Thesis for the Master Degree in Chemical Engineering "**Energy Upgrading Of Civil / Industrial Wastewater Treatment Of Dried Waste Sludge**" ("VALORIZZAZIONE ENERGETICA DA FANGHI DI DEPURAZIONE DELLE ACQUE CIVILI E INDUSTRIALI")

UNIVERSITÀ DEGLI STUDI DI GENOVA - FACOLTÀ DI INGEGNERIA CORSO DI LAUREA IN INGEGNERIA CHIMICA, anno accademico 2006/2007
Relatore: Chiar.ma Prof. Ing. Elisabetta Arato
Correlatore: Ing. Paolo Greppi
Allievo: Gianluca Binello
Data : 19-07-2007

At the moment two issues in Italy attract the interest of both politics and media: energy production from non-fossil, **renewable sources** and disposal of **waste**. **Waste-to-energy** technologies are an answer to these issues, since they reduce the quantity of waste and since wastes can be considered a renewable energy source.
Thermal treatment of wastes with energy recovery has to be considered in the more general framework of processes for the partial combustion and **gasification** of solids; these in turn are constrained by environmental legislation at the national and regional level that push towards more complex technologies such as Integrated Gasification Combined Cycles or pressurized combustion/gasification.

The objective of this work is to evaluate the potential of civil / industrial waste water treatment dried waste sludge as fuel for **innovative waste-to-energy processes** by means of process simulation.
The production of waste water treatment dried waste per capita is about 0.2-0.3 kg, with a marked growth trend. About one third end up as fertiliser in agriculture or as compost, another third in as an additive in the manufacture of clay products for constructional purposes, and the rest is incinerated.
The use in agriculture is likely to be unfavoured in the future, and due to the growth in the quantities of produced sludge there is a need for alternatives to incineration.

The innovative waste-to-energy process we considered is based on a **dual chamber gasification**, where a fluid bed circulates between an exothermic oxidation chamber and an endothermic gasification chamber. In this way a low inert-gas syngas and a carbon dioxide-rich exhaust flue gas flow are generated in the two separate chambers.

Process modelling computations were performed using the flow-sheetingand modelling tool **LIBPF** (**LIB**rary for **P**rocess **FFlow-sheeting** under active development by the UNIGE / DICAT group. The gasification reactions have been assumed to reach thermo-chemical equilibrium, with the exception of a certain amount of atomic carbon which would not participate to the equilibrium to account for tar formation.

The first simulated scenarios based single-chamber gasification gave a syngas with Lower Heating Value (LHV) of 2.2 MJ/Nm^3 and a gasification yield of 62%. Using the dual-chamber fluidized bed gasifier the syngas LHV is 4,2 MJ/Nm^3 and the gasification yield is 68%.
The high ashes content of the waste water treatment dried waste sludge (about 45%) and the presence of many toxic and dangerous substances such as heavy metals make it the worse possible biomass fuel and explain the modest results obtained.
Therefore more scenarios were tried with mixed feed, i.e. feeding to the gasifier an agricultural waste biomass (with low ashes content of about 1%) in addition to the waste water sludge. The mixed feed remarkably enhances the performance of the gasifier, and the feed mix ratio can be used as a design parameter to optimize the process.

Future line of development if this work could be:

- The investigation of the kinetic effects on the gasification to get a more accurate and realistic process model;
- Analysis of the means of separation of the ashes from the circulating fluid bed;
- Alternatives for the use of the syngas;
- Pilot scale test.