# STRUCTURE OF RAREFACTION WAVE FOR TNT DETONATION PRODUCTS

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Upon the detonation of high explosive (HE) charges, rarefaction waves behind the Chapman-Jouguet (CJ) plane causes pressure fall and detonation products (DP) expansion.

In Fig. 1 there are one-dimensional schemes for profiles of pressure, velocity and the Mach`s number behind the CJ plane.

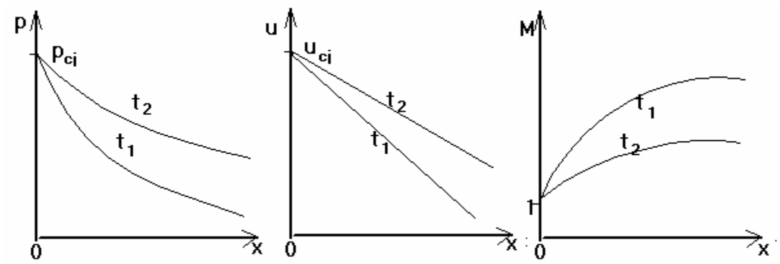


Figure 1. The process behind the CJ plane for the 2 moments $t_1<t_2$.

The Fig. 1 situation deals with monotonous Mach`s number increase behind the Chapman-Jouguet plane. The Mach`s number increase results on one hand from sound velocity fall within DP, on the other hand from flow velocity increase.

However, if expanding DP have sound velocity different from mentioned above, i.e. if it does not fall monotonously, then the Mach`s number may stop increasing monotonously. In fact, let us assume that at a certain point behind the CJ plane sound velocity increase takes place abruptly, accordingly the Mach`s number will fall by leaps, too. In this case the Mach`s number may happen to become less than 1. The profiles of pressure, velocity and the Mach`s number will occur as it is shown in Fig. 2. Evidently, in such a flow behind the CJ plane there is point S, where sound velocity is equal to local particle velocity (the Mach`s number is equal of 1). It means, that disturbances will not penetrate into OS zone from the zone to the right of S and flow structure in the OS zone will not depend on the DP expanding character behind point S. At point S itself there will be a bend of velocity, pressure, etc. profiles.

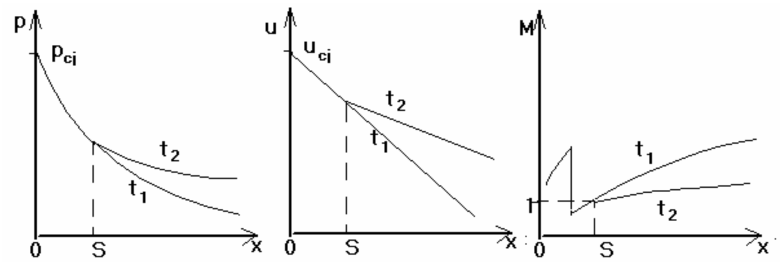


Figure 2. Scheme of the process behind the CJ plane with phase transition in DP for the 2 moments $t_1<t_2$.

So far we have not mentioned the reason of sound velocity change by leaps. Phase transition in DP can be such a reason. Earlier, in /1/, we noted, that the detonation of TNT with initial density of 1550 kg/m$^3$ takes place in anomalous regime, and in DP diamond-to-graphite phase transition occurs. To illustrate the possibility of the second sonic surface (the first sonic surface is known to be the CJ plane) occurrence in real situations, the structure of a rarefaction wave has been determined for detonation of TNT charge with 1620 kg/m$^3$ density.

In Fig. 3 profiles of pressure and velocity within DP are shown. At CJ plane the pressure is 2.17x10$^{10}$ Pa, the velocity 1947 m/s (4960 m/s in a system, where the front is in the quiescent state) and the density 2256 kg/m$^3$; among DP both graphite and diamond are found.

It follows from the presented calculations, that upon pressure fall and DP expanding the diamond-to-graphite phase transition takes place. At the point of the phase transition end sound velocity increases abruptly, and at a certain distance from this point the thing, that we called the second sonic surface, appears (Fig. 3). The process parameters in this plane are the following: pressure ~ $1.7x10^{10}$ Pa, velocity ~ 1450 m/s (5450 m/s in the front system). Here the bend of the flow characteristics occurs. Parameters at the bend point are constant in time. The zone dimension from the CJ plane to the second sonic surface changes in time very little as well.

Detonation of TNT with initial density lower than 1550 $kg/m^3$, takes place in regular CJ regime /1/. Accordingly, calculations for the charge of 1450 $kg/m^3$ density demonstrated, that its DP are free from the second sonic surface.

In /2/ experimental data on velocity profile bend of scattering TNT DP (initial TNT density 1620 $kg/m^3$) are presented. This bend takes place at a velocity of 1620 m/s (at $1.82x10^{10}$ Pa pressure) and is considered as the CJ plane. However, numerous thermodynamic detonation calculations, including the ones done in this paper, demonstrate, that the pressure and flow velocity in the CJ plane for TNT with 1620 $kg/m^3$ density are considerably higher, than the ones, defined in /2/ at the velocity bend point. In the same time, quantities, calculated in /2/ are quite similar of the ones determined in the present research for the second sonic surface. This coincidence in a certain indirect way demonstrates that the determined rarefaction wave structure was seen in the experiments before, but by mistake used to be identified as the CJ plane.

## REFERENCES

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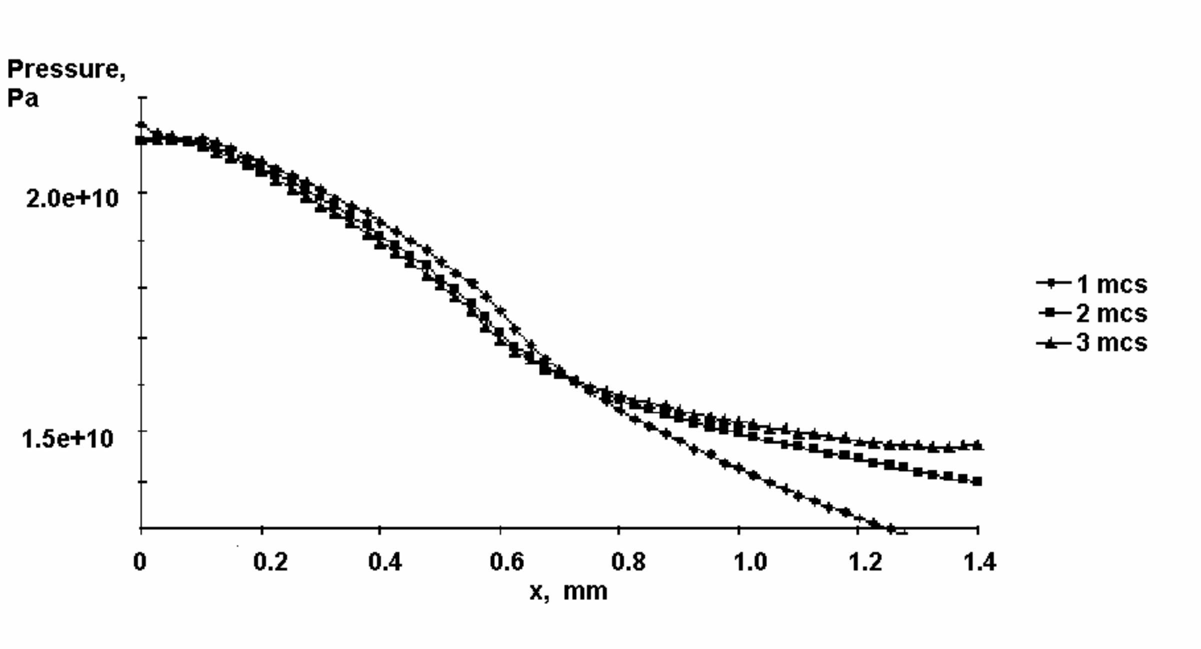
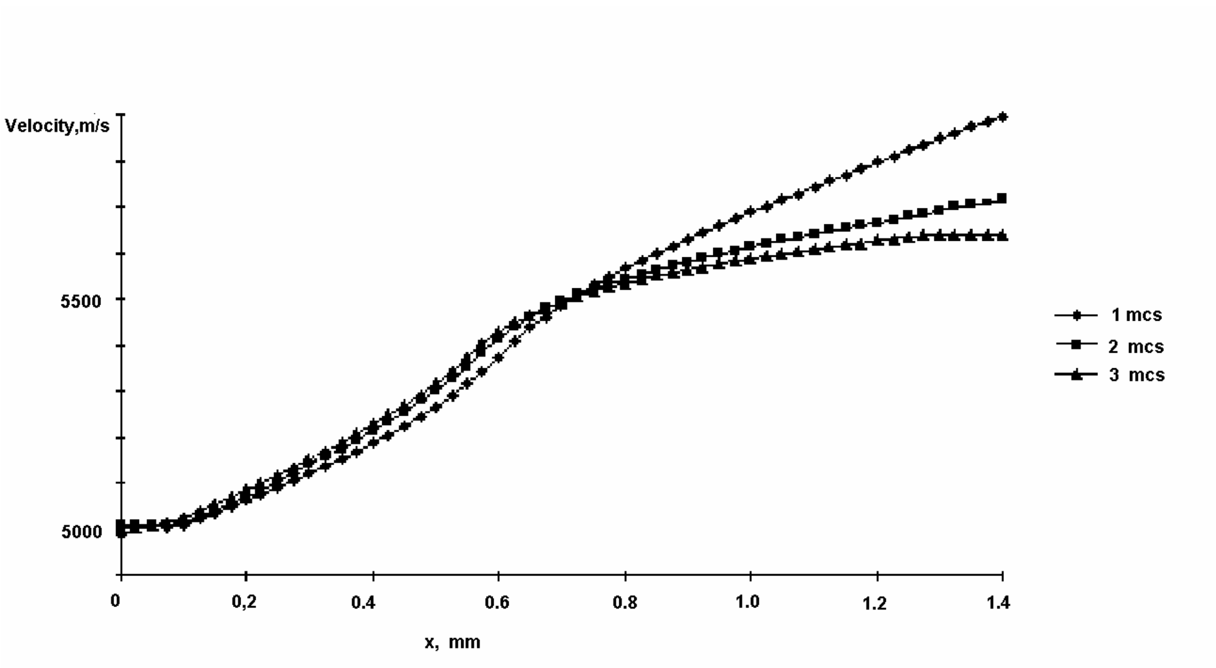



a)




b)

Figure 3. Pressure (a) and velocity (b) profiles behind the CJ plane for TNT with initial density 1620 kg/m$^3$ (1, 2, 3 mcs)