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ACTA PETROLEI SINICA

(PETROLEUM PROCESSING SECTION)

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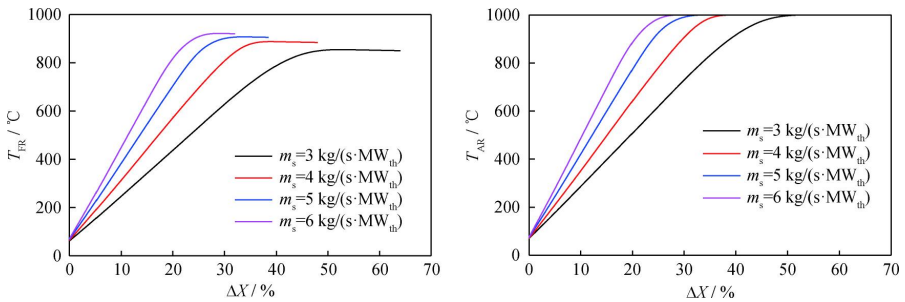
Chemical Looping Combustion

Acta Petrolei Sinica (*Petroleum Processing Section*), 2020, 36(6): 1111-1119 **doi**: 10.3969/j.issn.1001-8719.2020.06.001

Design and Analysis of 3 MW_{th} Coal-Fired Chemical Looping Combustion

CHEN Hu LI Zhenshan CAI Ningsheng

With the increase of ilmenite conversion difference or solid circulation rate, the AR and FR temperatures increase at first and then remain unchanged. The solid circulation rate should be greater than 4 kg/(s·MW_{th}) to maintain the FR temperature above 850 ℃, which is required by the reaction kinetics.

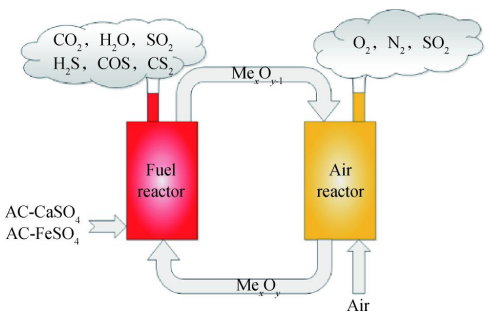


Acta Petrolei Sinica (*Petroleum Processing Section*), 2020, 36(6): 1120-1128 **doi**: 10.3969/j.issn.1001-8719.2020.06.002

Migration and Transformation of Sulfate Sulfur During the Chemical Looping Combustion

LUO Ming ZHANG Haiyan WANG Chao ZHOU Lunzheng

Two typical inorganic model compounds ($CaSO_4$ and $FeSO_4$) were selected to study the migration and transformation behavior of sulfate sulfur in coal during the CLC process by using Cu-based oxygen carrier.

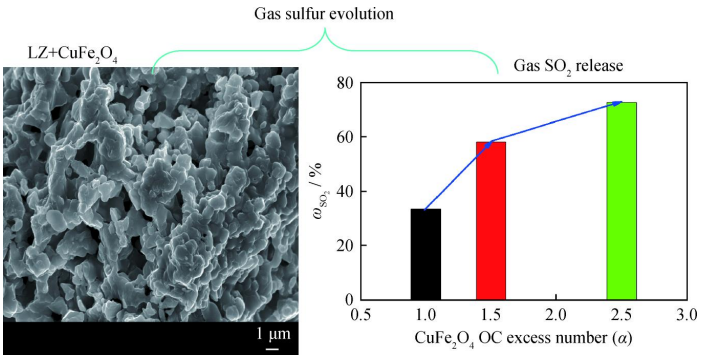


Acta Petrolei Sinica (*Petroleum Processing Section*), 2020, 36(6): 1129-1139 **doi**: 10.3969/j.issn.1001-8719.2020.06.003

Evolution and Distribution of Sulfur in Chemical Looping Combustion With Partial Oxygen Uncoupling of Coal

WANG Baowen LI Heyu WANG Wei CAI Zhongyuan JIANG Tao LIANG Yanchen

Chemical looping combustion under partial oxygen uncoupling (CLPOU) with $CuFe_2O_4$ combined oxygen carrier realizes flexible utilization of the oxygen involved as well as sufficient conversion of coal, and the sulfur included is mainly converted to gaseous SO_2.

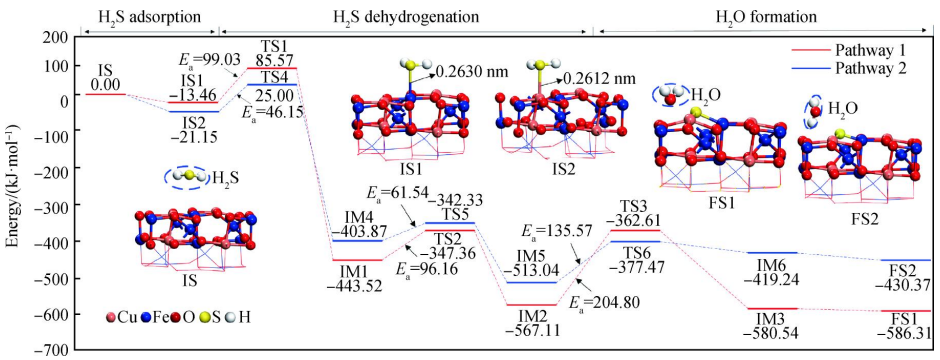


Acta Petrolei Sinica (*Petroleum Processing Section*), 2020, 36(6): 1140-1147 **doi**: 10.3969/j.issn.1001-8719.2020.06.004

Interaction Mechanism Between H_2S and $CuFe_2O_4$ Oxygen Carrier in Chemical-Looping Combustion

LI Yu LIU Jing LIU Feng FANG Ruixue

Based on density functional theory and periodic structural model, the interaction mechanism between H_2S and $CuFe_2O_4$ surface was studied. The results indicate that the interaction between H_2S and $CuFe_2O_4$ consists of three steps: adsorption of H_2S molecule, dehydrogenation of H_2S, and H_2O formation. Among them, the H_2O formation is the rate-determining step with an energy barrier being 135.57 kJ/mol.



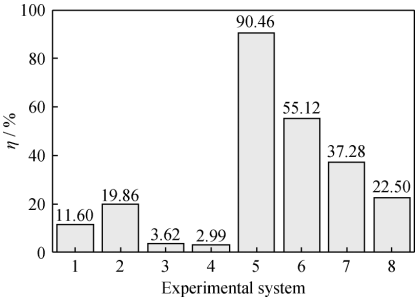
IS 1-2—Initial state 1-2; IM 1-6—Intermediate 1-6; TS 1-6—Transition state 1-6

Acta Petrolei Sinica (*Petroleum Processing Section*), 2020, 36(6): 1148-1160 **doi**: 10.3969/j.issn.1001-8719.2020.06.005

Effects of CO_2 on Mercury Removal in Furnace With High Iron and Calcium Coal Ash Oxygen Carrier

LIU Zhuang LIU Dunyu JIN Jing FENG Liang NI Mingguo

The effects of high iron and calcium coal ash (HICCA) on Hg^0 removal in chemical looping combustion were studied. The results show that CO_2 inhibits on Hg^0 oxidation in 'Hg^0 + HCl', 'Hg^0 + Fe_2O_3 + HCl' and 'Hg^0 + $CaSO_4$ + HCl' systems. Moreover, the pathways of the transformation between Hg^0 and $HgCl_2$ in these systems are established, respectively.



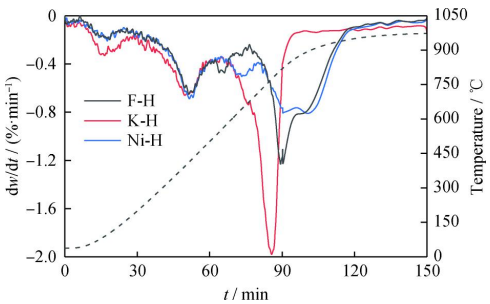
Experimental system: 1—'Hg^0 + HICCA'; 2—'Hg^0 + HICCA + CO_2'; 3—'Hg^0 + CO_2'; 4—'Blank test'; 5—'Hg^0 + HICCA + HCl'; 6—'Hg^0 + HICCA + HCl + CO_2'; 7—'Hg^0 + HCl'; 8—'Hg^0 + HCl + CO_2'

Acta Petrolei Sinica (*Petroleum Processing Section*), 2020, 36(6): 1161-1168 **doi**: 10.3969/j.issn.1001-8719.2020.06.006

Chemical Looping Conversion of Coal Using Modified Iron Ore Oxygen Carrier

WANG Haitao LIN Yan WEI Guoqiang HUANG Zhen
ZHAO Zengli FANG Yitian LI Haibin

Oxygen carriers modified by K, Na, Ca, Ni, Mn and Cu were synthesized, and the reaction performance were studied. The results show that K-modified iron ore has a better performance than the unmodified iron ore and the Ni-modified iron ore, indicating that introducing of the potassium element significantly improves the reactivity of oxygen carriers with lignite.

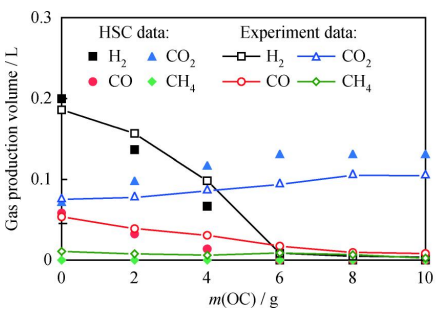


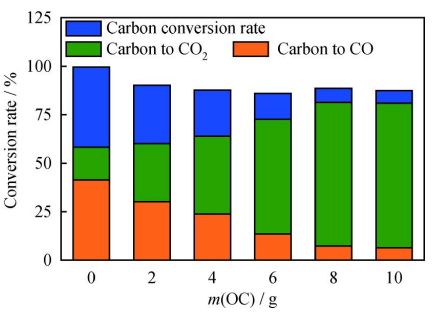
Acta Petrolei Sinica (*Petroleum Processing Section*), 2020, 36(6): 1169-1177 **doi**: 10.3969/j.issn.1001-8719.2020.06.007

Chemical Looping Combustion Characteristics of Ningdong Coal Based on the Manganese Ore Oxygen Carrier

LIANG Wenzheng WANG Kun ZHAO Rongyang YUAN Shirui WANG Cuiping

The experimental results of CLC of manganese ore are in good agreement with the simulation. The combustion efficiency increases with oxygen carrier mass increasing. The self heat balance is calculated and the corresponding parameters are obtained.



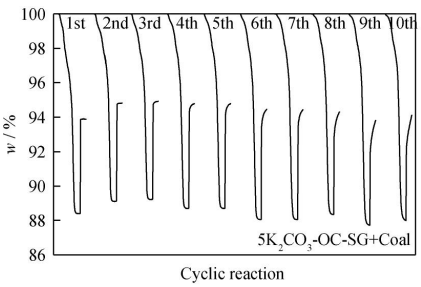


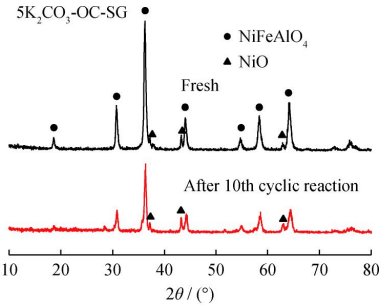
Acta Petrolei Sinica (*Petroleum Processing Section*), 2020, 36(6): 1178-1188 **doi**: 10.3969/j.issn.1001-8719.2020.06.008

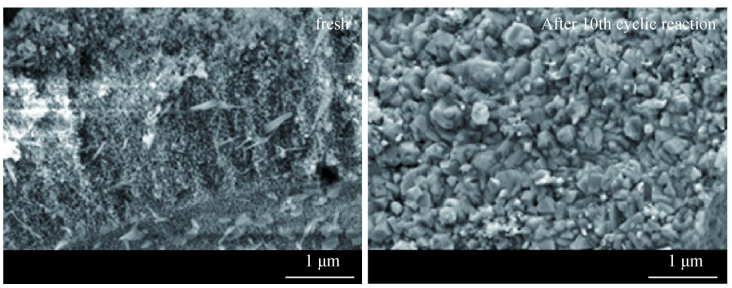
Effects of Alkali Metal Doping on $NiFeAlO_4$ Oxygen Carrier Structures and Its Coal Chemical Looping Combustion Performance

WEI Zehua LIU Daocheng
WANG Jiuzhan JING Jieying

Compared with $NiFeAlO_4$ oxygen carrier, $NiFeAlO_4$ oxygen carrier doped with 5% (mass fraction) K_2CO_3 exhibited higher carbon conversion and better cyclic stability. This is related to the fact that the potassium inhibits the grain agglomeration and crystal structures remain unchanged before and after reactions.





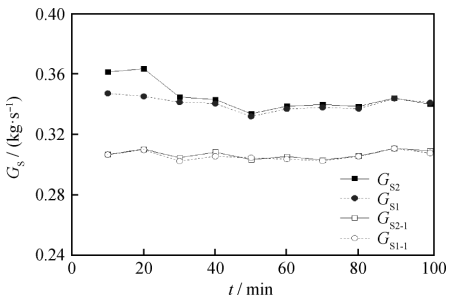


Acta Petrolei Sinica (*Petroleum Processing Section*), 2020, 36(6): 1189-1199 **doi**: 10.3969/j.issn.1001-8719.2020.06.009

Cold-Model Experiment of Dual Circulating Fluidized Bed Reactor for Chemical Looping Combustion

MA Jinchen ZHAO Haibo HUANG Zhen WEI Guoqiang

An interconnected fluidized bed reactor was designed for the chemical-looping combustion of coal. The air reactor was chosen as the turbulent bed and the fuel reactor as the bubbling bed. A bidirectional loop seal valve was configured to regulate the mass distribution of the bed inventories in the system.

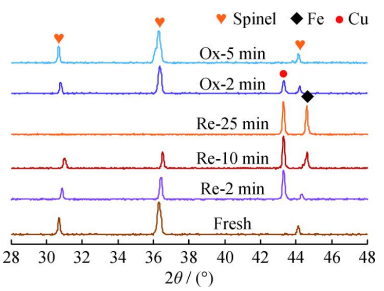


Acta Petrolei Sinica (*Petroleum Processing Section*), 2020, 36(6): 1200-1205 **doi**: 10.3969/j.issn.1001-8719.2020.06.010

Performance of a Cu-Fe-Al-O Oxygen Carrier in Chemical Looping Combustion

CUI Dongxu ZENG Dewang XIAO Rui

The active components copper and iron reversible exsolve and dissolve from and into the spinel support during the redox cycle, which hinders the sintering of active components and improves redox stability of oxygen carrier.



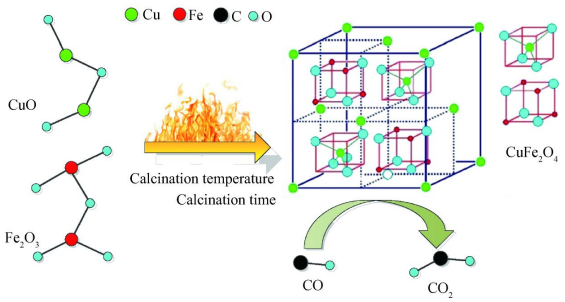
Re—CO reduction; Ox—Air oxidation

Acta Petrolei Sinica (*Petroleum Processing Section*), 2020, 36(6): 1206-1211 **doi**: 10.3969/j.issn.1001-8719.2020.06.011

Effects of Preparation Process on Characteristics of Cu-Fe Compound Oxygen Carrier

JIANG Shouxi SHEN Laihong YAN Jingchun

Calcination temperature and time in oxygen carrier preparation process determine the generation of $CuFe_2O_4$ and cyclic redox characteristcs for Cu-Fe oxygen carrier.

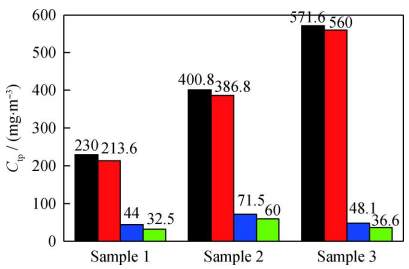


Acta Petrolei Sinica (*Petroleum Processing Section*), 2020, 36(6): 1212-1218 **doi**: 10.3969/j.issn.1001-8719.2020.06.012

Release Characteristics of Nitrogen Oxides From Cu-Based Oxygen Carrier Precursors During Calcinations in Argon Atmosphere

FAN Baoshan ZHENG Min WANG Jingquan LI Kang

The mass concentrations of NO and NO_2 increase firstly and then decrease with the increase of temperatures, and reach their peaks at about 220 ℃. NO is the main nitrogen oxide. The higher heating rate and less amount of urea are beneficial to reduce the release of NO_x.



Sample 1: The mass of urea added is 9.8 g; Sample 2: The mass of urea added is 14.7 g;
Sample 3: The mass of urea added is 19.6 g; C_P: Peak of mass concentration of NO or NO_2
Black columns: Peak of mass concentration of NO at 10 ℃/min heating rate; Red columns: Peak of mass concentration of NO at 15 ℃/min heating rate;
Blue columns: Peak of mass concentration of NO_2 at 10 ℃/min heating rate; Green columns: Peak of mass concentration of NO_2 at 15 ℃/min heating rate

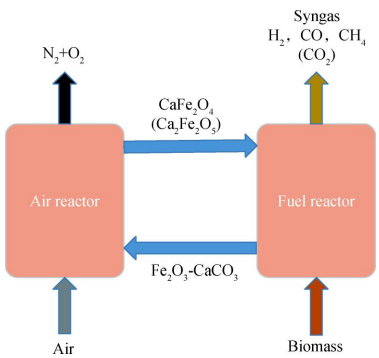
Chemical Looping Gasification

Acta Petrolei Sinica (*Petroleum Processing Section*), 2020, 36(6): 1219-1228 **doi**: 10.3969/j.issn.1001-8719.2020.06.013

Characteristics of Rice-Hull Chemical Looping Gasification With Calcium-Ferrite as Oxygen Carrier

SU Ziran SHEN Laihong YAN Jingchun WANG Lulu

Biomass chemical looping gasification is a novel technology to convert biomass into renewable syngas. Calcium ferrite oxygen carrier ($CaFe_2O_4$/$Ca_2Fe_2O_5$) has a weak oxidizing property and high selecitivity to CO. It can absorb CO_2, improving the low heat value of syngas during biomass CLG process.

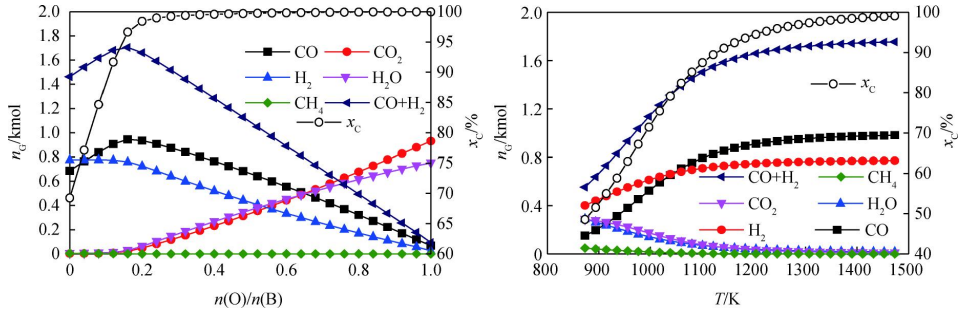


Acta Petrolei Sinica (*Petroleum Processing Section*), 2020, 36(6): 1229-1238 **doi**: 10.3969/j.issn.1001-8719.2020.06.014

Thermodynamic Analysis on Chemical Looping Gasification of Biomass With the $CuMn_2O_4$ Oxygen Carrier

FANG Ruixue HUANG Qixiang LIU Jing LIU Feng

Thermodynamic analysis of biomass chemical looping gasification was performed using $CuMn_2O_4$ as the oxygen carrier and pine sawdust as the fuel. The results show that $CuMn_2O_4$ improves the conversion of pine sawdust effectively, and the system performs best when $n(O)/n(B)$, reaction temperature, $n(H_2O)/n(B)$, $n(CO_2)/n(B)$ are 0.16, 1273 K, 0.40 and 0.20, respectively.

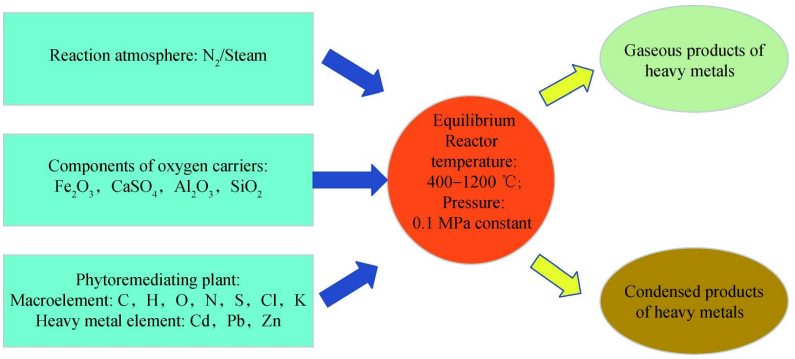


Acta Petrolei Sinica (*Petroleum Processing Section*), 2020, 36(6): 1239-1252 **doi**: 10.3969/j.issn.1001-8719.2020.06.015

Thermodynamic Equilibrium Analysis of Heavy Metal Migration in Chemical Looping Gasification of the Phytoremediating Plant

CHEN Tong JIN Baosheng WANG Xiaojia

The migration rules of heavy metal Cd, Pb and Zn were compared for pyrolysis and chemical looping gasification. The results show that chemical looping gasification shows advantages than pyrolysis in the solidification of heavy metals, which becomes more obvious by employing calcium-based oxygen carriers.

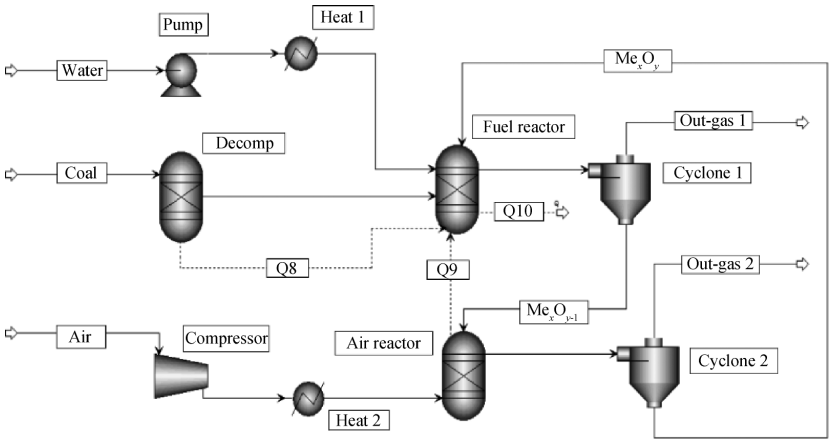


Acta Petrolei Sinica (*Petroleum Processing Section*), 2020, 36(6): 1253-1261 **doi**: 10.3969/j.issn.1001-8719.2020.06.016

Simulation of 1 MW_{th} Coal Chemical Looping Gasification Process

REN Tian HU Xiude AN Mei MA Jingjing GUO Qingjie

In this work, a 1 MW_{th} coal chemical looping gasification for syngas production process simulation was carried out with Aspen Plus, focusing on the influence of different operating factors and autothermal operation condition. The findings provide basic data for industrial scale-up and megawatt scale construction of coal chemical looping gasification system.



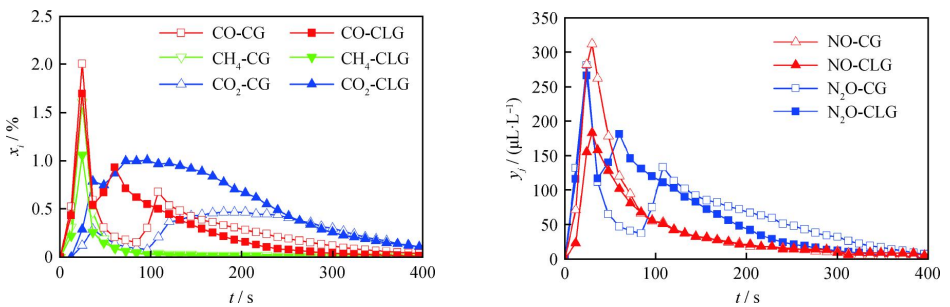
Decomp—Yield reactor; Q8, Q9, Q10—Heat flow

Acta Petrolei Sinica (*Petroleum Processing Section*), 2020, 36(6): 1262-1272 **doi**: 10.3969/j.issn.1001-8719.2020.06.017

Carbon and Nitrogen Conversion Mechanism During Coal Chemical Looping Gasification by Using Hematite as an Oxygen Carrier

WU Pingjiang HAN Long XU Guoqiang MA Kaili WU Yuelun WANG Qinhui

Conventional gasification (CG) and chemical looping gasification (CLG) both present two reaction stages. In the first volatilization stage, CLG has lower concentrations of CO, CH_4, NO and N_2O. In the second char gasification stage, CLG shows enhanced char gasification reactivity with earlier start time and higher CO, CO_2 and N_2O proportions.



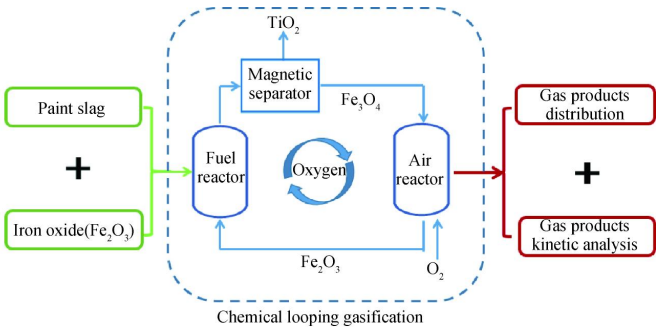
Reaction conditions: m(Coal)=0.3 g; T=950 ℃; F(Steam)=0.4 g/min;
n(O)/n(C)=0 in CG, n(O)/n(C)=1 in CLG;
m(Quartz sand)=12 g in CG, m(Hematite)=12 g in CLG

Acta Petrolei Sinica (*Petroleum Processing Section*), 2020, 36(6): 1273-1284 **doi**: 10.3969/j.issn.1001-8719.2020.06.018

Chemical Looping Gasification Characteristics and Kinetic Behavior of Paint Slag

ZHANG Jie ZHANG Bo GUO Wei WU Song XIE Tao YANG Bolun WU Zhiqiang

In order to explore the feasibility of chemical looping gasification technology for the treatment of paint slag, the chemical looping gasification characteristics and kinetic behavior of paint slag with Fe_2O_3 as the oxygen carrier were studied by thermogravimetric analyzer and tube furnace-online mass spectrometer. Since Fe_2O_3 reacts to produce Fe_4O_3, it is proposed to recover the metal oxides in the paint waste residue through a magnetic separation device.

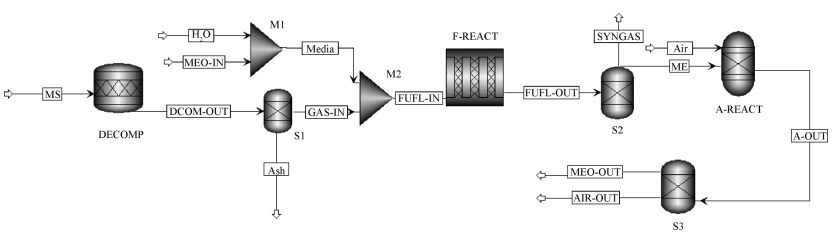


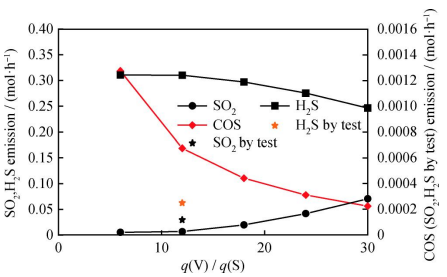
Acta Petrolei Sinica (*Petroleum Processing Section*), 2020, 36(6): 1285-1293 **doi**: 10.3969/j.issn.1001-8719.2020.06.019

Simulation and Experimental Study on the Gasification Characteristics of Municipal Sludge by the Fe-Based Oxygen Carrier

WANG Kun LIANG Wenzheng YAN Hao WANG Jinyu WANG Cuiping

Based on Aspen Plus simulations, effects of different reaction conditions of fuel and air reactor on sludge gasification characteristics and pollutant emission were studied and further verified by experiments. The results show that the reactor type could be switched via changing the gas atmosphere of the reactor.



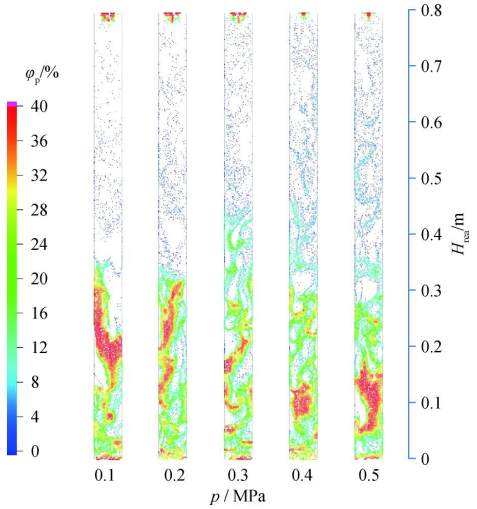


Acta Petrolei Sinica (*Petroleum Processing Section*), 2020, 36(6): 1294-1305 **doi**: 10.3969/j.issn.1001-8719.2020.06.020

Experimental and Numerical Research on Chemical Looping Gasification of Coal Char in a Pressured Fluidized Bed Reactor

GUO Xintong CHANG Guozhang TAN Xiaoli HU Xiude GUO Qingjie

The gasification of Erdos bituminous coal char with Fe_2O_3/Al_2O_3 was studied by CPFD simulation and experiments under the pressure of 0.1—0.5 MPa, focusing on the characteristics of multiphase flow and its influence on the reactions. The conclusions provide basic data for the design of fuel reactor, and effective methods for decoupling the mechanism of complex reaction in chemical looping gasification process.

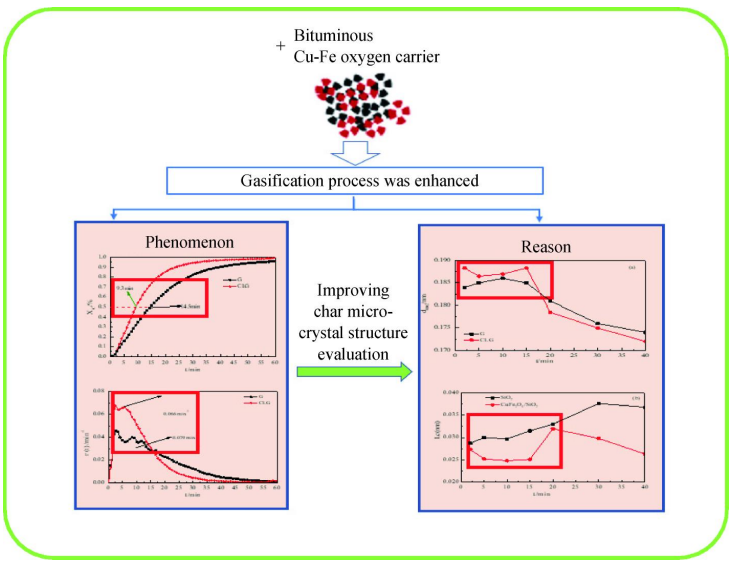


Acta Petrolei Sinica (*Petroleum Processing Section*), 2020, 36(6): 1306-1311 **doi**: 10.3969/j.issn.1001-8719.2020.06.021

Reactivity and Structure Evaluation of Coal Chemical Looping Gasification Based on Cu-Fe Oxygen Carrier

LI Xiao AN Mei GUO Qingjie

The effect of oxygen carrier on the microstructures and reaction activity during bituminous chemical looping gasification were investigated in a fluidized bed reactor using Cu-Fe oxygen carrier, which explains how Cu-Fe oxygen carrier improves the coal chemical looping gasification through coal char structure evaluation.



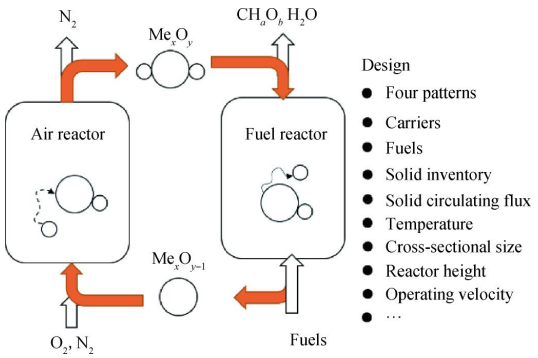
Reactor System Design Operation & Simulation

Acta Petrolei Sinica (*Petroleum Processing Section*), 2020, 36(6): 1312-1330 **doi**: 10.3969/j.issn.1001-8719.2020.06.022

Operation and Design Developments of Dual-Reactor Systems for the Chemical Looping Combustion/Gasification

WEI Yangjun CHENG Leming LI Liyao WANG Qinhui
FANG Mengxiang LUO Zhongyang

This paper reviews developments on operation and design of four dual-reactor systems, in which experiences on parameters design of chemical looping systems are summarized and discussed. It may give a help on the design for a chemical looping dual-reactor system.

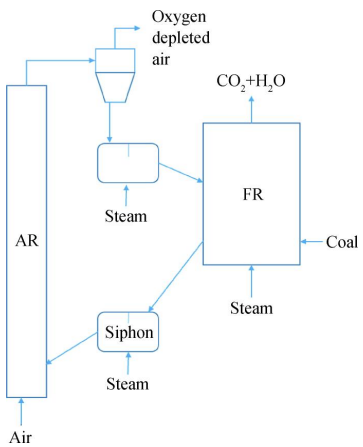


Acta Petrolei Sinica (*Petroleum Processing Section*), 2020, 36(6): 1331-1337 **doi**: 10.3969/j.issn.1001-8719.2020.06.023

Reactor Design of a 10 MW_{th} Chemical Looping Combustion System Based on Interconnected Fluidized Beds

MA Jiandong SONG Tao

Basing on mass balance, energy balance, reaction dynamics model and fluidization theory, the thermodynamic calculation of coal fueled CLC reactor were carried out with a heat input power of 10 MW_{th}, by using ilmenite as the oxygen carrier and Yimin lignite as the fuel.

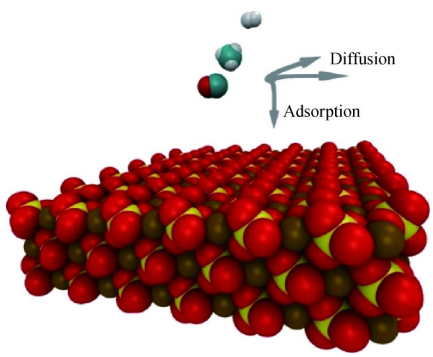


Acta Petrolei Sinica (*Petroleum Processing Section*), 2020, 36(6): 1338-1346 **doi**: 10.3969/j.issn.1001-8719.2020.06.024

Adsorption and Diffusion Characteristics of Gas Fuel on $CaSO_4$ (010) Surface for Chemical-Looping Combustion: Molecular Dynamics Simulations

HOU Fengxiao JIN Jing LIU Dunyu KOU Xuesen YANG Haoran
WANG Yongzhen

The adsorption and diffusion characteristics of CO on $CaSO_4$ (010) surface were simulated by molecular dynamics at 1123—1223 K, and they were compared with H_2 and CH_4. The results indicate the adsorption of CO on $CaSO_4$ (010) surface is the strongest and the diffusivity of H_2 on xy plane direction is the best.



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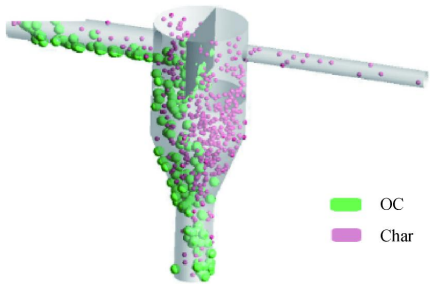
Scale-up Simulation of Directional Separation Process of Binary Particles in Chemical Looping Combustion Based on DDPM Model

GONG Yutong WANG Xiaojia ZHANG Bo

The process of directional separation of binary particles in a carbon particle separator from a chemical looping combustion system were studied by using a DDPM model coupled with DEM, and the working conditions at different outlet pressures and different temperatures were investigated.



Others

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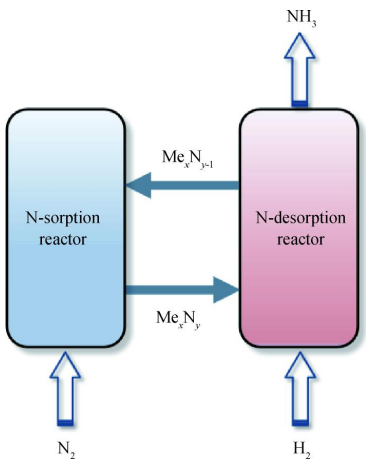
Fe, Mn Based Nitrogen Carrier in the Chemical Looping Ammonia Synthesis Technology

GUO Huixin WANG Baoyi SHEN Laihong

Ammonia is one type of clean energy which has broad development prospects. Chemical looping ammonia synthesis technology divides the traditional ammonia synthesis reaction into two steps: N-sorption process and N-desorption process. Fe, Mn and Fe-Mn based nitrogen carriers transport the nitrogen and heat between two reactors to complete the whole reaction.



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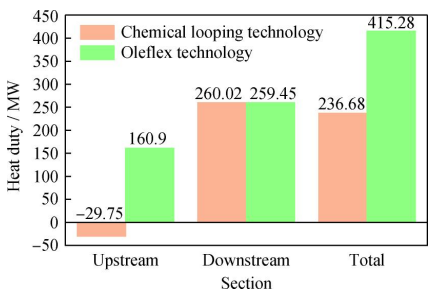
Process Simulation and Energy Consumption Analysis of Chemical Looping Oxidative Dehydrogenation of Propane

WEI Di Yu Junjie SHAO Yuanyuan ZENG Liang

Oleflex conventional propane dehydrogenation process and chemical looping oxidative dehydrogenation process were simulated using Aspen Plus. The results show that chemical looping oxidative dehydrogenation process reduces the energy consumption by 43.01% compared with the Oleflex process because of no needs for hydrogen environment, reactions on the hydrogen from the dehydrogenation with lattice oxygen in the catalyst, and the exist of coke reaction.



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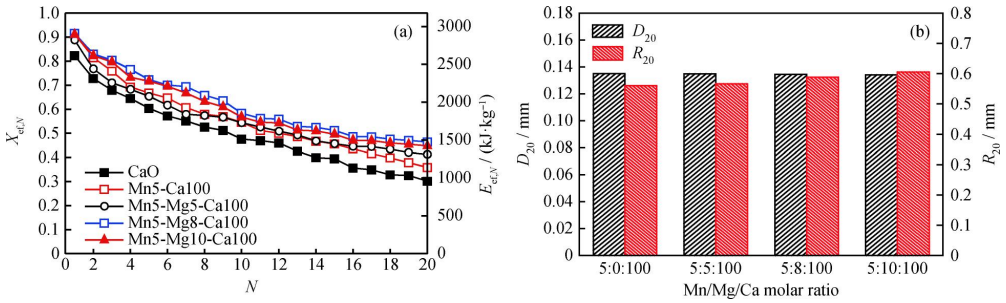
Heat Storage and Attrition Performance of Mn-Mg Modified Limestone Based on Calcium Looping Under Fluidization

MA Zhangke LI Yingjie BIAN Zhiguo ZHANG Yu WANG Tao LEI Wentao

The heat storage capacity of Mn-Mg modified limestone with the optimal Mn/Mg/Ca molar ratio of 5∶8∶100 is 54% and 30% higher than that of natural and Mn modified limestone, respectively.



(a) Valid heat storage convertion ($X_{ef,N}$) and valid heat storage dentistry ($E_{ef,N}$);

(b) Average diameter (D_{20}) and wear rate (R_{20}) of modified limestone particles after 20 cycles

Conditions: T=850 ℃; $F(N_2$ or $CO_2)$=2.5 L/min

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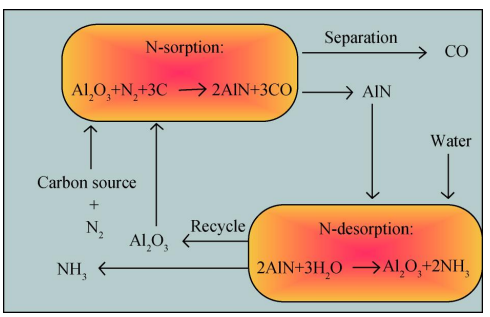
N-Adsorption/Desorption Performance of Al-Based N-Carrier During Chemical Looping Ammonia Generation

WU Ye ZHANG Quan FENG Mingqian LIU Dong

The N-adsorption performance of graphite, carbon black and bituminous/lignite/anthracite semi-coke were studied. The results show that the amorphous carbon promotes the N-adsorption performance of the N-carrier. Moreover, the effects of TiO_2 and ZrO_2 on N-desorption performance of N-carrier were studied. The results indicate that TiO_2 could increase the conversion efficiency of AlN while ZrO_2 could increase the yield of NH_3.



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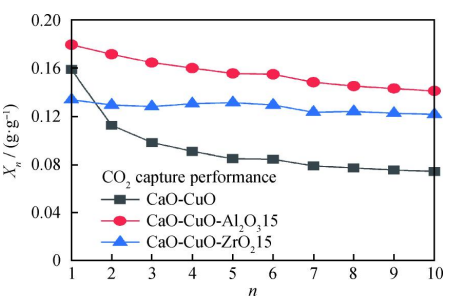
Analysis of Carbonation and Kinetic Performance of Inert Support-Stabilized CaO/CuO Composites

ZHANG Zhenmin CHEN Jian WANG Yankai LIAN Shiwen LI Fengquan WANG Chao YUAN Donghui LI Yingchun DUAN Lunbo

The addition of Al_2O_3 support significantly improves the cyclic CO_2 capture stability, mainly because of the increase in reaction rate, and reduction in decline rate and activation energies.

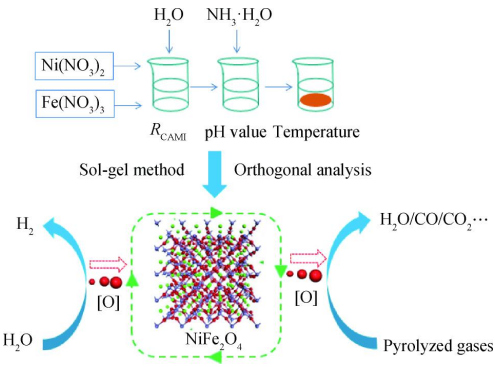


Acta Petrolei Sinica (*Petroleum Processing Section*), 2020, 36(6): 1398-1406 **doi**: 10.3969/j.issn.1001-8719.2020.06.031

Performance of $NiFe_2O_4$ Oxygen Carriers Prepared by Sol-Gel Method in Chemical Looping Process of Hydrogen Production

WEI Guoqiang ZHOU Huan WU Xianshuang FENG Jie
LI Haibin

The $NiFe_2O_4$ oxygen carriers were prepared by the sol-gel method, and the effects of preparation parameters on the physicochemical properties and chemical looping hydrogen performance were investigated by orthogonal experiments to achieve optimized preparation conditions.



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Dry Reforming of Methane and Metal-Support Interactions

SHI Jian ZHU Xing LI Kongzhai WEI Yonggang WANG Hua

The research results of methane dry reforming process and catalyst are elaborated in details, with emphasis on the new development of dry reforming process and the design of catalyst. Together with new strategies such as Ni-support interaction, bimetallic synergistic effect, crystal-plane effect and monatomic catalysis, basic scientific problems, existing difficulties and future development directions of dry reforming technology are discussed.