Faculty Engineering Technology
Program Sustainable Energy Technology

UNIVERSITY OF TWENTE.

COLLOQUIUM

Group: **Engineering Fluid Dynamics**

As part of his MSc thesis assignment

B. Vree

will give a presentation, entitled:

Rapid Depressurization of a Carbon Dioxide Pipeline

Date: Friday November 29, 2013

Time: 09.00

Room: Horstring N109

Summary:
The International Panel on Climate Change (IPCC) has recently revealed that the majority of climate scientists are more than 95% certain about the relation between global warming since the mid-20th century and human influence. Climate change mitigation policies have been rolled out on several levels resulting in e.g. CO_2 emission quotas. In this context, carbon capture, transport and storage (CCTS) can be applied e.g. to coal or gas fired power plants to severely reduce their carbon emissions. However, before CCTS can be applied on a significantly larger scale, it is important that a number of political, economic, social, environmental and technical challenges are faced.

This research mainly focusses on the technical challenges related to the modelling and experimentation in case of rapid depressurization of a CO_2 pipeline. The relevance of this study is very broad as depressurization effects can occur during transient operation of pipelines or when a pipeline is punctured or ruptured. The rate and composition of the CO_2 outflow will mainly depend on the flow regime and thermodynamic state of the fluid in the pipeline itself, thereby also influencing (health) risks. Being able to model, analyse and predict the behaviour of CO_2 undergoing a rapid depressurization is also very critical in terms of pipeline integrity as very low temperatures may be reached, resulting in brittle pipe material. The research is carried out in the framework of the Dutch research programme on CCTS (CATO2) at the Smart and Sustainable Energy (SSE) department of DNV KEMA Energy and Sustainability in Groningen.

Experimental research has been conducted on a 30 meter pipeline in which initially liquid CO_2 is depressurized from high pressures (±120 bar) to atmospheric pressure. Different depressurization rates are obtained by using different size nozzles. The pressure and temperature development during the depressurization process is governed by internal processes, exiting mass flow and heat transfer with the surroundings. The rate of phase change is an important phenomenon significantly influencing the pressure and temperature evolution during the depressurization process and is assessed by a physical model. The rate of phase change is found to be clearly dependent on the mass flow rate resulting in the highest phase change rate for the largest mass release rate, also resulting in the lowest measured CO_2 temperature.

In addition an axisymmetric two-phase flow model has been set up. This model has been implemented in the commercial computational fluid dynamics (CFD) package ANSYS Fluent 14.5. Turbulence is accounted for by the k-ε model with standard wall functions. Heat transfer from the surroundings is modelled by free convection on the pipe outside and heat conduction through the pipe wall. The goal is to assess the capability of the CFD package to simulate the (multiphase) depressurization process and to fine-tune its 'evaporation-condensation' model by validation against the experimental results. The available equations of state for modelling liquid and vapour CO_2 provide reasonable results but lack the required functionality to accurately describe the full depressurization process from initial conditions to atmospheric pressure. Furthermore the 'evaporation-condensation' model is found to reasonably predict the phase change rate if the model is initiated from the correct saturation conditions and the evaporation coefficient is chosen properly. The present model setup provides a start but requires improvement in terms of the multiphase flow model, equations of state employed and required computational effort.

Assessment committee:		**Chairman:**
Prof.dr.ir. H.W.M. Hoeijmakers	(chairman)	
Ir. L. Buit	(mentor)	
Dr.ir. M. Ahmad		
Dr. G.G.M. Stoffels		
Dr.ir. E.T.A. van der Weide		d.d.