EXAMPLE APPLICATIONS OF

VELOREX PDV

PHOTONIC DOPPLER VELOCIMETER

The VeloreX PDV Photonic Doppler Velocimeter is an instrument for measurement of velocity-time profiles of high speed moving objects. It can be used for determination of various detonation properties of explosives as well as for any other tasks where high precision in velocity or displacement measurement with extreme time resolution are crucial. The following example applications show various experiments and testing procedures in which the instrument excels.

All the graphs presented below show real experimental data measured using VeloreX PDV.

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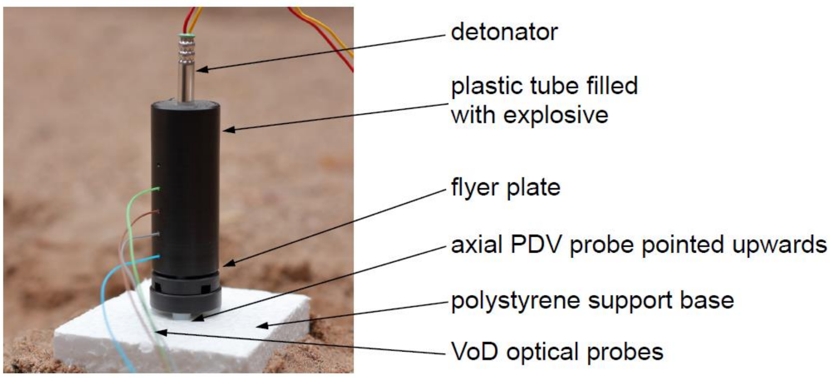
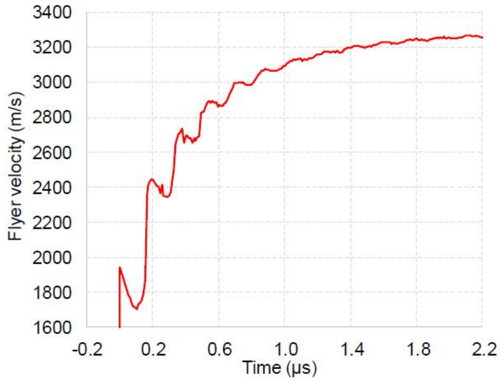
1. Flyer plate test of high explosives

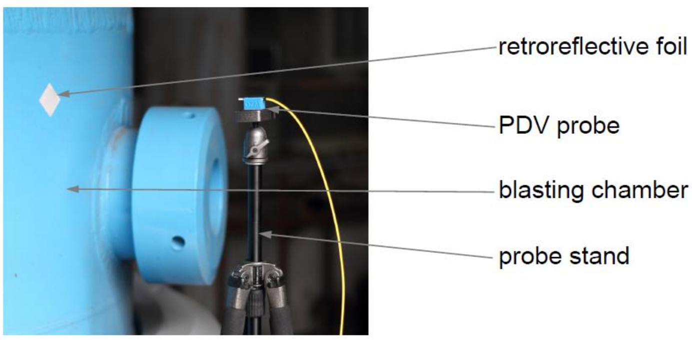
When a new explosive or explosive mixture is prepared, it is necessary to check its detonation properties to make sure that they are consistent with preliminary calculations or reference literature values. The measurement of velocity profile of explosively accelerated flyer (Flyer plate test or DAX) can be used to characterize the new material. Unlike traditional but outdated Hess or Kast tests, the PDV allows direct measurement of key parameters without the need of immediate comparison with standard samples. Initial velocities of explosively accelerated thin metallic flyers can be used to infer parameters of the **detonation reaction zone**. Moreover, velocity steps caused by shock reverberations in the disc can also be used to determine isentropic expansion path of the detonation products which is an important input for numerical modelling of blast loading processes. The limiting ("coast") velocity at the rear part of the profile corresponds to the energy transferred to the flyer from the detonation products – the acceleration ability of the explosive. From this, characteristic **Gurney velocity** can be calculated.

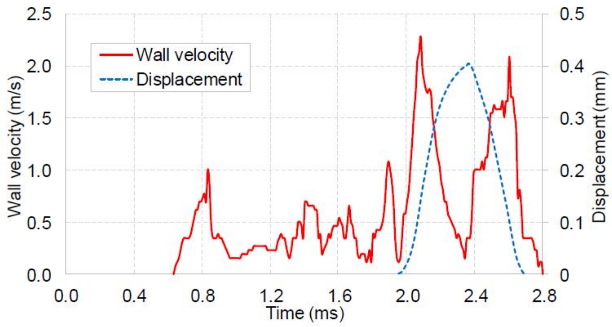




A single PDV-DBP probe was used for the test of sensitized nitromethane (PLX). Additional passive optical probes were employed for simultaneous detonation velocity measurement using OPTIMEX-8 instrument.

2. Vibrations of blasting chamber walls

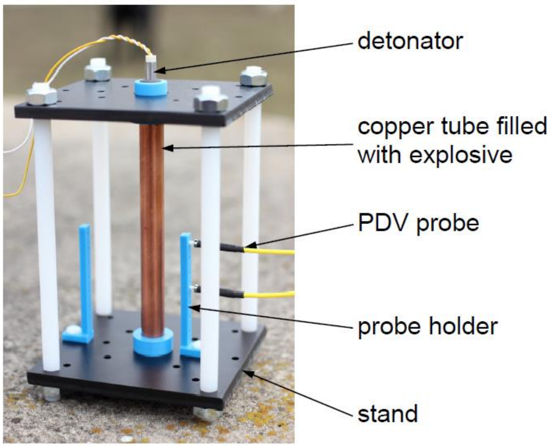


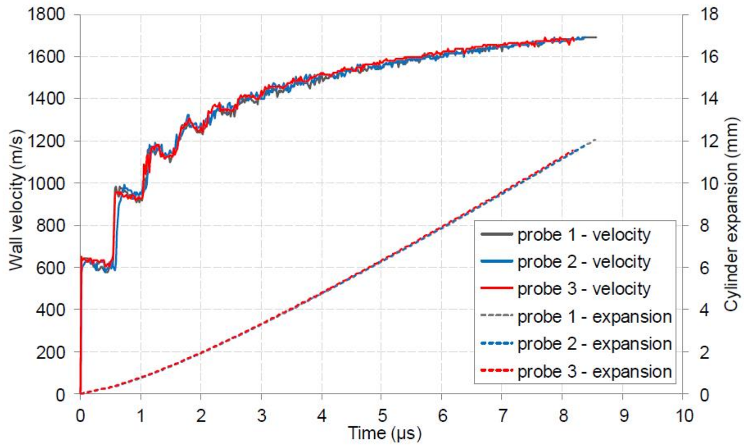


A large blasting chamber was loaded with high explosive charge placed in its center. The PDV-PBP probe allowed to measure velocity of the chamber wall as it was accelerated by shock waves generated by the explosion. Ringing of the wall continued until the end of the recording time window. **Displacement was obtained by integration of the velocity profile** for the most intensive pair of peaks. The maximum displacement agreed well with preliminary numerical model predictions.

3. Cylinder expansion test of high explosives

The cylinder expansion test is a classical procedure for characterization of explosives. An explosive charge is confined in a copper tube. Upon detonation, the tube expands radially and its expansion is recorded in time. The test quantifies ability of the explosive to accelerate surrounding materials and allows to determine equation of state parameters of the detonation products. Utilizing more than one measurement channel improves accuracy and eliminates random errors due to imperfections in the charge or the tube homogeneity. **The robust and precise PDV instrumentation excels over previously used methods of monitoring wall expansion by electric contact pin arrays or streak cameras.**

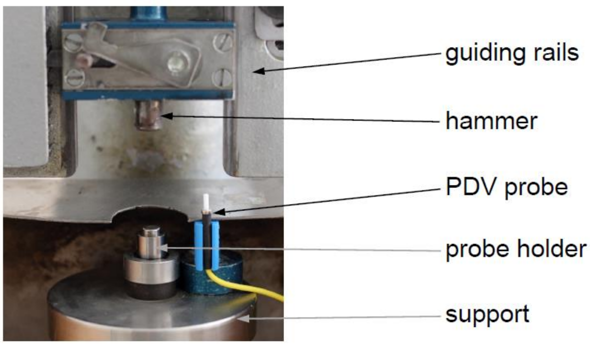


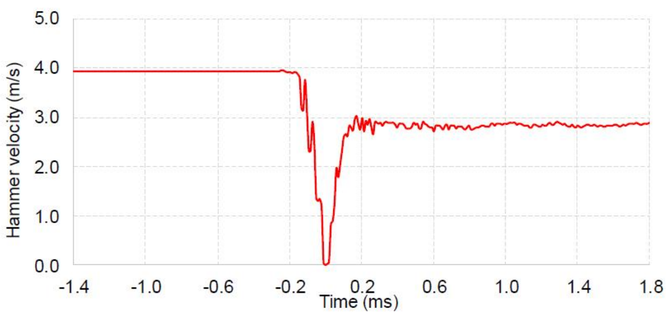


The PDV-DBP probes were used for this small scale experiment with erythritol tetranitrate. In this arrangement, detonation velocity can also be determined simultaneously from the times of arrival of the PDV signals.

4. Falling hammer examination

The falling hammer behaviour was observed at the moment of impact on a high explosive sample. Initial velocity of the hammer was measured with great confidence and **the kinetic energy of the hammer was determined at the moment of impact** which exhibits as a short drop to zero velocity. Various types of reflected hammer velocity profiles were obtained for different explosives and initiation mechanisms. The PDV-PBP probe was fixed to the base of the hammer and the laser beam reflected from a small piece of retroreflective tape placed on the hammer.





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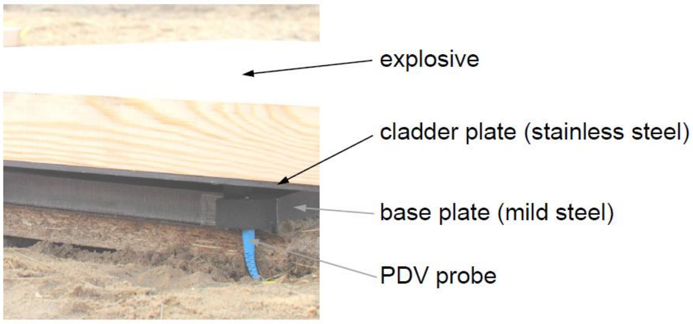
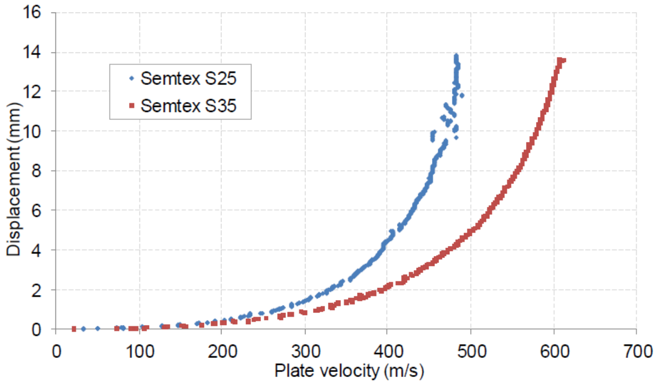
5. Explosion welding optimization

Explosion welding allows to weld practically any combination of metallic materials with excellent quality of the joint. However, parameters of the explosive and spatial relations of all parts must be adjusted correctly. A PDV probe placed against the flyer plate allows to determine the whole velocity profile of the plate including its terminal velocity at which the impact with the base plate occurs. This allows **optimization of the explosion welding process**.

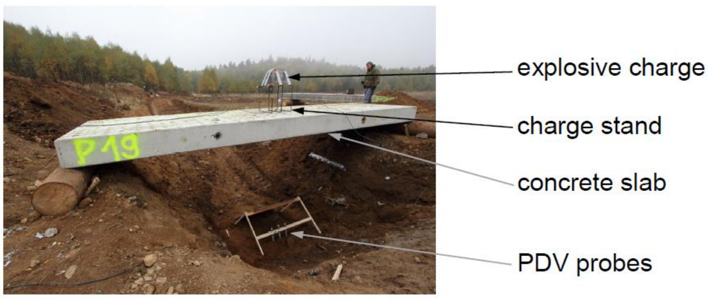


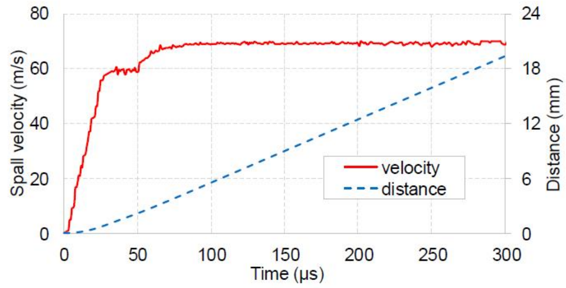


The PDV-DBP probe was fixed in a custom-made probe mount attached to the base plate. The difference between the two types of Semtex S has been revealed.

6. Spalling of blast loaded concrete slab

Blast-proof construction elements of buildings are becoming an important terrorist attack countermeasures. New construction materials with improved blast resistance must be tested in full scale experiments which are very expensive so the maximum amount of information must be collected. The PDV diagnostics allows to characterize blast response of the tested specimen with high time resolution and velocity accuracy.





A reinforced concrete slab was subjected to detonation of a high explosive charge (25 kg of TNT) placed above it. A large spall fracture occurred on the soffit of the slab and the spalled material was projected towards the PDV probe which captured early stages of **acceleration of the spall debris**. The resulting velocity profile provides input data for numerical modelling of blast response of the slab. The PDV-PBP probes were aimed from a distance of more than 2 m from the soffit of the slab. The soffit was covered with a retroreflective tape.

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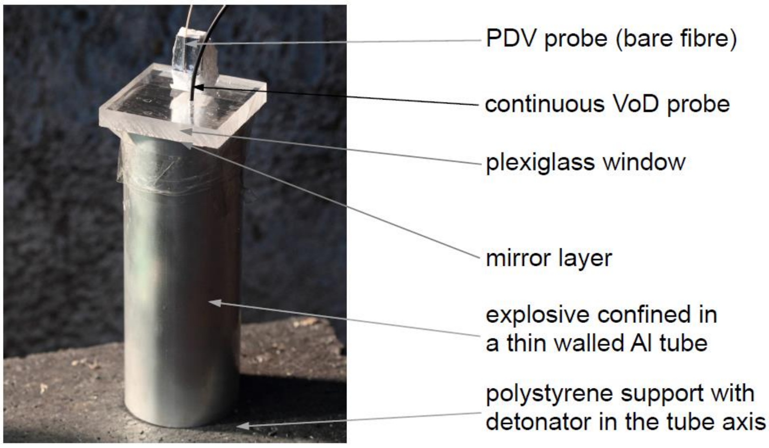
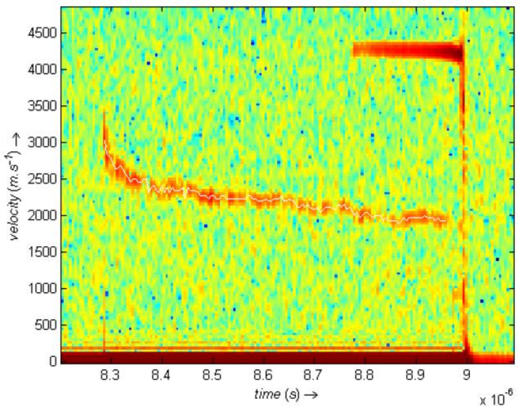
7. Impedance window measurements

The method of choice for determination of particle velocity and therefore pressure profiles in the detonation waves is the [impedance window method](). A layer of transparent window material such as plexiglass with a thin mirror layer at the interface is attached to the explosive charge and the interface velocity is recorded by the PDV. The particle velocity profile of the interface may subsequently be converted to the pressure profile using impedance matching technique and the **Chapman-Jouguet detonation pressure** of the explosive can be determined.





A bare fiber probe was used for this test. Detonation velocity was measured simultaneously using the OPTIMEX-8 with continuous perforated fiber probe inserted in the charge parallel to its axis.

Further applications

Photonic Doppler Velocimetry diagnostics can be used for a wide variety of other tasks such as:

- Down-bore tracking of a gas-gun projectile
- Shaped charge jet tracking at early stages of its formation
- Characterization of particle clouds
- Observing bridgewire explosions in EBW detonators
- Laser adhesion test (LASAT)
- and more…

The list will never be complete as new applications arise with new users, experiences and ideas.

For technical questions on VeloreX PDV, consulting your specific needs, or optimizing the system parameters for any application, please contact

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