MINUTES OF MEETING

FLACS USER GROUP (FLUG)



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FLUG meeting 30-31 October 2012

FLUG chairman: Chris Savvides (BP)

FLUG Meeting – 30 October:

Welcome to FLUG
Chris Savvides (BP) welcomed the participants to Pau on behalf of GexCon.
Henri Tonda (Total) presented Total and the CSTJF campus in Pau, location of the technical center of Total E&P.

FLACS simulations of methane DDT experiments
Nicolas Salaün (GexCon) presented a study on the validation of FLACS for DDT prediction for confined methane explosions. Simulations of the Kuznetsov 2001 experiments with two different geometries (30% and 60% blockage ratio) were run to investigate when a significant likelihood of DDT in FLACS simulations can be diagnosed and whether, on the other hand, one is also able to obtain a non-significant DDT likelihood when no DDT is observed.
The computational grid was prepared according to the best practices (with preference on smaller grid cells when there is a choice, to better resolve the circular geometry); the obstacles are resolved on-grid.
For the 30% blockage ratio (BR) base case with stoichiometric mixture, pressures reach up to 18 bar, and many locations with DPDX > 5 are observed in the simulation result; this indicates that DDT is likely, which matches the experimental results.
For the second case, 30% BR but lean concentration conditions (7% vol., only concentration is changed), no values DPDX > 1 are present in the FLACS result, and also no DDT was observed in the experiments.
The third case with 60% BR and stoichiometric conditions (only geometry changes with respect to the base case) has DPDX up to 5, but the flame speed does not exceed 850 m/s, which renders a DDT unlikely based on the simulation.
Based on these results, the assessment of DDT potential has to be based on several criteria, not just DPDX; additionally, e.g. the maximum overpressure and/or flame velocity should be taken into account. Further, non-CFD approaches, e.g. estimation of (characteristic detonation cell size of fuel/typical geometric parameter), may compliment the overall picture.
Nicolas emphasized that one should use the terms “likelihood” and “potential” when using FLACS simulations for assessing DDT risk.

Olav Sæter (Statoil) and Chris Savvides (BP) raised questions regarding the grid sensitivity of the results, how porosity contributions due to the stepwise Cartesian grid representation of the circular tube contribute to the results, and how well-resolved do the obstacles need to be. Nicolas commented that the grid is linked to the geometry in this case; the porosity pattern may possibly lead to some extra acceleration, but this was not investigated further than choosing the smallest grid available to limit a too big influence of this “geometrical layer” effect.
Olav Hansen (GL Industrial Services) commented that a dedicated setup file could be used to compensate for artificial acceleration.
Karim Osman (GDF Suez) enquired whether Nicolas had tested simulations with open areas, i.e. non-confined/enclosed systems. Nicolas answered that the following presentation would contain some additional information regarding unconfined geometries.

Deflagration to detonation transitions: is my facility at risk of a DDT?

Prankul Middha (GexCon) held Scott Davis's presentation regarding DDT potential in realistic geometries. He illustrated how long flame acceleration distances with congestion can lead to DDT and that reduced congestion can stop the acceleration and avoid DDT. He stressed that when looking at DDT one has to take into account the entire gas cloud, not just the one in the obstructed area.

Prankul presented an overview of recent DDT incidents: four occurrences that likely involved DDT (based on damage observed at the sites) were recorded in the years 2005-2009. One of them, the Buncefield accident has been studied intensively by GexCon and a significant likelihood of DDT has been confirmed by FLACS simulations when the vegetation along the alley is included in the geometry modeling.

Prankul continued to explain the DPDX criterion and current and future work to improve modeling of the onset to DDT. Part of this is a JIP, in which GexCon will contribute with medium/large scale experimental tests. GexCon's research collaboration includes Texas A&M and SRI and will lead to the expansion of the prediction capability to various hydrocarbons, and validation with more small, medium and large scale tests.

Prankul summarized that it is important to consider DDT in facility siting, and that FLACS is a tool to help predict the onset of DDT.

Explosion analysis on large floaters – explosion loads

Shengjun Zhang (DNV) gave a presentation about work motivated by the increasing FPSO/FLNG market for production located far from existing, land-based infrastructure.

Shengjun explained that the explosion load on an object consists of the combustion load, the inertial differential blast overpressure, and the form drag, and discussed which of these are neglected for structures of different sizes: for small diameter equipment one focusses on drag loads, for large equipment on the differential pressure loads; at intermediate size both must be considered. The maximum pressures due to the different loads occur at different times. DNV in practice uses the estimate pressure load = pressure differential(=overpressure) + ½ drag. The loads are computed from NPMAX and NDMAX, with the problem that NPLOT needs to be reasonably low to catch the maximum (leading to big output files), and fine gridding being required at the equipment of interest.

Olav Hansen (GL Industrial Services) commented that just reducing grid cell size "somewhere" is not a good approach.

Shengjun contrasted the previous approach with the extraction of NP and NDRAG from monitor points. In this case, the disadvantage is that the monitor points need to be inserted manually, and their number is limited. He suggested to increase the limit to 2000 or more, also for panels.

Further, Shengjun suggested to add software support for placing monitor points on the equipment of interest automatically. Also, he wished for extended guidelines on gridding and improvement of the simulator regarding the far-field (multi-block method).

Olav advised that the multi-block capability in FLACS is currently not recommended because of difficulties with the time step, cf. Hansen et al (2010).

Shengjun further mentioned a problem with handling the geometry of a large onshore plant in CASD, which had to be cut into several parts.

Olav commented that comerge can be used to select parts of the geometry; it was also mentioned that one can filter a geometry before opening it.

Chris Savvides (BP) pointed out the limit in level of detail that can be attained by simulations in which many structures are sub-grid and questioned the using large numbers of monitor points.

Experience from assessing equipment density

Torunn S. Davidsen (Scandpower) shared some experiences from updating the QRA for a North Sea platform. During the project, the existing geometry model from about ten years ago was updated with new PDMS import. The question that arose was whether a new explosion study was required due to the geometry changes.

The available PDMS model for the platform was "almost complete" but it was unclear how the completeness of the geometry should be assessed. Possible ways could be evaluation of the input, e.g. by a scanned model, PDMS import, or manually from drawings/pictures. The assessment of "what is missing" needs to take into account at which stage in the design process the input is created: in early stages, many details may not be known and thus be missing from the resulting geometry.

As a consistency check, one might also compare the equipment density with a database. Parameters that could be compared include the accumulated length of piping of different diameters or the surface

area. Torunn showed results regarding the cylinder length per volume comparison of different installations and stressed that while one cannot expect to have equal results, the large diameters match quite well, whereas for the small diameters larger deviations occur. For the surface area per volume, both the old and new model yielded higher results in the medium range of diameters than a scanned reference installation.
Torunn concluded that a method of assessing equipment density should include both cylinders and boxes.
A question was raised whether the geometry was first imported into KFX and then into FLACS, which may lead to lost geometry.
Shengjun Zhang (DNV) triggered a discussion about congestion factors and their use by different companies.

Grid sensitivities for ventilation studies
Ranveig Niemi and Kjetil Hersvik (Safetec) presented a study in which they ran simulations for four different platforms using different grid resolutions. They showed that the ventilation depends on the grid resolution, but that the trend is not the same for all platforms and wind directions. For example, a 2 m grid could give on average 10 % less ventilation, and a 0.5 m grid 5 % more ventilation relative to a 1 m grid, but the trend could go either way. The presenters closed with the questions how to decide which grid resolution to use and which grid resolution agrees better with validation.
Olav Hansen (GL Industrial Services) commented that at least the resolution of the coarse grid, which had only three grid cells over the height, was too low to resolve the relevant physics and flow pattern. For the problem at hand, an anisotropic grid, e.g. 2 m x 2 m x 1 m, could be used.
Djurre Siccama (GexCon) mentioned that GexCon is working on improving the guidelines for dispersion.

Experience using the pool spill model in FLACS
Tahir Bhola (GL Industrial Services) showed results from modelling of LPG releases from tanks with bund and channel. Spill scenarios with both propane and butane were discusses and for some of them, a deluge system was also modelled.
Without a deluge system, propane evaporates faster than butane and eventually disappears. However, with a deluge system, represented by spill on a water surface, butane evaporates faster than propane. This reversal was attributed to the heat flux from the underlying material, based on simulations set up with varying ground/water temperatures. Thus, while initially surprising, the result was in line with theory.
Tahir concluded that LPG spills on water may not behave as initially expected and that evaporation depends on the boiling mechanism. He advised to check the difference between the boiling point and the ground temperature during simulation setup, and to set up simulations with varying temperature differences to determine whether one is in nucleate, transient or film boiling regime.
Karim Osman (GDF SUEZ) asked whether any pool spill experiments were planned. Tahir answered that this was not the case.

Efficiency of blast walls to protect against vapour cloud explosions in offshore facilities
Jerôme Hocquet (Technip) presented a sensitivity analysis regarding a small platform in the North Sea. The study concerned the possible addition of two fire and blast walls and included ten simulations for each geometry, three flammable cloud sizes, and several ignition locations.
For the first wall, the results were as expected: adding the wall leads to higher overpressures in the area where the gas explosion occurs (process area), but reduces the overpressure level in the well intervention area. This held true for all cloud sizes and ignition locations.
Addition of the second blast wall led to qualitatively similar results for the process area: approximately 25 % overpressure increase with the wall compared to without it. Unexpectedly, however, the overpressure for the living quarter was found to be higher with fire and blast wall in place. The simulation results show that this is due to reflection of the pressure wave. At about 10-15 m downwind of the wall, almost the same overpressures were observed with and without the wall.
Jerôme concluded that for some geometry configurations, blast walls may lead to locally higher overpressures and that the attenuation of a blast wave may be limited to a few metres downwind of the wall and the wave may reconstitute itself at some distance behind the wall. Therefore, the use of safety gaps to reduce overpressure should not be discarded prematurely. Jerôme stressed that in any case the efficiency of the design solution has to be demonstrated.

Olav Hansen (GL Industrial Services) remarked that the study should be complemented with cloud size variation. He also pointed out that the simulation result of 3.5 bar overpressure on the wall may be too much for it to withstand, so it actually limits ventilation and possibly does not improve safety.

Transformer explosion risk assessment of the Frades II hydropower plant

Arnt-Lennart Fuglestad (GexCon) gave a presentation on gas explosion accidents in underground hydroelectric power plants and electric substations. These may occur as a consequence of faults in electric components and are dangerous due to the strict confinement. The transformers contain oil-insulated components enclosed in tanks. In case of failure, gaseous pyrolysis products are formed and consequently the internal pressure rises which may lead to breaking of the transformer tank as a primary explosion scenario, without chemical combustion. The arising oil mist and liquid oil pool can then lead to a secondary explosion scenario, in which the gas cloud formed as a consequence of the primary explosion of the transformer undergoes a combustion process. Such secondary explosions were modelled with the help of FLACS.

Arnt-Lennart described how the available quantity of low hydrocarbons as product of the pyrolysis is determined based on the arc energy. This flammable matter is introduced in the simulation setup as butane equivalent fraction determined according to molecular weight and combustion heat of the gas species and concentrations. The gas clouds were shaped and positioned such that they (partially) surround the transformer and the ignition position was set nearby. Subsequently, the risk analysis methodology of choice (worst case/realistic worst case/probabilistic) may be applied to the gas explosion problem.

Arnt-Lennart showed how the exceedance curves for main targets of the power plant had led to the definition of four arc energy classes and oil mist classes chosen in terms of added oil mist amount. FLACS scenarios for a case study for Frades II were then set up based on the couple arc energy class, oil mist class, using the gas cloud volume and weight calculated based on them.

The result of the study was that the customer's proposed solution for venting was too limited; a different solution was developed by varying the vent geometry, panel weights and opening pressures.

Kjetil Hersvik (Safetec) and Torunn Davidsen (Scandpower) asked how the frequencies for the probabilistic study were determined. Arnt-Lennart answered that these were based on expert knowledge.

Karim Osman enquired how turbulence was taken into account. Arnt-Lennart's reply was that the initial turbulence around the transformer is set in the simulation setup.

Modelling of dust explosions to determine optimum explosion protection

Chris Coffey (GexCon) spoke about the mitigation measures for dust explosions and how to design these when the applicable EN standards and codes are not relevant or considered too conservative.

Venting is the most frequently used method for mitigation of dust and gas explosions and methodologies for determining the proper parameters of venting panels have been developed for a long time and lead to many standards. In particular, EN 14491:2006 assumes homogeneous, stoichiometric, and turbulent gas cloud. This standard is, however, limited in vessel volume, and this limit is nowadays often exceeded. Therefore alternative methods to determine panel parameters are desirable.

Chris showed sample simulation results with a wide range of possible overpressures, in contrast to a single value (for given panel size) determined according to the standard. In particular, much higher pressures than predicted by the standard were obtained for high turbulence cases. On the other hand, the standard over-predicts the required panel size for low turbulence.

Chris concluded that the standard gives a first indication, and that CFD simulations can help to determine more precisely the required panel size.

Tim Jones (MMI Engineering) asked how many extra steps and how much additional knowledge were required to run DESC compared to FLACS. Chris responded that one has to know about the extra requirements for DESC setups but that it was not much more complicated for someone used to set up FLACS simulations.

Olav Hansen (GL Industrial Services) commented that for dust explosions the amount of dust that can be lifted is critical. Chris agreed and added that the study was conservative with respect to this.

Djurre Siccama (GexCon) enquired how silos with sizes exceeding the applicability range of the EN standard are currently planned. Chris answered that to his knowledge this is done by a combination of extrapolation and CFD.

Trygve Skjold (GexCon) remarked that there are strong indications that previous dust explosion accidents have resulted in higher pressures than predictions according to the guidelines based on pneumatic injection would suggest.

FLUG Meeting – 31 October:

Agenda and minutes from last meeting

Chris Savvides welcomed the participants to the second day of the FLUG meeting and thanked Henri Tonda and Total for organizing it. The meeting minutes from the previous FLUG gathering in Bergen were displayed and gone through; no suggestions for additions or changes were raised.

GexCon R&D: Activities in 2012 and beyond

Trygve Skjold (GexCon) gave an update on activities in the GexCon R&D department. Recruitment is ongoing: currently there are open positions for a senior engineer in dispersion, (senior) software developers, and a technical team leader. Some positions are open to replace personnel that have left the company in 2012. A new industry PhD project on modelling of mist and spray combustion has been initiated and Laurence Bernard has been selected for the position.

Trygve informed that GexCon R&D has recently held an internal strategy meeting to identify future directions for FLACS development. Important challenges need to be distilled from the many (>500) reported issues and prioritized for future resource allocation. He emphasized that as the software grows in complexity it is becoming more and more important to simplify its use where possible so that not only users with many years of experience can apply FLACS. Trygve challenged the audience to identify and propose potential simplifications.

Next, Trygve touched upon the delay of the new release, FLACS v10. In part this has been caused by overload with many new versions (previous JIP results, CASD 7, new geo2flacs, developments based on FLUG wishes, etc.) which were not combined and finished on time. Additionally, supporting more platforms demands more resources. The ambition is to treat less new items at a time in the future and complete these before addressing other items, so that the overhead for the final testing and validation becomes less.

Trygve presented some of the results of the JIP “FLACS 2011 and beyond” and highlighted which ones have found their way into FLACS v10. Among the other changes in the new release is a fix in the sub-grid turbulence model regarding turbulence production at corners; this change is linked to the porosity calculation, so that the FLACS v10 simulator and Porcalc need to be used together, porosities for existing scenarios should be recalculated for simulations with FLACS v10. Consequences of the modifications were illustrated by some of the more than 900 scenarios GexCon R&D has rerun; the changes in the overall results are typically within 10 %.

As an example of the recent validation studies prepared by GexCon R&D, Trygve showed selected results from a series of urban canyon blast load calculations. In particular the modest change in results obtained with on-grid geometry as compared to results obtained when using a 45° rotated geometry is encouraging with respect to the use of inclined objects in FLACS. Olav Hansen (GL Industrial Services) raised the question whether FLACS explo, which was used for the blast simulations, will become available to FLACS users. Trygve answered that it is a goal to include FLACS explo in the public release, but that it currently does not meet the standards for documentation and usability set for the commercial FLACS release.

Trygve also illustrated the challenge of using small-scale experiments for model validation with a study of propane explosions in a3.6 m rectangular flame acceleration tube.

To support the validation work of GexCon R&D, which also constituted a comprehensive deliverable in the JIP “FLACS 2011 and beyond”, GexCon plans to develop a database for validation cases and associated simulation results as part of an integrated validation framework. It was pointed out that the new framework will be important for future model improvements, including the new JIP on FLACS extension and consolidation. Three main focus areas have been identified for the JIP project that will presumably start in 2013: improved modelling of dispersion and explosion in large-scale congested and unconfined geometries (e.g. onshore plants), improved modelling of dispersion and combustion of liquid releases by means of the Lagrange model developed during the previous JIP (e.g. LNG and LPG releases), and prevention, mitigation and barriers (this work would also utilize the Lagrange model from JIP “FLACS 2011 and beyond”). Of particular importance for the future of FLACS would be completion of static adaptive mesh refinement (AMR) and further implementation of dynamic AMR in the solver Flacs. All FLACS users are of course welcome to sponsor the new JIP, but it would be

particularly welcome if the major oil companies would contribute to this urgently needed upgrade of the software.

Status of the new release: FLACS v10

Djurre Siccama (GexCon) reported the news from GexCon's software department. With a recent new hire, the department now has five people responsible for support, training, and sales. Regarding training, GexCon is working on an advance FLACS/explosion/probabilistic course, an ACM geometry course and an improved DESC course.

Djurre then focused on the new release, FLACS v10, which should have been delivered in the summer. Initially there was a delay due to stability issues with the Windows version. Subsequently, GexCon has had to implement a new security solution to protect FLACS for use only by license holders. Due to the large amount of new features in v10, it was decided not deliver this version without the new security solution in place. FLACS v10 is now scheduled for mid-December 2012. The new version will have a security solution with a dongle that has to be connected to a USB port of the computer.

Several participants posed questions regarding the practical consequences of the dongle solution. Djurre emphasized that the basic treatment of licenses (local or via license manager) will remain the same; instead of relying merely on a license key, a dongle will be provided. Henri Tonda (Total) expressed doubts regarding the timely distribution of the dongles. Erik Aadland (GexCon) assured that GexCon will take care of this and that a suitable solution for all customers will be found; customers who renew their licenses on time will receive the dongle(s) automatically and in good time.

Djurre proceeded to highlight a few features of the new release: all main programs (CASD, simulator, Flowvis) will be delivered in both 32 and 64 bit versions, CASD 7 has a completely new user interface including scenario menus and wizards for common tasks. A solver with DDT indication by the DPDX criterion is included, as are the improved porcalc, run manager and a beta release of the new geo2flacs. The Flacs solver is parallelized and includes the non-compressible solver and the surface area leak functionality.

To illustrate the power of CASD 7, Djurre gave a demo in which he touched upon many improvements that concerned previous FLUG wishes.

During Djurre's presentation, the following questions were raised:

Shengjun Zhang (DNV) asked about the python scripting capability of CASD 7 since DNV may want to use in-house scripts together with CASD scripting. Trygve promised that a description of the API and/or examples will be included in the release.

Chris Savvides (BP) enquired how many objects are required to crash CASD 7. Neither Trygve nor Lars had an answer but promised that GexCon will check and report this.

Extra information: In CASD 7, the maximum number of objects that can be created depends on the available memory on the system; in experiments on a 64-bit system with 12 GB memory, no crashes were observed even for 5 million (box) objects. Long before reaching this number, the geometry model may become hard to use due to computing time limitations (rendering takes too long). The memory usage in the limit was about 0.35 MB per 1000 boxes. Notably, the combination of primitives into objects and objects into a database will eliminate almost all limitations, also for the older CASD versions: GexCon's own CAD operators stressed that they are hardly ever constrained by CASD memory use/crashes. Proper geometry handling will also be part of an advanced FLACS course, see above.

Alexander Agapov (STC Industrial Safety) asked a question regarding releases from pipeline systems. Trygve answered that the pipeline release tool is a research version delivered in the JIP. GexCon has currently no plan for further development of the tool but considers creating an interface to relevant software, e.g. LEDA/OLGA.

Olav Sæter (Statoil) asked which expansion process is followed by the jet program: isentropic (i.e. the entropy of the system remains constant), isenthalpic (i.e. the enthalpy of the system remains constant) or constant energy. Trygve replied that he thought it was isentropic but would have to check.

Extra information: The process is described in the FLACS User manual, please see the section "Jet release from a high-pressure reservoir - JET utility program".

FLACS-Fire: status and prospects

Bjørn Lilleberg (GexCon) gave an overview of developments for fire-modelling. While FLACS was traditionally developed for dispersion and explosion risks, the capability to model pool, jet and flash fires is currently being added. The presence of competitors in the same segment is acknowledged, but

GexCon is determined to offer a comprehensive risk analysis tool and focus on attaining the same standards/criteria for validation for which it is recognized and known by the industry.
Bjørn described the physical models in FLACS-Fire and showed validation results for non-premixed flames. Overall the results are good compared to, with some over-prediction. In particular Bjørn discussed the over-prediction in case of a heptane pool fire, which may require a different turbulence and/or combustion model. For compartment fires some results with very good agreement were presented, but for the SINTEF compartment case differences between predicted results and measurements were significant close to the floor, while they followed the trend in the experiment for higher elevations. Bjørn illustrated how the inclusion of radiation modelling gave significantly better results.
As future developments he mentioned the following topics: the flow solver with more options for turbulence modelling and models for sprinkling and particles. Regarding the combustion modelling, other models than the one currently implemented may be tried. Modelling of multiphase combustion and pyrolysis are on the list as well as improved soot modelling. Regarding thermodynamics, coupling to other tools is an option.

FLUG wishes

Lars Pesch (GexCon) held the session where old and new FLUG wishes were discussed. An overview of suggestions from the previous FLUG meetings was given together with their status. Lars pointed out that a number of long-standing wishes will be closed when FLACS v10 is available, since it includes both a lot of the work done in the JIP "FLACS 2011 and beyond" and first or beta releases of some long-term projects focusing on rewriting several parts of FLACS (e.g. CASD, geo2flacs).
During the discussion of wishes regarding the different parts of FLACS, Olav Hansen (GL Industrial Services) raised two suggestions: firstly that Flowvis 5 should be able to plot values on (object) surfaces in the computational domain. Lars commented that this was part of the spec since this functionality is of special interest for the applications regarding fire. Secondly, Olav pointed out a problem with FLACS when gas from a reservoir with very high pressure is expanded through an orifice to atmospheric pressure; up to at least 100 bar reservoir pressure this is possible, but at e.g. 200 bar the simulator runs into problems. Lars promised to add this to the issue database and investigate.
Shengjun Zhang (DNV) commented on the use of python scripts in CASD 7 and Flowvis 5. DNV would like to be able to use its in-house scripts together with the scripting capabilities in the new FLACS version. Trygve Skjold (GexCon R&D) and Lars replied that a description of the API needs to added and that examples of how to extend CASD/Flowvis with python scripting will be provided.
Kjetil Hersvik (Safetec Nordic) asked about guidelines for anticipated congestion. Lars pointed out that due to the complexity of the problem it is difficult to both give simple guidelines as well as to provide them as an automated software solution. Djurre Siccama (GexCon) added that GexCon is working on an advanced FLACS course that includes the topic of anticipated congestion. Several participants agreed that it would be good to exchange experiences or standardize the different approaches used by different companies.

Formal issues - Closing

The next FLUG meeting will be held in May 2013 in Bergen, Norway, presumably in the week starting with the 20th of May. GexCon will inform the FLUG members when the dates are fixed.
The chairman thanked the participants for all contributions and closed the meeting.