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BY MEANS OF GASEOUS EXPLOSIVE MIXTURES
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GENERATION OF HIGH DYNAMIC PRESSURES BY MEANS OF GASEOUS EXPLOSIVE MIXTURES

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Résumé - Ce travail décrit deux installations qui permettent d'étudier les caractéristiques des produits de détonation de mélanges explosifs gazeux à pression initiale élevée.

Abstract - This paper describes two setups devoted to the investigation of the characteristics of the detonation products of gaseous explosive mixtures at high initial pressures.

Despite numerous studies performed in the field of the equations of state of dense gases, a lack of knowledge actually remains in the range of pressures from several hundreds of bars up to several kilobars. Such pressures can be obtained in the detonation products of gaseous explosive mixtures at a high initial pressure. The main difficulty arising when such explosives are used, is the design of appropriate devices that can withstand safely quite high detonation pressures. In order to provide data on the properties of detonation waves of gaseous explosive mixtures at elevated initial pressures, an investigation has been undertaken. The aim of the present paper is to describe two devices that allow the detonation of gaseous mixtures at initial pressures reaching 200 bars. Their common feature is the high pressure technology involved in their design. The experimental study is focused on the measurement of the detonation velocity. In that purpose, ionization probes are used and the mixtures are ignited by means of a powerful energy delivered through a detonator. In such a case, a stable detonation can be expected.

I - EXPERIMENTAL

Device 1: initial pressures up to 100 bars

The corresponding setup (fig. 1) is a 4 m long tube with an inside diameter of 55 mm.
It can withstand detonation pressures up to 3 kbars. This allows to detonate mixtures at initial pressures reaching 100 bars. It is on the way to be part of a detonation product gun and therefore, a systematic study of its behavior in detonation conditions is performed.

The explosive mixtures are prepared in a tank at a pressure of 150 bars, using a weighing system. This method eliminates the uncertainty on composition due to the compressibility effects and appears to be reliable since a systematic gas chromatography analysis is performed for each mixture, yielding an even more accurate value of the composition.

Device 2: initial pressures up to 200 bars

The corresponding device (fig. 2) is a 2 m long tube with an inside diameter of

![Diagram of Device 2]

Fig. 2 - Device n°2.

20 mm. It can withstand dynamic pressures up to 10 kbar. Previous studies have shown that the detonation velocity was no more dependent on the tube diameter as soon as the initial pressure is greater than 10 bars or so. In that case, the detonation velocity can be regarded as the ideal one. The mixtures are prepared at a pressure of 100 bars and then compressed in the detonation tube through a hydraulic system, in order to reach the expected initial pressure.

II - RESULTS AND DISCUSSION

A large number of new data have been obtained with device n°1, dealing with the influence of the initial pressure on the detonation velocity. Those related to $C_2H_4$ - Air are presented on fig. 3.

![Fig. 3 - Calculated and experimental detonation velocities of a $C_2H_4$-Air mixture]
These experimental velocities were compared to calculations based on several equations of state and performed with the QUATUOR thermochemical code /5/. Most of them are used in the case of high explosives. More precisely three types of equations of state (E.0.S.) were involved in the QUATUOR code:

(i) an empirical one : BKW E.0.S. /6/. The empirical parameters were properly adjusted,

(ii) an equation of state based on the simplified assumption that only like molecules interact : Boltzmann E.0.S. /3/,

(iii) equation of state based on sophisticated interaction laws : Percus Yevick E.0.S. /7/.

The results presented on figure 3 show the good agreement (deviation less than 1%) between calculation and experiments in the case of Boltzmann E.0.S.. However as this equation of state may be less reliable for higher initial pressures than an equation of state based on more sophisticated molecular interactions, the results obtained with the Percus Yevick E.0.S. are presented as well. It appears to yield the same agreement with the experimental results as does the former one.

The other equations of state, apart from the empirical ones lead to less satisfactory results. However, a comment must be given concerning this Percus Yevick E.0.S. Although the analytical expression of this equation of state remains unchanged, an adjustable parameter has been involved in the mixing rule that is used to describe the molecular interaction distance. This parameter, once adjusted to a value close to those proposed by Edwards and Chaiken /7/ in the case of high explosives, leads to calculations that are in good agreement with experiments for most of the explosive mixtures. In other words this parameter would have a single value for initial pressures ranging up to 100 bars. The C.J. detonation pressure has been calculated with this equation of state for an initial pressure up to 1000 bars (fig. 4). It shows that quite high dynamic pressures, i.e. up to several tens of

Fig. 4 - Calculated detonation pressure of H2O2 and C2H4-Air mixtures.

kbars, can be obtained by means of gaseous explosive mixtures. So far, such a range of pressure was seldom investigated.

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