental emission inventory of CO_2 and each gas pollutant are shown in Table □.

C. Inventory Analysis

Table □ Environmental emission inventory of tons of oil production by composite viscosity reduction technology

kg/t

Emissions	Well filling	Underground oil production	Produced oil delivered to joint station	Joint station process	Total
CO_2	3.63E-03	17.931	1.237	8.064	27.236
CH_4	4.27E-07	1.94E-04	3.22E-05	2.00E-04	4.27E-04
CO	9.42E-06	0.033	1.03E-03	7.59E-03	4.14E-02
NO_x	1.84E-05	2.7E-04	1.73E-03	1.16E-02	0.014
SO_2	1.74E-06	0.075	5.72E-04	7.23E-03	0.083
Smoke dust	1.5E-06	0.022	1.84E-03	1.30E-02	3.68E-02
Liquid waste	8.38E-04	--	0.304	1.99	2.292
Solid Waste	8.49E-06	--	3.07E-03	2.01E-02	2.32E-02

High efficiency oil soluble viscosity reduction technology only considers 3 main links, based on oil production per ton as the evaluation criterion, the environmental emission inventory of the various links of high efficiency oil soluble viscosity reduction technology for heavy oil production was obtained, which is shown in table□.

Table □ Environmental emission inventory of tons of oil production by oil soluble viscosity reduction technology

kg/t

Emissions	Underground oil production	Produced oil delivered to joint station	Joint station process	Total
CO_2	17.931	1.237	8.064	27.231
CH_4	1.94E-04	3.22E-05	2.00E-04	4.27E-04
CO	0.033	1.03E-03	7.59E-03	4.13E-02
NO_x	2.7E-04	1.73E-03	1.16E-02	0.014
SO_2	0.075	5.72E-04	7.23E-03	0.083
Smoke dust	2.24E-02	1.84E-03	1.30E-02	3.72E-02
Liquid waste	--	0.304	1.986	2.291
Solid Waste	--	3.07E-03	2.01E-02	2.31E-02

According to the research in literature [17], the national average emission inventories of crude oil production in 2010 are calculated, compared with environmental emissions by composite viscosity reduction technology and oil soluble viscosity reduction technology in this research. Although technical level in 2010 may be not better, the emissions of pollutants can show the overall trend of environmental emissions, which has comparison and reference value as table –

Table □ The comparison list about Environmental emissions

kg/t

Emissions	Composite dropping viscosity technology	Efficient oil-soluble dropping viscosity technology	National average emissions in 2010
CO_2	27.236	27.231	129
SO_2	0.083	0.083	1.08
NO_x	0.014	0.014	0.306
CO	4.14E-02	4.13E-02	1.554
CH_4	4.27E-04	4.27E-04	7.28E-03
Smoke dus	3.68E-02	3.72E-02	0.372
Liquid waste	2.292	2.291	610(2002)
Solid Waste	2.32E-02	2.31E-02	6.16□2002□

Note: National average emissions in 2002 about liquid and solid waste are selected because of lack of data.

Table□shows the list of environmental emissions per kg of crude oil, from which we know that through the two kinds new chemical viscosity reduction technology in oil production, the pollutant emissions of CO_2 and other gases were lower than the national average emission levels, liquid waste and solid waste emissions are also lower than that of the national average level. As a result, the environmental benefit is good.

4. Impact Assessment and Interpretation Results

According to the inventory of environmental emissions, and [23] in accordance with the selection principle of the type of the environmental impact, production process of the technology of composite viscosity and environment emissions of efficient oil soluble viscosity technology in M oilfield were assessed about impact. First, we determined the influence of environmental factors and the corresponding type. Then we made the equivalent of different pollutants, which can make the horizontal comparison, the process is characteristic.

In this study, the environmental impact types of pollutants discharge refer to the UN program (UNEP), the America society of environmental toxicology and chemistry (SETAC) and environmental impact type which research center ecological environment of the Chinese Academy of Sciences elected in the study of environmental evaluation on the method of life cycle [23]. according to the research objectives, scope, life cycle and the hot environment issue our country is facing, we chose three main types of environmental impact to make the assessment: global warming potential (GWP), acidification potential (AP) and photochemical smog.

Different types of the environmental impact correspond to different interference factors (pollutants), and different interference factors have different characteristic factors. We character Potential impact on the respective environment type interference factor [24], computation formula is as follows:

$$EP_i = \sum EP_{ij} = \sum Q_j \times EF_{ij} \quad (8)$$

In the formula, EP_i is the characteristic value of the types of environment which lists i; EP_{ij} is the first j kind of pollutant contribution in the i types of environment; Qj is the first j kind of pollutant emissions; EF_{ij} is the characteristic factor of pollutant j in the environment type of i

Including characteristic factors of the influence type corresponding to various parameters were decided, as in [24],[25],according to the relevant numerical, which are shown in the table □ below:

Table□ Type classification and basic characterization factor of environmental impact

Effect Type	Unit	Interference factor	Characteristic factor	Evaluation method
Global warming	CO_2 equivalent /kg	CO_2	1	IPCC2006
		CH_4	25	
		CO	1.57	
		NO_x	320	
Acidification	SO_2 equivalent /kg	SO_2	1	IMPACT2002
		NO_x	0.7	
Photochemical smog	C_2H_4 equivalent /kg	NO_x	2.80E-02	CML2001
		CH_4	6.00E-03	
		CO	2.70E-02	

a. Impact Assessment of Life Cycle

Oil production process of the technology of composite viscosity is divided into four stages, oil production process of the technology of oil-soluble viscosity is divided into three stages, with tons of oil mining as the benchmark, according to the link list of gas emissions of pollutants, we attained characteristic value of global warming, acidification, the photochemical smog of two kinds viscosity reduction technology in different process units, as is shown in table □.

Table The potential effect of viscosity technology at different stages on three types of environmental impact

		Composite dropping viscosity technology				Oil-soluble dropping viscosity technology		
Effect Type	Emissions	Well filling	Underground oil production	Produced oil delivers to union station	Union station process	Underground oil production	Produced oil delivered to joint station	Union station process
Global warming □kgCO_2 equivalent □	CO_2	3.63E-03	17.931	1.237	8.064	17.931	1.237	8.064
	CH_4	1.07E-05	0.005	7.65E-04	5.00E-03	4.85E-03	8.04E-04	5.00E-03
	CO	1.48E-05	5.14E-02	3.14E-04	1.19E-02	5.12E-02	1.62E-03	1.19E-02
	NO_x	5.87E-03	0.086	0.5408	3.712	0.554	0.554	3.712
	Total	9.53E-03	18.074	1.79	11.793	18.541	1.793	11.793
	Contribution ratio %	3.01E-02	57.07	5.66	37.24	57.71	5.58	36.71
Acidification □kgSO_2 equivalent □	SO_2	1.74E-06	0.075	5.72E-04	7.23E-03	0.075	5.72E-04	0.007
	NO_x	1.28E-05	1.89E-04	1.21E-03	8.12E-03	1.89E-04	1.21E-03	8.12E-03
	Total	1.46E-05	7.52E-02	1.78E-03	1.54E-02	7.52E-02	1.78E-03	1.54E-02
	Contribution ratio %	0.016	81.43	1.91	16.62	81.44	1.93	16.63
Photochemical smog □kgC_2H_4 equivalent □	CH_4	3.92E-09	7.56E-06	1.84E-07	3.25E-04	7.56E-06	4.85E-05	3.25E-04
	NO_x	5.27E-07	1.16E-06	4.73E-05	1.20E-06	1.16E-06	1.93E-07	1.20E-06
	CO	1.95E-07	8.84E-04	5.40E-06	2.05E-04	8.81E-04	2.79E-05	2.05E-04
	Total	7.24E-07	8.93E-04	5.29E-05	5.31E-04	8.90E-04	7.65E-05	5.31E-04
	Contribution ratio %	0.051	59.48	5.1	35.37	59.44	5.11	35.45

Global warming was impacted most severely of the three types of environmental impact. For the composite viscosity reduction technology, impact potential value of each link to global warming, acidification, photochemical smog are equivalent to 31.67kgCO_2, 0.092kgSO_2, 1.50×10^{-3}kgC_2H_4 respectively; For oil soluble viscosity reduction technology, impact potential value of each link to global warming, acidification, photochemical smog are equivalent to 32.127kgCO_2,0.092 kgSO_2,5.75×10^{-3}kgC_2H_4. Underground oil production is the largest links among all links of environmental emissions, which has the biggest impact on the three types of environment impact.

Interference factors contributing to global warming are mainly CO_2, CH_4, CO and NO_x; the main materials causing acidification are SO_2, NO_x; the main materials resulting in photochemical smog include CH_4 ,CO and NO_x. Different interference factors contribute to various types of environmental impact, specific contribution rates are shown as fig.3 below.

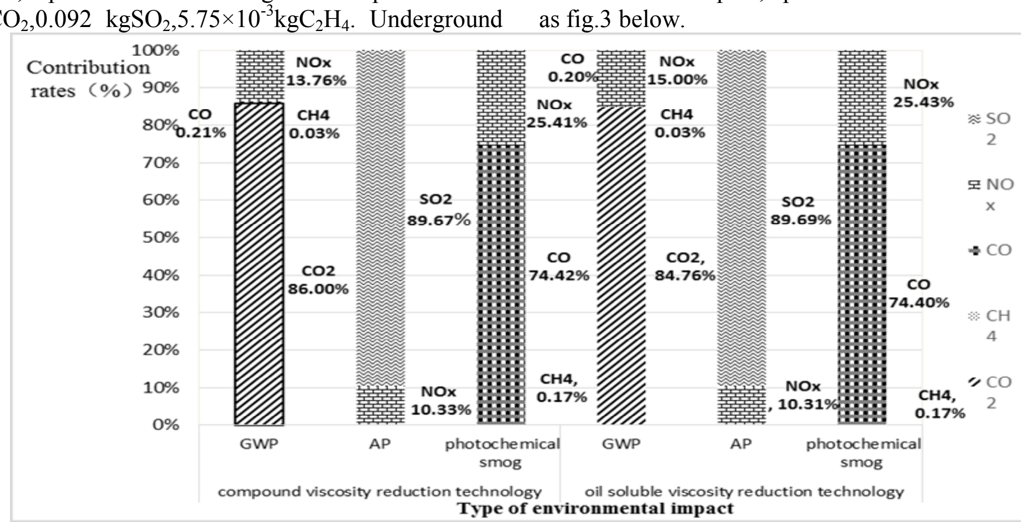

Fig. 3 Contribution rates of three types of environmental impact made by different interference factors

The contribution rates of two types of viscosity reduction technology made by different interference factors are analyzed as figure 3, which shows that in the interference factors causing global warming, the greatest contribution to global warming is CO_2 , accounted for 86%; NO_x contribution rate is 13.76%; SO_2 contributes most to acidification ,which is about 89%, the contribution rate of NO_x on acidification is

about 10%, sulfur and nitrogen purification measures are very important; The interference factor that contributing most on photochemical smog is CO, the contribution rate is about 74.42%.

b. *Life Cycle Interpretation*

According to the result of the life cycle assessment of composite viscosity reduction technology, underground oil production and joint station treatment are two main processes causing environment pollution. The contribution rate of global warming, acidification and photochemical smog are 57.07%, 81.43%, 59.48%, respectively; the contribution rate of the treatment in joint station was 37.24%, 16.62%, 35.37%, the two process units accounted for over 94% of the total environmental impact. The life cycle assessment results about the oil soluble viscosity reduction technology showed that the most severe environmental pollution process are the same with that of the composite viscosity reduction technology, the contribution rates of underground oil production process on GWP, AP and photochemical smog are 57.71%,81.44%,59.44%,respectively; contribution rates of the oilfield joint station process are respectively 36.71%, 16.63%, 35.45%, two processes account for more than 93% of total environmental impact of oil production system through viscosity reduction technology.

The main cause of environmental pollution is the consumption of a large number of electricity and natural gas in the process of oil production, and indirectly bear the environmental emissions in the process of energy production. Electricity is the main energy consumption during underground oil production and fundamental source of environmental emissions. Improving the work efficiency of the production equipment to reduce the power loss is an effective measure of reducing environmental emissions in energy. The production and use of natural gas are accompanied by certain environmental emissions, with large contribution rate on various types of environmental impact, looking for more clean and environmentally friendly heating fuels, instead of the use of natural gas, can greatly reduce the environmental pollution.

According to the contribution rate of interference factors on the global warming, contribution rate of CO_2 is the largest, followed by the NO_x. Visibly, reducing power resource consumption and increasing efforts to reduce emissions of greenhouse gases and NO_x for the mitigation of global warming are significant. SO_2 and NO_x are two interference factors effect the acidification mostly. It is of great significance to improve flue gas treatment technology, reduce the sulfur, nitrogen content of fuel combustion flue gas, control sulfide, nitrogen emissions limits strictly for reducing the acidification; The contribution of CO on photochemical smog is the largest, followed by CH_4, NO_x, to reduce the impact of photochemical smog on the environment, first of all, we should start from the control of CO emissions and the reduction of the associated energy consumption.

5. Conclusion

In this paper, based on life cycle energy analysis□LCEA□ technology framework, the composite viscosity and oil soluble viscosity reduction technology of two heavy oil are analyzed in life cycle assessment. According to the characteristics and environmental technology viscosity results list of each process, we select three kinds of environment categories including the global warming, acidification and photochemical smog, from which we identify the trend of environmental impact of the two kinds viscosity reduction technology.

1)Introducing the extended analysis method of LCEA into the environmental impact assessment of the application of viscosity reduction technology, the resource consumption and environmental emissions of different production processes are defined. The main energy consumption is electricity and natural gas, diesel oil consumption is small. According to the related data and emission calculation formula during different process of energy production and use. It is concluded that the value in different sectors of the energy consumption and environmental emissions, and China's petroleum mining industry of each pollutant environmental emissions. By comparing the two kinds of CO_2 emission and atmospheric pollutant emission in the process of oil production with the corresponding environmental emission level during the national average oil production, the application of viscosity reduction technology shows that CO_2 emissions and atmospheric pollutant emissions below the national average level of emissions and the environmental benefit is better. At the same time, the evaluation of LCA environment provides some data base and theoretical basis for the life cycle assessment of oil and gas field exploitation industry in China.

2)The LCEA's extended analysis method for the environmental impact assessment of viscosity reduction technology has identified a key emission link, which provides a scientific basis for energy saving and emission reduction in heavy oil production industry. In the heavy oil production with viscosity reduction technology, underground oil production and joint station treatment are two key processes for emissions, among which the environmental impact of the underground oil production is the largest, the contribution rate of GWP, AP and photochemical smog are greater than 50%. The identification of key emission link leads to the consumption of main energy sources, which is the important premise to reduce environmental pollution and improve the efficiency of environmental protection. Studies have shown that the main energy consumption during underground oil production link is electricity, process of electric power production is the main source of environmental emissions, improving energy utilization and reducing electricity consumption are of guiding significance to reduce the impact of pollutants on the environment from the source. Electricity and natural gas consumption take a large amount in joint station treatment, the natural gas combustion and the production process is accompanied by environmental emissions, reduce the use of natural gas and improve the efficiency of natural gas combustion are of great importance in slowing down the environmental pollution during the process of oil production with viscosity reduction technology.

3) The study provides a basis for the precise control of the oil and gas production process in China. NO_x and CO_2 are the main gases that cause global warming, SO_2 and NO_x are the main gases causing acid rain, and CO is the main gas of photochemical smog. According to the related conclusion of the study on LCEA, improving the work efficiency of the equipment, reducing power consumption, exploring more effective flue gas treatment technology, increasing recycling efforts of NO_x, strengthening to control SO_2 emission reduction, controlling strictly of nitrogen and sulfide emission

limit values, strengthening the monitoring efforts of greenhouse gas emissions, looking for much cleaner energy for heating, can effectively inhibit the destruction of these major environment impact factor of disturbance to the environment.

The study of LCEA method is extended and applied in the environmental evaluation of viscosity reduction technology, not only identify the contribution of viscosity reduction technology to the environmental impact in oil and gas mining industry, but also provides a broader space for development and application market for LCEA method. However, there are some limitations in the study, correct identification and treatment of the limitations of this study provide a reference for the next step of work.

1) Data issues on case studies. In this research, the main problem is the lack of statistical data on energy consumption and operating conditions in the process of oil and gas production . Because of the complexity of the data collection, there are certain limitations on the adoption of indirect data on energy consumption and related emissions during oil and gas production process.

2) Consumption of other resources and environmental impact. Such as water, soil, animals and plants living environment and the ecological landscape, because of inadequate data and operating difficulties, there is no relevant evaluation and analysis on the impacts of water, soil and other resources, the next step work needs to be extended to the other resources, environment, make evaluation results more perfect.

3) In this study, no environmental impact categories were normalized and weighted, only considered the characteristics stage, Although the subjective errors becomes less, there still lack of measurement on environmental impact of standards and analysis of testing data quality. The next step should be to increase the sensitivity analysis and uncertainty analysis of data quality, and improve the accuracy of the data.

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