Gas Detonation and its Technological Adaptation

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The perspectives of technological adaptation of gaseous detonation are based on a supersonic character of propagation of detonation wave (DW), the highest burning rate of a combustible mixture, higher pressure, density, temperature and mass velocity of detonation products (DP). As a rule, the application of detonation is connected with an outflow of gaseous DP from detonation chamber.

Among problems originating at technological application of detonation, it is necessary to mark the problems of qualitative and fast mixing of moving mixture components, problems of effective initiation of detonation, geometrical and concentration limits, strength and weight of apparatus, requirements of explosive and ecological safety to detonation equipment, their reliable work and high efficiency, problems of cooling of apparatus working in a cyclical condition, necessity of highly qualified serving personnel, etc.

The destination of gas-detonation apparatus can be connected with the creation of a tractive force in engines, force or destroying action of shock wave or stream of detonation products on different objects located as inside, and outside of an apparatus, heat and throwing of condensed particles, fast burning of fuel, etc.

In this report the examples of technological adaptation of gas detonation are represented.

Detonation sprayed coating. One example of adaptation of gas detonation is the coatication of wear-resistant, or heat-shielding, or electro-insulating powder coatings on outside surfaces of different details. The kernel of this method consists in pre-heat and acceleration of powder particles with the help of gas DW and its throwing on work surface. At impact of heated and molten particle into a surface of details the self-diffusion of materials of particle and detail happens on depth about several inter-atomic distances. At sufficient warming-up of particle the strength of an adhesion and cohesion of coating layer is comparable to strength of an initial material and does not depend on hardness of details.

Clearing of equipment from dust sediment. The impulse jet of detonation products, flowing out from an open end of detonation tube, can be used for clearing of a production equipment

from dust sediment at the expense of direct action on sediment, or by creation of vibration of metal-construction, on which such sediment are located. In the latter case the impulse transmitted to construction is the main parameter.

The similar impulse detonation cameras (IDC) of various diameter and lengths with detonation burning of mixture were successfully adapted for clearing of electrofilters for catching of cement dust from dust sediment, for clearing of blades of ventilators from sticking cement dust (irregular dust sediment on rotating blades of large ventilators destroy both ventilators, and their seating because of amplifying of beatings of blades at adhering of dust), for destruction of sediment of precipitated cement dust in areas of turning of pipelines for cement transporting (practically on each curving the accumulation and sedimentation of dust is happened, that produce the negative effect for an industrial rhythm). IDC can successfully be applied on any plants and factories, where the formation of various kind of dust sediment is possible - in metallurgy, power engineering, cement industry, etc.

Fragmentation and drilling of rock. The destroying action of detonation products of gasoline-air mixture at impulse work of the detonation camera is successfully adapted for creation of bore-hole (spur) in a ground (water-hole or hole for cables,...), for drilling and fragmentation of rock .

Utilization of tires. The gas detonation can effective use for destruction of various envelopes. The method is successfully applied for destruction of automobile worn-out tires (beforehand cooled) with the purpose of their utilization and separating of rubber from metal cord: the explosion of an explosive mixture, filling the tire, fragments the rubber on bits of small size and separates it from cord.

Deleting of rough edges. The adaptation of gas detonation for deleting of rough edges, originating on metal details at machining, is known. The process is effective especially for clearing interior sites of details, such as deep drillings, which are difficult of access. The details put in the air-proof high-strength chamber, fill the chamber by gas explosive mixture under pressure in some tens atmospheres and initiate a detonation. The deleting of rough edges not happens under action of dynamic pressure of products, but at the expense of them melting. It is not necessary to put in the chamber the large and small-sized details together because of a possibility of full burning of last. The process is regulated by the selection of initial pressure. At not so high pressure even an impulse thermal treatment of plastic is possible with the aim of producing of a smooth surface.

Initiation of shock and detonation waves. The gas lock of easy-detonated gas mixture is effectively used as the high-power initiator for creation of shock waves in shock tube (usually in an initial condition two sections are separated by easy-destroyed diaphragm). With the help of detonated gas it is possible to ensure the shock wave with «cross-linked contact surface», that considerably extends the duration of gas-lock with constant SW-parameters. The given effect can successful be used in impulse gas-dynamics lasers. The similar gas-lock of detonated mixture can be used for DW-initiation of hard-detonated gaseous and heterogeneous mixtures. In last case it is possible to work without diaphragm, and to inject the easy-detonated mixture to electrodes directly before the initiating impulse. The transition of DW in mixture from tube into volume (or from the narrow channel in broad) is well known mode of initiation of spherical (cylindrical) DW.

Gas-detonator. DW, propagated on a gas mixture, is capable under certain conditions to initiate the detonation process in a heterogeneous medium, for example, in a charge of poured HE. Considerably large possibilities are ensured at using of overdriven DW, which is capable to initiate the industrial HE, used at blasting operations. If in traditionally used electroblasting chain, the electric detonators to replace on gas-detonators, integrated by uniform gas-main in an extended and branched chain (for example, with the help of flexible PVC-tube), then after filling all system by an explosive gas mixture and its initiation, the DW being propagated along a gas chain, sequentially initiates all individual charges. If some charge will not triggered, the operation till its elimination extreme becomes simpler - it is necessary once again to clean out the gas-main blowing by nitrogen or usual air. It is equivalent to elimination of detonator from HE-charge and consequent work with this charge in the correspondence with the nominal instruction.

Acceleration of solid. At propagation of projectile by a diameter d in a tube of the greater diameter, filled by explosive gas mixture, in a system of oblique shock and detonation waves, originating in a ring clearance between projectile surface and tube wall, it is possible to organize the burning of a mixture so, that projectile will be moved along a tube with constant acceleration (concept of the Ram Accelerator). Accelerated up to hypersonic velocities projectile can be used then for many tasks: researches of substance state under extreme conditions, interaction of high-energy streams with substance, defence of ground buildings from impacts with large meteorites, start into space of flight vehicles, thermonuclear ignition...

Detonation engine. The detonation burning of gas or liquid fuels in rocket or air engines is rapidly development direction of application of a gas detonation. A basis of this orientation in

investigations is the high degree of gas compression in DW and higher thermal efficiency on comparison by the cycle of fuel burning at P = const. The development of impulse apparatus goes in direction of a raise of specific impulse and frequency of the process. The frequency of shots can be enlarged at use of the scheme of multi-barrel detonation engine with in-turns operation of each pair of barrels, located diametrically.

Along with the scheme of an impulse detonation engine the scheme of detonation burning of a mixture with the help of rotated DW is known, which firstly was offered and realized in Lavrentyev Institute of Hydrodynamics (LIG) by B.V.Voitsekhovski on premixed fuel-oxygen gas mixtures. The basic idea consists that at a constant injection of a mixture normally to the plane of DW-rotation it is possible to select the velocity of a mixture and dimensions of the combustion chamber so that it ensures the DW-propagation across on a constantly renewed layer of freshen mixtures. The further researches of this process in LIG have allowed to receive the regime of a stationary rotated detonation on miscible components (both gas, and heterogeneous), and also to receive a detonation in fuel-air mixtures.

Alongside with the considered scheme of PDE, in which the barrel (tube) with closed end face and open exit end (as analog of rocket engine working on liquid or rigid fuel) is the basic element, the huge practical interest is represented by the scheme of detonation engine with a flowing barrel (both open end faces), similarly to the scheme of the athodyd. In the latter case fuel system considerably becomes simpler, as it is necessary to inject only fuel in a stream of an air.

In summary it is necessary to mark, that, despite of an alert attitude of many laypersons to explosive process engineerings, the gas detonation begins gradually to discover the application in an engineering. The science has enough knowledge of this process and owns tools of its controlled use.

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