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Paper

THE BASIS OF HIGH EXPLOSIVES WASHING OUT TECHNOLOGY

FROM HEAVY-ARTILLERY AMMUNITION

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ABSTRACT

The method of high explosives washing out process from old artillery ammunition (shells) using high-pressure waterjet technology was discussed in the paper. Experimental results were presented in that let to define explosives washing out mechanism and its potential effectiveness. Finally, there were presented exemplary structures of washed out explosives pointing on methods of its utilization.

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1. INTRODUCTION

The method and its technical aspects of ammunition utilization mainly are conditioned by explosives properties. Comprehensive classification of above materials and consequently proper utilization methods, were discussed in previous authors papers (BORKOWSKI J., BORKOWSKI P., WOZNIAK D., 2004), (BORKOWSKI J., WOZNIAK D., SZYMANOWSKI J., 2004), (SZYMANOWSKI J., MILEWSKI E., BORKOWSKI J., BLACHNIO B., 2001) that described practically all the area of the scope, e.g. utilization of high explosive, detonators and powder charge. Mentioned utilization methods concerns: burning, mechanical crushing, chemical treatment like nitro-groups reduction, chemical decomposition using molten salt or so-called bio-degradation method that uses oxygen or no- oxygen bacteria's and mineralization or joined method of above one (SZYMANOWSKI J., MILEWSKI E., BORKOWSKI J., BLACHNIO B., 2001). Thanks to explosives recycling, what in practice means secondary recristalization, there is a possibility to use such high explosives for different industrial processes (BORKOWSKI J., BORKOWSKI P., WOZNIAK D., 2004), (CUDZILO S., MARANDA A., NOWACZEWSKI J., TRZCINSKI W., MORAWA R., 1994), (MILEWSKI E., MISZCZAK M., SZYMANOWSKI J., 1997), mostly for the mining (MARANDA A., MISZCZAK M., NOWACZEWSKI J., 1993), (SZYMANOWSKI J., MILEWSKI E., BORKOWSKI J., BLACHNIO B., 2001).

Generally, today methods of high explosives removing from heavy-artillery ammunition and rocket shells rely on:

- overheated steam melting process,
- hot water washing out process,
- combustion and firing process,
- mechanical removing,
- high-pressure water jet washing out or rarely with cryogenic jet (HASHISH M., MILLER P., 2000).

Such methods of ammunition deactivation have been used in the USA (REYNOLDS S., MILLER P.L., 2004) with a success for over twenty years (FOSSEY R.D. BLAINE J.G., TYLER L.J., SABIN M., SUMMERS D.A., SIMS K., 1997). Close techniques are in use in Europe lately (BORKOWSKI J., WOZNIAK D., SZYMANOWSKI J., 2004), (FOLDYNA J, HAUNER M., SEDLARIK A., 1998). Sometimes, such a purpose jets are characterized by complicated trajectories of its flow (BORKOWSKI P., 2005) achieved by a proper nozzle movement.

Some basic information connected to washing out of high explosive using high-pressure water jet is presented in the paper. Nowadays in Poland, it is actual problem mostly connected with ammunition storage. The problem results from ammunition past due but first it assortment change because of NATO procedures also adequate normative of EU.

2. RESEARCH METHODOLOGY

In order to carry out the research of the most important physical factors occurred in the process of explosives washing out from the heavy-artillery ammunition shells using high-pressure water jet, it is very important to analyze the dynamic influence of the high-pressure jet. The main experimental setup (Fig. 1) used in the jet erosiveness investigation of such high explosives is based on the new Hammelmann type HDP 483 pump system (Fig. 2) giving the power of 750 KM.

The general schema of the examining object that let to establish objective test plan of explosives erosion process carried out in the aspect of its optimization, is presented in the Fig. 3. As it shows, there are presented the most important details of examined factors of the erosion jet.

Similar more general in character schema of such process realized in order to define its erosion effectiveness during high-pressure washing out is presented in the Fig. 4. And also here, the most important detail factors are presented in the aspect of cleaning process effectiveness minimization taking into account important safety reason.

The research method detailed characterization of all examined factors is too extensive. Most of those specific measurement techniques were developed and verified experimentally in close hydrodynamic conditions during many own works (over 100 publications in that scope including 2 books).

3. EXPERIMENTAL RESULTS

The first stage research was directed to find out so-called model (substitute) of high explosives that ensures safety experimental process. Such a searching aim was to develop a sample material characterized by mechanical and technical properties e.g. grindability, hardness, impact resistance that would be similar to typical high explosives. Over thirty of such composites were taken into consideration, consisted of different cement base compounds with addition of nitrocellulose lacquers, epoxy resins, linseed oil varnish also tree dust and potato flour as filling materials. As a result of above procedure a following model of explosive material was established including: 28% of Portland cement, 8,5 % of lime, 53% of sand quartz (#0.8 ÷ 1.2 mm), 5% of wooden fluid and 4% of flour also 1.5% of residual compounds. Such a material is characterized by suitable mechanical properties adequate to TNT. The usage of above material results in safe processing of high-pressure water jet shells washing out.

The main research was conducted for 85÷125 mm caliber artillery shells (Fig. 5). During that, it was applied so-called spiral test presented in Fig. 6. These were the basis for preparing kinematical nomogram of that process (Fig. 7), which let consciously plan all the conditions of effective process. As it shows, increasing both rotation velocity of the shell and spiral radius, causes proportional increase of the jet move velocity regarding to model of high explosives. Moreover, it shows real values of above kinematical relations and their influence on the cut depth. Typical eroded shape of above tests is presented in Fig. 8.

However, those spiral tests are different from real conditions where high-pressure water jet injects through a front fuse hole and simultaneously flows out the same way including high explosive pieces. Such a process requires high explosive size reduction causing effectiveness decrease. Considering all those specific relations allows planning accurate process as well as to properly evaluate its effects. Some exemplary effects of such a model material washing out efficiency illustrated for 100 mm caliber shells using water jet pressured up to 50 MPa are presented in Fig. 9.

An experimental analysis indicates that water nozzle diameter increase as well as water pressure resulting in high explosive washing out effectiveness increase. For example, using 1.0 mm diameter nozzle causes that the washing out time is twice longer than for 1.5 mm nozzle type. In turn, the rest process parameters e.g. water jet length or spraying angle, has no significant influence on washing out process time. It is also worth notice that comparing 100 mm diameter shells to 125 mm once, this time increases over 65% while 85 mm caliber cleaning time decreases of about 20%.

Moreover, one shelle washing out process needs at least 90÷100 dm^3 of water (Fig. 9b) while energy consumption is rather low average 1 kWh/pcs (Fig. 9c). Basing on above data it should be stated that taking into consideration only water and energy rate, the minimum unit cost of explosives washing out from 100 mm type shell doesn't exceed 0.25 USD (Fig. 9d).

The hydrodynamic of the process is the one of the most important aspect that straightly corresponding with established model material structure grinding. The overgrinding is an effect also of the inlet shell hole closely connected to its caliber (Fig. 10). Therefore, too much overgrinding occurred mostly during sieve fraction analysis. Exemplary effects of above results are presented in Fig. 11 showing out distribution of geometrical fraction analysis.

Usually such fraction was obtain using sieves in the range of no. f 12 (# >63 mm) to f 1 (# <0.125 mm) while smaller pieces in the form of sludge were recovered using sedimentation. Testing results shown that most often fraction of explosives were granules in the range of no. f 11 (# 31÷63 mm) to no. f 8 (# 4÷8 mm) while most often were sludge participation.

Granulometric fraction difference of high explosives together with its surface morphology has significant influence taking into account the method of its utilization. The morphology of model explosives considerably depends on the size. Generally, its surface is greatly developed, what can be seen in Fig. 12 showing out the view and its microscopic structure as well as TalyScan's analytical pictures presented in Fig. 13. Results of carried research indicate, that high explosive can be recycled. Some of those large particles could be directly used as an explosive. Recovered medium size fractions in the range of 4÷31 mm could be use as elements of mining ammunition while the smallest ones for different explosives founding. Therefore, high explosive recovered from large caliber artillery ammunition using waterjetting technology can be applied to mining in a wide range.

4. CONCLUSION

So far, conducted research of model explosives loosening and washing out from large caliber artillery ammunition using waterjetting technology are distinguished by reliable repeatability. It enables good base for developing effective method of real ammunition disarmament. Conducted experiments of different erosion processes let also decrease process time increasing simultaneously its effectiveness. It is especially connected to multi- test bed technological system.

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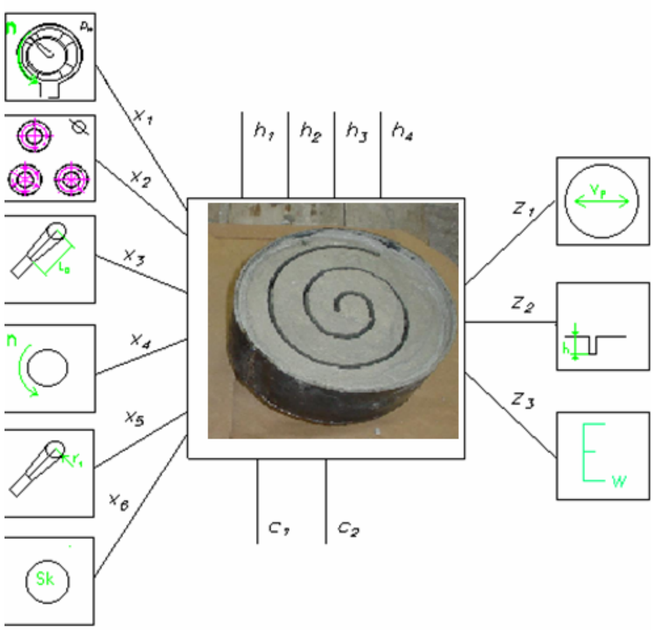
6. GRAPHICS

Fig. 1. Test stand elements

Fig. 2. Hammelemann HDP 483 pump system



Input data

x_1 – jet pressure p=30, 40, 50 MPa,

x_2 – nozzle diameter d=0.6, 0.8, 1.0, 1.5, 2.0mm

x_3 – jet length L_o= 10, 50, 100, 200 mm

x_4 – shell rotation speed n [rev/min]

x_5 – spraying radius r [mm]

x_6 – jet radial leap [mm/rev]

disturbance data

h_1 - jet pressure measurement error

h_2 - jet spraying angle inaccuracy

h_3 – jet pressure pulsation

h_4 – nozzle wear

constant data

c_1 – model explosives type

c_2 – jet type

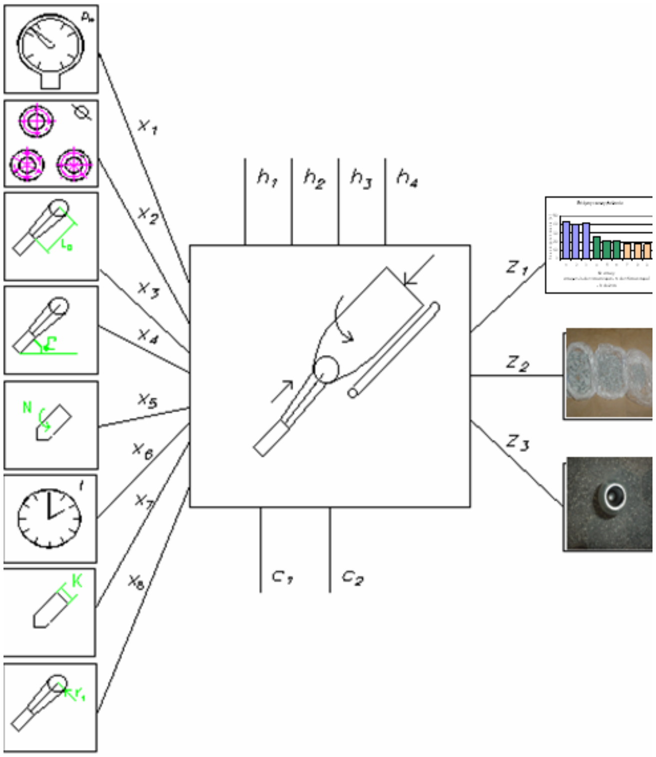
output data

z_1 – jet feed rate v_p [mm/min]

z_2 – cut depth h [mm]

z_3 – process effectiveness E_w

Fig. 3. General schema of research object including explosives erosion process optimization



Input data

x_1 – jet pressure p=30, 40, 50 MPa,

x_2 – nozzle diameter d=0.6, 0.8, 1.0, 1.5, 2.0mm

x_3 – jet length L_o= 10, 50, 100, 200 mm

x_4 – spraying angle

x_5 – shell rotation speed n [rev/min]

x_6 – spraying time t [s]

x_7 – shells caliber k=85, 100, 122, 125 mm

x_8 – jet spraying radius r [mm]

disturbance data

h_1 - jet pressure measurement error

h_2 - jet spraying angle inaccuracy

h_3 – jet pressure pulsation

h_4 – nozzle wear

constant data

c_1 – model explosives type

c_2 – jet type

output data

z_1 – process effectiveness E_w

z_2 – granulometrical fraction type f [mm]

z_3 – washed out surface quality J

Fig. 4. General schema of research object including HPWJ shells washing out process effectiveness

Fig. 5. Group of tested shells (caliber range 85÷125 mm)

Fig. 6. Surface view of spiral samples

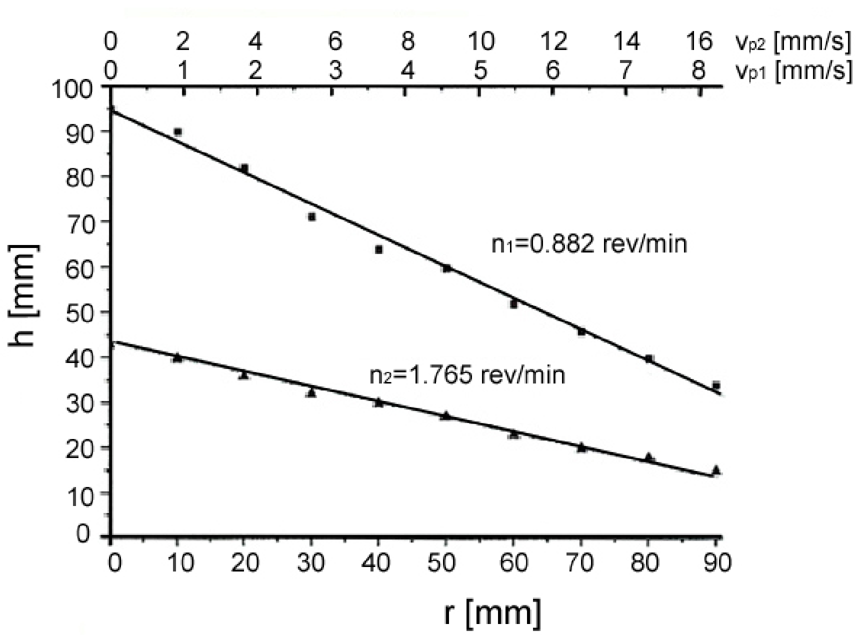


Fig. 7. Influance of the shells rotary velocity (n) and spiral radius (r) on the feed rate (v_p) and explosives cut depth (h) defined during spiral tests.

Fig. 8. Examples of exposive material washed out from artillery shells

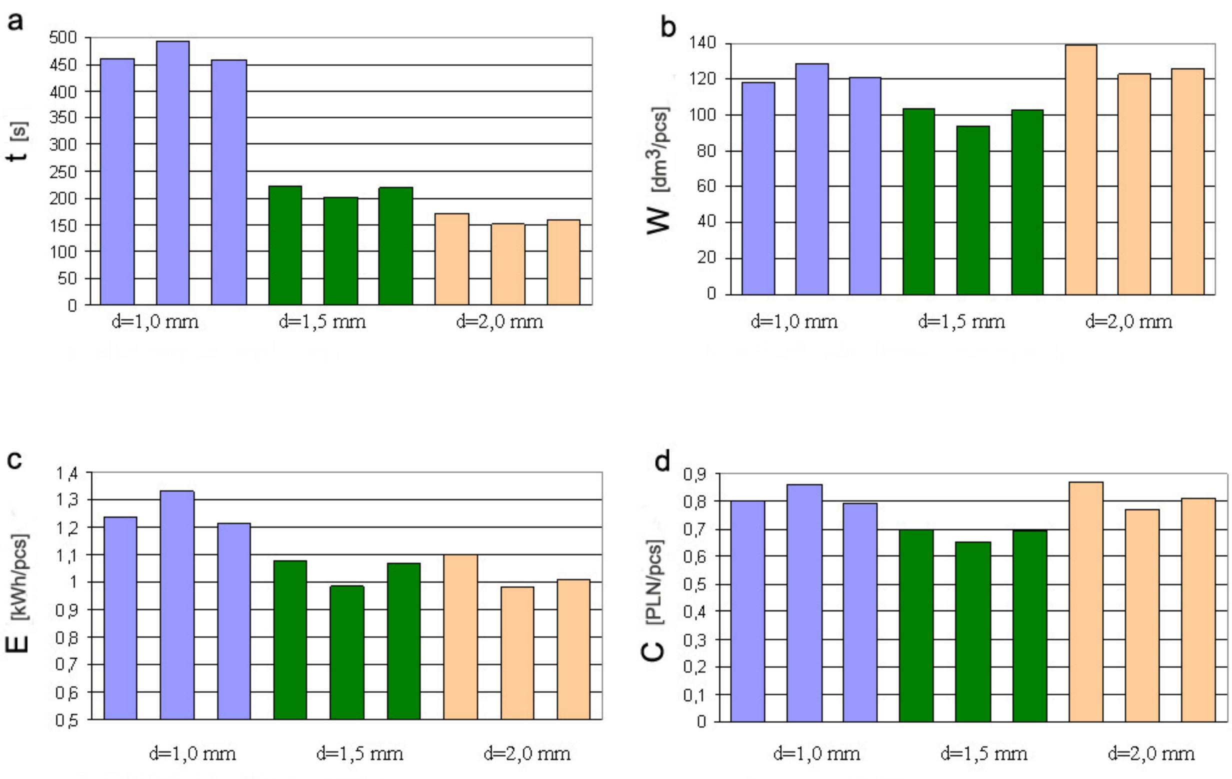


Fig. 9. Different washing out process rates indicated for shell cal. 100 mm and different nozzle types, p=50 MPa, Lo=50 mm. (a – time, b – effectiveness, c – energy consumption, d - costs)

Fig. 10. Typical examples of washed out explosives fractions

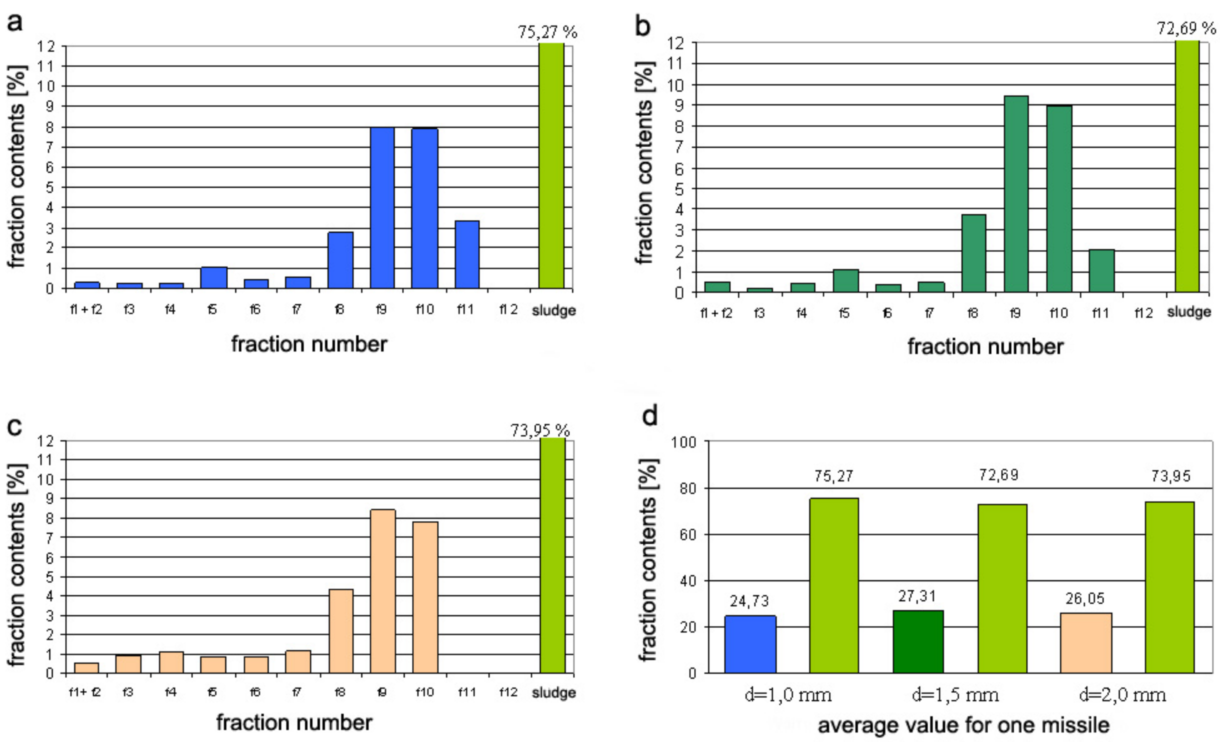


Fig. 11. Percentage contents of explosive material granulometric fractions washed out from shell cal. 100 mm (p=50 MPa, Lo=50 mm) using following nozzle diameters: d=1,0 mm (a), d=1,5 mm (b), d=2,0 mm (c) and comparision of grain and sludge fraction washed out from shell (d)

Fig. 12. Explosives washed out fractions

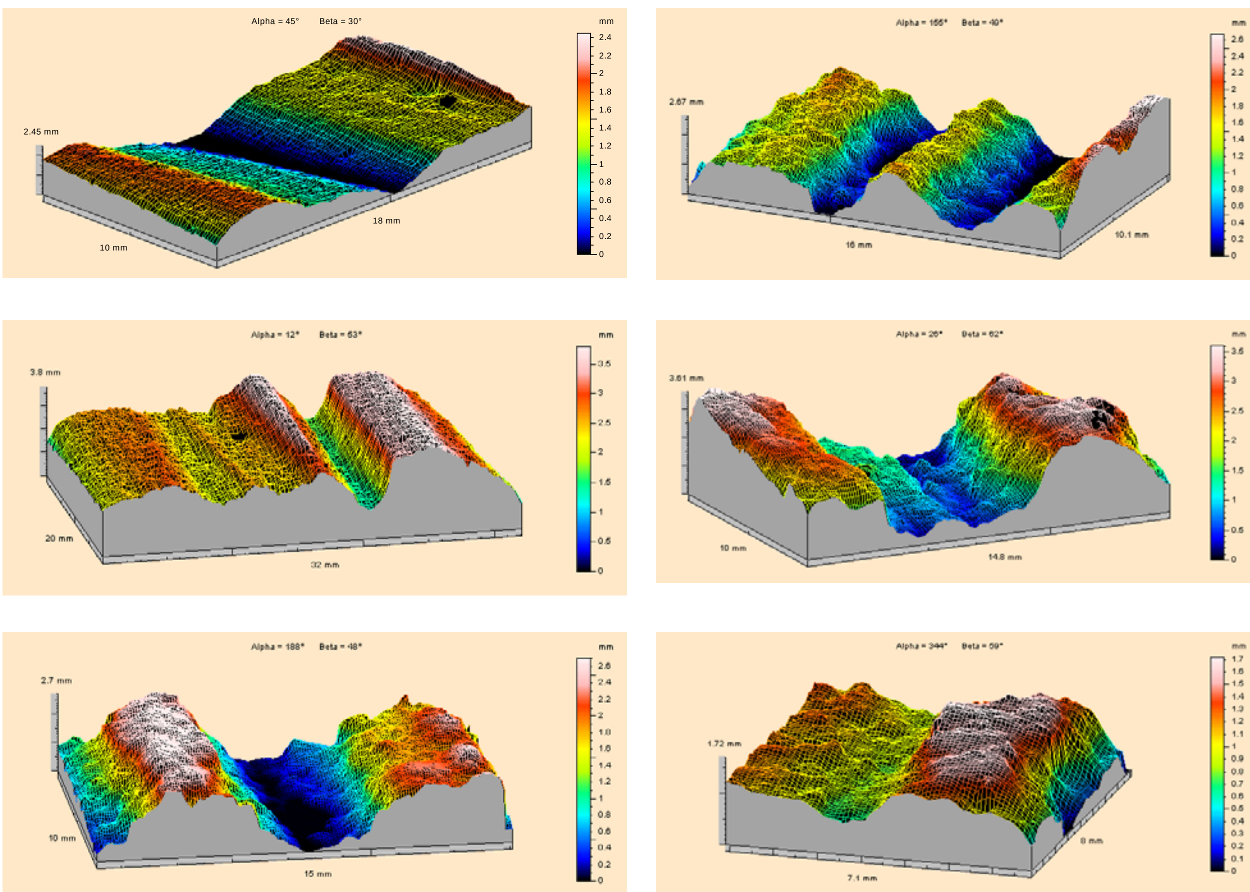


Fig. 13. Examplary morphology scans of washed out explosive materials