Les Rencontres Scientifiques de l'IFP

IFP-Lyon, France ■ 17 - 19 March 2010

1st International Conference on Chemical Looping

An Alternative Concept for Efficient and Clean Use of Fossil Resources

Final program

Wednesday 17 March

8.30 Registration

9.15 Welcome address: P. Ungerer, Scientific Director (IFP, France)

Chairpersons: Hugo de Lasa (Univ. of Western Ontario, Canada) and Arnold Lambert (IFP, France)

9.30 Keynote address**: Oxygen carriers for chemical looping combustion - operational experience**
A. Lyngfelt (Chalmers Univ. of Technology, Sweden)

Session 1: Chemical looping materials, reaction mechanisms and kinetic studies

10.10 **Reactivity analysis of mixed metal oxides**
B. Moghtaderi, H. Song, E. Doroodchi, T. Wall (Univ. of Newcastle, Australia)

10.30 **CLCMAT project – Material development for "Chemical Looping Combustion"**
S. Rifflart[1], A. Lambert[2], A. Delebarre[3], J. Salmi[4], B. Durand[5], S. Carpentier[6] (1 Total S.A., 2 IFP, 3 ESSTI Univ. Henri Poincaré, 4 Marion Technologies, 5 CIRIMAT, Univ. Paul Sabatier, 6 Gaz de France, France)

10.50 Break

11.20 **Spray-dried NiO oxygen carrier with highly attrition resistance**
J.-I. Baek[1], C. K. Ryu[1], J.-W. Kim[1], J. Ryu[1], J. B. Lee[1], T. H. Eom[1], J. Yi[2] (1 Korea Electric Power Research Institute, 2 Seoul National Univ., Korea)

11.40 **Using low-cost iron-based materials as oxygen carriers for chemical-looping combustion**
E. Jerndal, H. Leion, T. Mattison, A. Lyngfelt (Chalmers Univ. of Technology, Sweden)

12.00 **Performance of ilmenite as oxygen carrier for chemical looping combustion using coal as fuel**
A. Cuadrat, A. Abad, J. Adánez, L. F. de Diego, F. García-Labiano, P. Gayán (CSIC, Spain)

12.20 **The oxidation and reduction of ilmenite in chemical-looping combustion: a phase-chemical description**
P. den Hoed[1], A. Luckos[2] (1 Anglo Research, 2 Sasol Technology, South Africa)

12.40 Lunch

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Innovation
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Environment

Chairpersons: Marie Bysveen (SINTEF Energy Research, Norway) and Arnaud Delebarre (ESSTIN, France)

14.00 Keynote address: **Oxygen carrier materials for chemical looping processes - fundamentals**
J. Adanez (CSIC, Spain)

14.40 **Water splitting for hydrogen production using a chemical looping process with a perovskite-type mixed conducting ceramic as oxygen carrier**
A. Murugan, R. Franca, A. Thursfield, I. S. Metcalfe (Newcastle Univ., UK)

15.00 **Effect of H_2S on chemical looping combustion of coal-derived synthesis gas over Fe_2O_3 - MnO_2 supported on ZrO_2/sepiolite**
E. Ksepko[1], R. V. Siriwardane[2], H. Tian[3], T. Simonyi[3], J. A. Poston Jr.[1], A. Zinn[3], M. Sciazko[1] (1 Institute for Chemical Processing of Coal, Poland ; 2 DOE, 3 Parsons, USA)

15.20 **Investigation on reaction mechanism of chemical looping combustion of coal utilizing oxygen carriers**
R. Siriwardane[1], H. Tian[1,2], D. Miller[1,2], G. Richards[1], T. Simonyi[1,2], J. Poston[1] (1 DOE ; 2 Parsons, USA)

15.40 **Kinetic mechanism derived through dosing reactants over NiO, Ni and NiC**
F.-X. Chiron[1], G. S. Patience[1], S. Rifflart[2] (1 Ecole Polytechnique de Montréal, Canada ; 2 Total, France)

16.00 Poster session

Session 2: Chemical looping developments and pilot studies

17.00 **Chemical looping with copper oxide as carrier and coal as fuel**
E. Eyring, G. Konya, J. Lighty, A. Sahir, A. Sarofim, K. Whitty (Univ. of Utah, USA)

17.20 **Effect of gas impurities on the behaviour of Cu-based oxygen carriers on chemical looping combustion**
C. R. Forero[1], P. Gayán[2], F. García-Labiano[2], L. F. de Diego[2], A. Abad[2], J. Adánez[2] (1 EIDENAR, Colombia ; 2 CSIC, Spain)

17.40 **Hydrogen production coupled with CO_2 capture by chemical looping combustion using mixed Fe-Ni oxygen carriers**
M. Ortiz, L. F. de Diego, P. Gayán, M. A. Pans, F. García-Labiano, A. Abad, J. Adánez (CSIC, Spain)

18.15 Bus departure to the meeting point in Lyon (Ibis Centre Perrache, 28 cours Verdun)

Thursday 18 March

8.30 Registration

Chairpersons: Marie Anheden (Vattenfall, Sweden) and Sébastien Rifflart (Total, France)

9.00 Administration views: **Research Fund for Coal and Steel - RFCS**
L. Boillot (European Commission, Belgium)

9.20 Administration views: **US Department of Energy carbon sequestration progral overview**
W. E. Fernald (DOE, USA)

9.40 **Operation of a chemical looping pilot plant up to 150 kW fuel power – results for a nickel-based oxygen carrier and discussion of further scale-up scenarios**
T. Pröll, P. Kolbitsch, J. Bolhàr-Nordenkampf, H. Hofbauer (Vienna Univ. of Technology, Austria)

10.00 **Long term operation experience in a 50 kW_{th} chemical looping combustor using natural gas and syngas as fuels**
H.-J. Ryu, S.-H. Jo, Y. C. Park, D.-H. Bae, S. D. Kim (Korean Institute of Energy, Korea)

10.20 **Chemical looping combustion of solid fuels in a 10 kW_{th} pilot**
N. Berguerand, A. Lyngfelt, P. Markström, C. Linderholm (Chalmers Univ. of Technology, Sweden)

10.40 Break

11.10 **Chemical looping combustion of coal in a 1 kW_{th} reactor with iron ore as an oxygen carrier**
J. Wu, L. Shen, J. Hao, H. Gu (SouthEast Univ., China) *Cancelled*

11.30 **Effect of pressure on chemical looping combustion of coal with iron ore as oxygen carrier**
Q. Song[1,2], R. Xiao[1], S.Zhang[1], W. Zheng[1], Y. Yang[1], L. Shen[1] (1 SouthEast Univ., China ; 2 Univ. of Cambridge, UK)

11.50 **Chemical looping of solid fuels in laboratory fluidized bed reactor**
H. Leion, T. Mattisson, A. Lyngfelt (Chalmers Univ. of Technology, Sweden)

12.10 **Chemical looping combustion with different types of liquid fuels**
A. Hoteit, A. Forret, W. Pelletant, J. Roesler, T. Gauthier (IFP-Lyon, France)

12.30 **Gasification of biomass and CO_2 capture using chemical looping combustion**
M. M. Hossain[1], M. R. Quddus[2], E. Salaices[2], H. I. de Lasa[2] (1 King Fahd Univ. of Petroleum & Minerals, Saudi Arabia ; 2 Univ. of Western Ontario, Canada)

12.50 Lunch

Chairpersons: Corinne Béal (Alstom, France) and Gregory Patience (Ecole Polytechnique de Montréal, Canada)

14.10 Keynote address: **Chemical looping processes and applications**
L. S. Fan (Ohio State Univ., USA) - *via telephone link*

Session 3: Chemical looping scale-up, reactor technology and process modeling

14.50 **Design and performance of a full scale cold flow model of an innovative chemical looping combustion reactor system**
A. Bischi[1], O. Langorgen[2], J. X. Morin[3], J.Bakken[2], M. Bysveen[2], O. Bolland[1] (1 NTNU, 2 SINTEF, Norway ; 3 C02-H2, France)

15.10 **A novel CLC configuration with independent solid flow control**
M. M. Yazdanpanah[1], A. Hoteit[1], A. Forret[1], A. Delebarre[2], T. Gauthier[1] (1 IFP-Lyon ; 2 ESSTI, Univ. Henri Poincaré, France)

15.30 **The role of attrition and solids recovery in a chemical looping combustion process**
M. Kramp, A. Thon, E.-U. Hartge, S. Heinrich, J. Werther (Hamburg Univ. of Technology, Germany)

15.50 **Investigation of the attrition behaviour of an iron oxide oxygen-carrier under inert and reacting conditions**
T. A. Brown[1], F. Scala[2], S. A. Scott[1], J. S. Dennis[1], P. Salatino[2,3] (1 Univ. of Cambridge, UK ; 2 Istituto di Ricerche sulla Combustione ; 3 Univ. di Napoli Federico II, Italy)

16.10 Poster session

17.15 Bus departures:

- to Pérouges village for the participants registered to the conference dinner *sponsored by Total and Alstom*
- or to the meeting point in Lyon (Ibis Centre Perrache, 28 cours Verdun)

Friday 19 March

8.30 Registration

Chairpersons: Tobias Pröll (Vienna Univ. of Technology, Austria) and Ali Hoteit (IFP, France)

9.00 Keynote address: **What industry should expect from chemical looping combustion**
A. Pfeffer (Alstom Power, USA)

9.40 **Computational fluid dynamics simulation of the fuel reactor of a coal fired chemical looping combustor**
K. Mahalatkar[1,2,3], T. O'Brien[1], E. D. Huckaby[1], J. Kuhlman[1,2] (1 NETL ; 2 West Virginia Univ. ; 3 ANSYS-Fluent, USA)

10.00 **A numerical study of fluidization behaviour of bidispersed gas-solid flow using an eulerian multifluid modeling approach**
N. Nouyrigat, R. Ansart, H. Neau, O. Simonin (Univ. de Toulouse, CNRS, IMFT, France)

10.20 **CLC modeling: the fuel-reactor at fast fluidization-conversion of CH_4 using a NiO-based oxygen-carrier in a 120 kW_{th} unit**
A. Abad[1], J. Adánez[1], F. García-Labiano[1], L. F. de Diego[1], P. Gayán[1], P. Kolbitsch[2], T. Pröll[2] (1 CSIC, Spain ; Vienna Univ. of Technology, Austria)

10.40 **Parameter study in order to reveal critical design issues in the design for a CLC power plant using solid carbon as fuel**
B. Fillman, M. Anheden, J. Wolf (Vattenfall, Sweden)

11.00 Break

11.20 **Alstom's chemical looping combustion coal power technology development prototype**
H. E. Andrus, J. H. Chiu, P. Thibeault (Alstom Power, USA)

11.40 **Development of metal oxides chemical looping process for coal-fired power plants**
C. Béal[1], B. Epple[2], A. Lyngfelt[3], J. Adanez[4], Y. Larring[5], A. Guillemont[6], M. Anheden[7] (1 Alstom Power Systems, France ; 2 Technische Univ. Darmstadt, Germany ; 3 Chalmers Univ., Sweden ; 4 CSIC, Spain ; 5 Sintef, Norway ; 6 Air Liquide, France ; 7 Vattenfall, Sweden)

12.00 **Round-table** chaired by Andreas Ehinger (IFP, France)

Participants:

M. Anheden (Vattenfall, Sweden)
T. Gauthier (IFP, France)
A. Lyngfelt (Chalmers Univ. of Technology, Sweden)
T. O'Brien (NETL, USA)
G. Patience (Ecole Polytechnique de Montréal, Canada)
A. Pfeffer (Alstom Power, USA)

13.00 Closing of the conference

13.15 Lunch

14.35 Visit of IFP-Lyon premises (upon registration)
or first bus departure to Lyon railway stations and to Lyon Saint-Exupery Airport

16.00 Last bus departure to Lyon railway stations and to Lyon Saint-Exupery Airport

List of posters

Session 1 - Chemical looping materials, reaction mechanisms and kinetic studies

- **Chemical looping combustion with Ni-Co/La-γAl_2O_3 oxygen carrier in a fluidized bed reactor**
  M. R. Quddus, M. M. Hossain, H. I. de Lasa (Univ. of Western Ontario, Canada)
- **Chemical looping materials : can NiO-$NiAl_2O_4$ carriers be outperformed?**
  A. Lambert, P. Briault, E. Comte (IFP-Lyon, France)
- **Characteristics of various new oxygen carriers for chemical looping combustion**
  J. Lagerbom, T. Pikkarainen, U. Kanerva, A. Moilanen, P. Koskinen, J. Saastamoinen, P. Kauranen (VTT, Finland)
- **Support effect on the performance of NiO-based oxygen carrier**
  J.-I. Baek[1], J.-W. Kim[1], J. B. Lee[1], T. H. Eom[2], J. Ryu[1], C. K. Ryu[1], J.Yi[2] (1 Korea Electric Power Research Institute ; 2 Seoul National Univ. Korea)
- **$La_{1-x}Sr_xM_yFe_{1-y}O_{3-\delta}$ perovskites as oxygen-carrier materials for chemical-looping reforming**
  L. Nalbandian, A. Evdou, V. Zaspalis (CERTH, Greece)
- **Preparation of oxygen carriers for chemical looping combustion by industrial spray drying method**
  F. Snijkers[1], E. Jerndal[2], I. Thijs[1], T. Mattisson[2], A. Lyngfelt[2] (1 Vito, Belgium ; 2 Chalmers Univ. of Technology, Sweden)
- **Ilmenite agglomeration during sequential oxidation-reduction**
  P. Perreault[1], S. Rifflart[2], G. S. Patience[1] (1 Ecole Polytechnique de Montreal, Canada ; 2 Total, France)
- **Kinetic modeling in CFD simulations of chemical looping**
  H. Kruggel-Emden[1,2], F. Stepanek[1], A. Munjiza[1] (1 Imperial College London, 2 Univ. of London, UK)
- **A comparison between the carbon deposition on nickel supported and perovskite-type redox materials in hydrogen production chemical looping processes**
  A. Murugan, R. Franca, A. Thursfield, I. S. Metcalfe (Newcastle Univ., UK)
- **Effect of CO_2 concentration on reduction reactivity of oxygen carriers**
  H.-J. Ryu[1], J. Park[1], S.-Y. Lee[1], M.-H. Park[2] (1 Korea Institute of Energy Research, 2 Hoseo Univ., Korea)

Session 2 - Chemical looping developments and pilot studies

- **Performance of mixtures of natural minerals and a nickel-based material as oxygen carriers in chemical looping combustion in a 120 kW pilot plant**
  K. Mayer, T. Pröll, H. Hofbauer (Vienna Univ. of Technology, Austria)
- **Reduction performance of ilmenite and hematite oxygen carriers in the context of a new CLC reactor concept**
  G. L. Schwebel, F. Wiedenmann, W. Krumm (Siegen Univ., Germany)
- **Sulfur release from chemical looping combustion of coal in a 1 KW_{th} reactor with nickel-based oxygen carrier**
  L. Shen, J. Wu, J. Xiao, H. Zhang (Southeast Univ., China)
- **Effect of Ash on CLC of a solid high carbon char**
  A. Rubel, K. Liu, J. Neathery (Univ. of Kentucky, USA)
- **Chemical looping reforming of biomass tar**
  T. Mendiara, A. D. Jensen, P. Glaborg (Technical Univ. of Denmark, Denmark)
- **H_2 production utilizing chemical-looping for CO_2 capture**
  M. Rydén, A. Lyngfelt, T. Mattisson (Chalmers Univ. of Technology, Sweden)

- **A study of a chemical looping carbon capture for high-hydrogen content syngas**
  S. Stendardo[3], A. Calabrò[1], G. Girardi[1], P. U. Foscolo[2], C. Hercé[1] (1 ENEA, 2 Univ. of l'Aquila, Italy ; 3 European Commission Joint Research Center, The Netherlands)
- **Chemical looping partial oxidation for energy conversion**
  T. Hatanaka[1], S. Matsuda[1], E. Fumoto[1], H. Hatano[1], J. Otomo[2] (1 AIST, 2 Univ. of Tokyo, Japan)
- **Capture of CO_2 calcium cycle under circulating fluidized bed conditions**
  C. Schönnenbeck , E. Bouquet, G. Leyssens, (Univ. de Haute-Alsace, France)

Session 3 - Chemical looping scale-up, reactor technology and process modeling

- **Development of novel two-interconnected fluidized bed system for chemical looping combustor**
  H.-J. Ryu, D. Shun, G.-T. Jin, C.-K. Yi (KIER , Korea)
- **Status of CLC at the University of British Columbia**
  J. Cheung, N. Ellis, C. J. Lim (Univ. of British Columbia, Canada)
- **Simulation of the fuel reactor of a 1MW_{th} chemical looping plant for coal**
  J. Strohle, M. Orth, B. Epple (Univ. Darmstadt, Germany)
- **Simulations of circulating fluidized bed chemical looping combustion system utilizing gaseous fuel**
  K. Mahalatkar[1,2,3], J. Kuhlman[1,2], E. D. Huckaby[1], T. O'Brien[1] (1 NETL, 2 West Virginia Univ., ANSYS, USA)
- **Multiphase CFD-based models for a chemical looping combustion process**
  S. Cloete, S. T. Johansen, S. Amini (Sintef, Norway)
- **Modeling the hydrodynamics of chemical looping reactors**
  R. Ocone (Heriot-Watt Univ., UK)
- **CPFD Eulerian-Lagrangian numerical scheme applied to the NETL bench-top chemical looping experiment**
  D. Snider[1], C. Guenther[2], J. Dalton[2], K. Williams[1] (1 CPFD Software, 2 NETL, USA)
- **HotCO_2: packed-bed chemical looping combustion for small-scale applications**
  P. Geerdink, L. J. P. van den Broeke (TNO, The Netherlands)
- **CarboLoop: a novel concept of looping combustion of carbon**
  P. Salatino[1,2], O. Senneca[1], L. Cortese[1] (1 IRC, 2 Univ. di Napoli Federico II, Italy)
- **On the development of a rotating reactor concept for chemical looping combustion – part 2**
  S. F. Hakonsen, I. M. Dahl, M. Stange, A. I. Spjelkavik, R. Blom (Sintef, Norway)

Supported by

ALSTOM TOTAL cpfd COMPUTATIONAL PARTICLE FLUID DYNAMICS VATTENFALL