History of technical protection. 60 years in science: to the jubilee of Prof. V.F. Minin

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Abstract. The article briefly describes the scientific achievements of the full Professor, Doctor of Technical Sciences, the founder of the Institute of Applied Physics, the academician of the Russian Academy of Technological Sciences, the winner of the State Prize of the USSR Vladilen F. Minin.

1. Introduction

Prof. Vladilen F. Minin (Figure 1) was born on May 27, 1932 in the Rudinka Gorlovskogo area of the Ryazan. Dr. Minin is a graduate of the Moscow Physical-Technical Institute (MFTI). His professional career began as a teacher of night school. In 1958, at the invitation of academic M.A. Lavrent'ev, he moved from Moscow to work in the Novosibirsk Academytown.

Figure 1. Prof. Vladilen F. Minin

2. Main scientific results

His scientific activity began in Institute of Hydrodynamics where at first time he has been researching the interaction of shock waves and cavitation effect. A series of experimental investigations of the propagation of strong shock wave (SW) in a liquid with gas bubbles, which made it possible to establish the basic laws governing the process, the mechanism for the transformation of the energy of the SW, attenuation of the SW, and the formation of the structure, and experiments on the analysis of the attenuation of waves in bubble screens with different acoustic properties were begun by pioneer works of V.F. Minin at the Institute of Hydrodynamics (Novosibirsk, Russia) in the 1957th - 1960th, who examined also the first convenient model of a screen - a sequence of alternating flat one-dimensional liquid and gas layers [1].

In an experimental investigations of the dynamics of the form of pulsating gaseous cavities and interaction of SW with bubble clouds in 1957-1960 V.F. Minin [1] discovered that under the action of SW a bubble collapses asymmetrically with the formation of a cumulative jet, which forms in the process of collapse and causes fragmentation of the bubble.

Amongst studies of surface effects we should call attention to two works on the problem of modeling of an explosion on a free surface. Based on investigations of eddy dynamics Deribas et al [2] concluded that the flow arising is self-similar, and the parameter determining the effect of the explosion is the momentum imparted to the liquid. Accurate experiments, performed for the first time by Minin [3], clarified the fact that the law governing the development of the eddy, obtained in the preceding work, does not correspond to the motion of a weightless liquid. The self-similarity remains, however, and its indicator equals 0.47 and 0.38 for cylindrical and point explosions, respectively.

This problem was connected with formation of a crater and with movement of the ground in the explosion of a meteorite near the surface or upon collision with the ground. The basic mechanical properties characterizing this process are the parameters of the shock wave formed in the ground and the pattern of permanent displacements produced (in particular, the dimensions of the crater formed). The possibility of estimating shock-wave parameters for an explosion near the surface using known relationships for underground explosions has been discussed several times [3, 4].

As has been noted previously [3, 4] cavity growth in electrical explosion on the surface of water proceeds according to a law close to the law of self-similar motion at constant energy. This fact allow us to introduce the energy transferred to the ground and estimate its value (perhaps somewhat arbitrarily) by comparing the mechanical action parameters of contact and slightly submerged charges.

In the beginning of 1960th at the Institute of Hydrodynamics, Minin also laid down the experimental foundations of electromagnetic accelerating of bodies to hypersonic velocity. Since the organization of Novosibirsk State University, V.F. Minin has lectured to students of preparatory courses and organized more than 150 laboratory works on physics, some of which are still unique.

A few years later Minin investigated and discovered a wide class of jet flows in an analysis of vertical plumes on the free surface of a liquid with underwater explosions. The plumes were distinguished by the directed nature of the ejection, characteristic only for a liquid and not occurring for analogous explosions in soils.

Later in the middle of 1970th M.A. Lavrent'ev wrote “Was given that from 1958 to present Minin V.F. works at the Institute of Hydrodynamics SB USSR Academy of Sciences (since 1970 Head of the Laboratory number 3) where he are in person, with help of senior laboratory Kotov and A.I. Feoktistov, and later a senior laboratory V.M. Volosuhi, the experimental studies in the field of propagation of shock waves in water with gas bubbles, in the water with a layer of air, a study on the stability and the anomalous properties of nitric glow plasma, a study on the possibility of creating devices "Heat" and "magnet", a study on the explosive sound sources, the experimental studies on the formation of the Sultan in the explosion, other work. In other laboratories of the Institute in these areas of work not carried out. Director of the Institute of Hydrodynamics SB USSR, Academician M.A. Lavrent'ev” (Figure 2).

These effects later were studied in application to hypervelocity impact of meteorite with earth’s surface [5]. Later [6] an experimental study of an explosion close to a free surface was conducted.

Principles connected with the penetration depth of the discharge were established. It was shown that the nonsymmetry of the explosion bubble compression produced by the free surface leads to the formation of vortex motion during bubble compression. Experiments were conducted under laboratory conditions using an electrical discharge and explosive charges of 1 g. Under natural conditions, charges up to 10 kg were detonated. For the plane case under laboratory conditions a fluid velocity field and particle trajectories were obtained.

Figure 2. The first Siberian seminar on explosion problem at the middle of 1970th. From left to right: Prof. V.F. Minin, Prof. L.A. Turoc and Ak. M.A. Lavren'tiev.

Based on the results mentioned above Dr. V.F. Minin's in the middle of 1970th has also presented major technological contributions in the defense against terrorism. He has created physical development principles that have resulted in the creation of a family of unique devices including explosive-protection chambers, gas detectors, x-ray control, etc. These devices were employed as part of the security system for the 1980 Olympic Games held in Moscow (Figures 3-4). Figure 4 on the right shows the first hologram there words in Russian "hologram" and "SHF".

Figure 3. Left: Explosion-protection chamber based on damping of shock waves in water with gas bubbles, middle: X-ray complex at Sheremetyevo Airport, right: X-ray inspection of a car.

Figure 4. Sound vision system (left) and the first microwave hologram (right, beginning of 1980th).

Prof. V.F. Minin has carried out in-depth studies on the creation of effective machine-sensitive methods and algorithms for numerical modeling of physics and the study of mechanics. Some of the research projects conducted by Dr. Minin include the development of automated computer programs - Program-Technical Systems (PTS) - that allows experiments to process results in the terminology of the researcher or the designer. Developed under the supervision of Prof. Minin, PTSs utilize bundles of applied programs for a variety of applications, including: non-stationary problems of mechanics of continuous environment, including explosive physics and hypervelocity impact, and systems for automated design of systems by mechanical engineering (Figure 5). The innovative special program complex is based on new high-effective method of individual particles developed under the scientific leadership of Prof. Minin. Mechanical engineering problems entailing the increase of efficiency have also been solved with the assistance of high-speed computing processes developed by Prof. Minin. In addition the ability to fundamental model protection of the “Vega” space vehicle from potential meteoric hypervelocity impacts up to speed of 30 km/s with wide-range equation of state of target was developed (Figure 6). The method of computation, calculation experiment technologies and some of examples of application in explosive and hypervelocity physics are described at [7–11].

In 1988, for his work in the creation of computer facilities and technological advancements in computer experiments, Prof. V.F. Minin was awarded The State Medal of the U.S.S.R., 1st Class and he was the winner of the Statepremium of the USSR for the developed and investigation of the hypervelocity meteorite shield concept for the “Vega” spacecraft.

Prof. Minin investigated Hypervelocity impact phenomenons also in application to the problem of thermonuclear fusion and compressing of different material under high-pressure conditions [12–13].

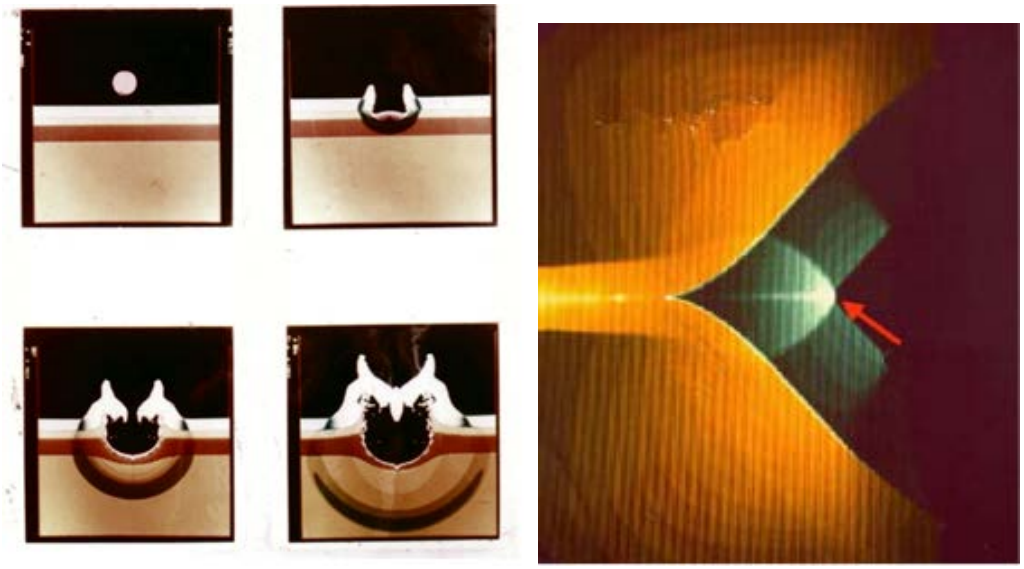

Figure 5. Left: Impact of asteroid with ocean surface, Right: Mach wave generator (the right picture was also used in: V. Fortov. Intense shock waves and extreme states of matter. International Albert Einstein Gold Medal Lecture, but without specifying the authors of the simulation).

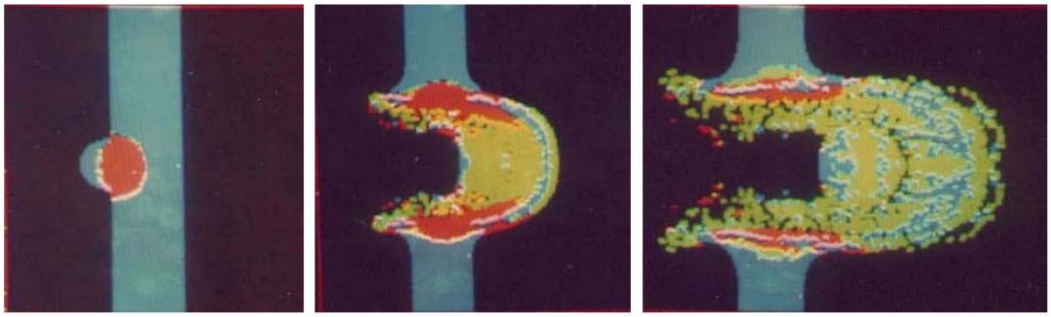

Figure 6. Simulation of the macroparticle impact (V~30 km/s) with aluminum screen: blue – solid, red – liquid, green – plasma states of matter.

Fundamental studies of shaped charge hypervelocity jet formation allow formulating by Prof. Minin the following main conditions: it was shown, that in axisymmetrical case the criterion of Walsh of jet formation is inapplicable; In axisymmetrical case the cumulative jets are formed always [14].
These results allow to formulate an innovative concept of so-called “forced jet formation” for hypervelocity shaped charge jets which has a big advantages before classical shaped charge jets (big mass of jet, speed, the jet without slag, hypervelocity interaction with different targets and so on) [7, 15, 16]. Based on these principles Prof. Minin developed innovative fundamental physical principles of hypercumulative shaped charge jet formation which haven’t analogies in the World for today [7, 15, 17]. These principles allow increasing both as the speed as a mass of hypervelocities jets in several times.

The fundamental physical effects accompanying the flight of cumulative jets at hypersonic speeds in the air and air penetration were studied. The influences of a grain size of microstructure of the surface layer material of a hypersonic body on the properties of air plasma were studied at the first time under the scientific leadership of Prof. Minin. Some new physical effect were discovered when hypervelocity body forming by shaped charge moving in the air with normal pressure (the effects of erosion from the surface of the jet, but not an ablation) [18].
Some of Prof. V.F. Minin many citations and achievements include; The Red Banner Award of Labor, he is the winner of the State premium of the USSR, academician of the Academy of Technical Science

of The Russian Federation, he is the founder and President of the Uralo-Siberian branch of the Academy of Technological Sciences of Russia. He is the winner of the Order of Lenin as well as numerous other awards and medals for his scientific and academic achievements. Dr. Minin has also authored the openings of more than 600 technical proceedings, several monographs and holds patents on more than 150 inventions.

3. Conclusion

In conclusion, we would like to wish Prof. Vladilen F. Minin Siberian health, talented students for further research and getting new discovers and scientific results!

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