

REPORT

for the 64th IUVESTA Workshop on Practical Applications and Methods of Gas Dynamics for Vacuum Science and Technology

This report summarizes the main parts of the workshop and presents the main conclusions.

Background:

The 64th IUVESTA workshop was organised under the auspices of the IUVESTA Vacuum Science and Technology Division on 15-19 May 2011 in Leinsweiler, Germany. It was jointly organised by Prof. Felix Sharipov, University Curitiba, Parana, Brazil, Dr. Oleg Malyshev, ASTeC Accelerator Science and Technology Centre, Daresbury, UK and Dr. Christian Day, Karlsruhe Institute of Technology, Germany. The latter also acted as Local Organiser, supported by the Workshop Secretary Dr. Stelios Varoutis.

The motivation behind this workshop was to bring together for the first time three communities, namely theoretical physicists in the area of rarefied gas dynamics, vacuum scientists working in the field of vacuum flow simulation in all flow regimes, and representatives of vacuum industry with applications in the gas dynamics area. The purpose was to promote the recent progress in vacuum gas dynamics and to foster a better communication between these communities and to create a certain awareness for the view and issues of the others.

Workshop participants:

Altogether, there were more than 60 participants attending the workshop. This number was much higher than what was originally planned for (40-45) and was in the end given by the limitations of the venue. The number of people who expressed interest was close to 75, so that we even had to reject. In the end, this gave us the opportunity to have a good mix, also including early-stage researchers in this area.

The participants were clearly international and represented 19 countries from all over the world (12 European countries + Brazil, Canada, China, Japan, Russia, Saudi-Arabia, USA). Ten Companies were actively taking part (Agilent, Italy; Oerlikon Leybold, Germany; Pfeiffer Vacuum, Germany; Pi-DSMC, Germany; VACOM, Germany; AOES, Netherlands; Edwards, UK; Fluidyn, France; Hiden, Germany; Inficon, Liechtenstein), the first five were also sponsoring the workshop. The participant mix was very healthy, about half were representing vacuum science, the other quarter theory and the rest industry. About one third of the attendants were belonging to academia, the other two third to National Research organisations or industry. The share of female researchers was 10%.

Workshop scheme:

The 4 day long workshop started at Sunday evening with a welcome reception and closed Thursday noon with a final common lunch. The workshop was divided in 9 topical sections:

- Vacuum metrology
- Vacuum pumps
- Experimental activities
- Numerical modelling
- Benchmark problems
- ITER
- Vacuum system design
- Transient problems
- Accelerator vacuum systems.

The nine topics evolved from the response and comments received from the community on a longer list of topics which was circulated in preparation of the workshop. The most sections were especially introduced with a keynote address by a distinguished lecturer. For this purpose, seven scientists were personally invited.

Altogether, there have been 49 talks and 3 industry posters. The regular contributed talks were short (12-15 min), in order to force the speakers to focus on the point they want to make. Also, discussion time immediately after the talk was limited to one or two questions only. At the end of each section there was a 20-30 min general discussion, the aim of which was to discuss the specific topic of the section in a wider sense and to use the contributed talks as stimulating input for doing that. Moreover, at the end of each day, there was a 'Summary of the day' session which was aimed to reflect the topics discussed during the day in view of the workshop objectives, namely to better interlink the different communities. This unconventional scheme turned out to work very well and the participants much welcomed the ample time for discussion, which also included the common times for the reasonably long coffee breaks and the joint meals.

The venue was a scenic spot in the countryside which provided all the comfort and quietness needed for an intense workshop.

Financial:

The workshop fee was 670 EURO (early registration) and 750 EURO (late registration), respectively and covered the full board at the Workshop hotel, the Social Programme and the workshop participation. The incoming amount of money was 44,800 EURO, including the IUVESTA contribution of 7,600 EURO as main sponsor and ~ 1,600 EURO by the industrial co-sponsors; the workshop fee of invited scientists was waived.

Of this amount, 6,150 EURO have been consumed by the Social Activities (Walking Dinner in Speyer, outdoor wine-tasting), 38,480 EURO for the Workshop facilities, accommodation, full board and all other hotel services. Additional services, such as local transportation, badges, prints, website etc. were provided for free by the local organiser KIT, partly sponsored by the KIT Nuclear Fusion Programme.

Outcome:

The discussions and debates were lively and open. It was seen with great pleasure that in spite of good weather outside, especially in the last two days, the attendance of the sessions did not shrink.

This report does not specifically address the individual scientific highlights of the workshop, of which we had quite a few - they will be reported elsewhere, see below - but wants to focus on a summary of the main aspects of the discussion, especially the one at the final Round Table, in view of the central objective to bring people together to create an added value:

1. From industrial perspective, simulation/calculation is only interesting and will only be preferred over experiments, if there is a potential factor 10 gain in time, a factor 5 gain in cost and a confidence in the results (based on successful previous modelling).
2. Industry stated that there has not yet been done sufficient modelling of complete systems (real systems with all the non-idealities), on which such a confidence could build.
3. For mechanical vacuum pumps, there is a special need to describe multi-channel flow networks, often including thermal effects.
4. For the modelling of real components, the industrial requirements in terms of accuracy are of the order 10%.
5. The simulation experts have the opinion that the currently available methods can be applied for whatever complexity with sufficient reliability. The various mathematical approaches for solving the Boltzmann equation (be it stochastically or deterministically) were all presented with their advantages and disadvantages. It was concluded that all approaches have their own justification.
6. Much welcomed was the benchmark session on pressure driven short tube and parallel plate flow, organised by Felix Sharipov. Except for one approach, it showed a good consistency of the found results.
7. There is a cultural gap between industry's requirement to have more worked-out examples for 'real systems' and the theoreticians' lack of interest to work on 'less exciting' problems.
8. The discussion on experiments was diverse. On one hand, experiments are asked to be parametric and with well-defined boundary conditions so that they are suited for model validation, on the other hand, especially experiments done by industry are specific, i.e. aimed to characterise a complete component, which makes it difficult to use the results for benchmark purposes.
9. For theory validation, experimental uncertainties below 1% are needed. This is about a magnitude more challenging than what is currently typically achieved.
10. The area of transient problems is considered to be most important (leak rate evolution, highly dynamic processes), but not much work seems to be done there. All experts are encouraged to start working in this area.

The final conclusion was that it is now time to form an open-minded interdisciplinary team, comprising simulation experts who do not hesitate to invest the specific effort to describe a complex component, and for industry to guide and support this effort. One option which was discussed was to use the momentum which has been built up by this workshop and try to do the next step together in collaboration between various industrial and modelling partners:

As next target step was discussed to develop a community-approved and validated Gas Dynamics toolbox, which can be used by skilled engineers (rather than fundamental physicists). Such a development is clearly a major enterprise, which would have to be organised in an established research frame (The European Framework Programme may be such a one).

The workshop participants also agreed that this approach should be complemented by organising a (regular) school on Vacuum Gas Dynamics. The excellent interest and response of young researchers received during the workshop showed that vacuum gas dynamics is a field which is considered both interesting and powerful and industrially relevant.

Another important outcome of the workshop was the announcement to compile a special issue of the journal *Vacuum*, devoted to Vacuum Gas Dynamics. It will be edited by Felix Sharipov and Oleg Malyshev, and all workshop participants were encouraged to take home the momentum and spirit of the workshop and contribute original research papers to this issue (deadline November 2011).

The workshop website will be maintained for at least one additional year so that detailed information as well as all the presentations are still accessible via: <http://www.itep.kit.edu/VGD-2011>

On behalf of the Organising Committee of the 64th IUVSTA workshop,

Christian Day , August 2011.