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Measurement analysis of parameters of three-dimensional shapes

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Abstract, Measurement of three-dimensional shapes appears as a task in many areas of technical practice. In architecture, in special tasks of industrial robotics applications, in navigation and control systems of military technology, in solution for manipulation problems of space exploration in many cases we have to deal with definition, measurement of specified points of space. From measurement technology point of view, it is regarded as a classical solution to solve a problem by application of calculation according to the principle of three-dimensional triangulation. A newer possible solution is provided by application of imaging systems, which may give good results with proper software support. In our article we deal with measurement technology problems of a special area. Measurement of parameters of spectacle elements for pyrotechnics is important from the point of view of qualification of applied pyrotechnical tool and of programming of the planned effect. We will describe the results of development by introduction of experiments of parameters according to a new measurement procedure and by comparative analysis of them.

Keywords: measurement technology; pyrotechnic; military technology; three-dimensional triangulation; planned effect

1 Introduction

Specific form of three-dimensional shapes is image shape of spectacle elements that can be sent to variable heights with various extensions and forms and that are produced by pyrotechnic tools. (Fig. 1.) Directive 2007/23/EC concerning placing on the market of pyrotechnic tools was proclaimed in 2007, but for examination of pyrotechnic tools different transitional periods were determined. Products belonging to “professional” fireworks, stage pyrotechnic tools and other pyrotechnic tools from 4 July 2013 must be examined and certified by an independent registered organisation.

Development target was to establish a measurement tool system required for examinations that satisfy specifications of standards by observing the corresponding laws. Expectation to the tools system was that it must have proper accuracy also in

international comparison and minimum time and human resources are required for measurement and the tool can be made with low investment costs.

2. Environment for task definition

Legal environment is given by specifications of the European Union. Decree 765/2008/EK of the European Parliament and the Council concerning accreditation and standards for market surveillance specifications, regarding to placing the products on the market governs the rules of accreditation, criteria and market surveillance specifications of organisations who wish to perform compliance evaluation.

Directive 2007/23/EK of the European Parliament and the Council concerning placing on the market of pyrotechnic products (hereafter directive) specifies criteria that are required for placing on the market of pyrotechnic products, their satisfying is indispensable for placing the products on the internal market of EU.

Harmonised standards of the decree 2007/23/EK describe in detail the examination requirements, concepts for each category and type according to compliance evaluation procedures.

According to standard specification: entertainment pyrotechnic tools can be classified into 4 classes. The first three classes are accessible for anybody by observing the minimum age requirement assigned to the categories and the usage restrictions. The 4. class (F4): fireworks involving high risk, intended exclusively for use by persons who have professional knowledge, and noise level of which is not harmful to human health (known as professional fireworks).

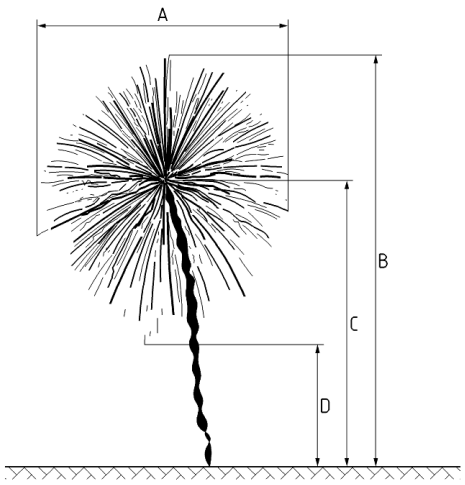


Fig. 1. The Effect
Legends: A – Effect width; B – Effect height; C – Demolition / ascent height; D – Fall-back height

Side drift is the distance of the section projected squarely from the demolition point to the ground plane and of the shooting point. Effect distance is maximum distance of the effect in direction of shooting measured from device base. Radial effect distance is maximum distance of the effect in any direction, except the shooting direction (generally in the direction perpendicular to shooting).

3. Hypothesis – Video system is the most suitable

In case of tools with a video-based system the measurement can be registered, archived, is traceable and at any time reproducible or can be made more accurate in case of using new calculations or software.

In case of not video-based tools that are suitable for parallel measurement of horizontal and vertical angles it is very difficult or is not possible at all to measure obligatory effect parameters specified in requirements of the standard in case of measurement of multi shooting devices. Two persons using the tool must perceive the maximum demolition or effect height from the given place at the same time, they must direct the tool to that height and in the meantime read and register the two angles.

Not video-based tools due to their character and measurement principle are not suitable for parallel measurement of obligatory and optional parameters.

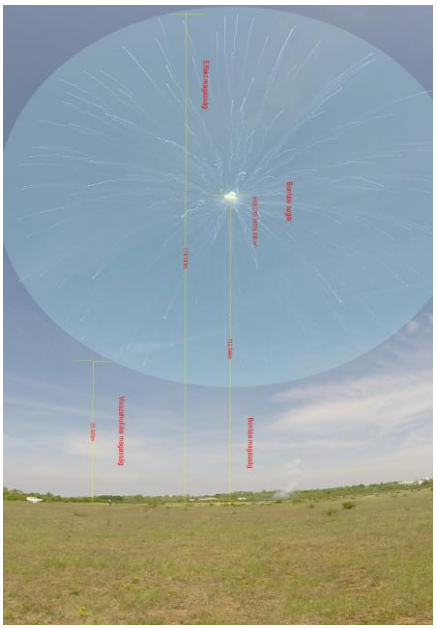
Foreign example. One of organisations using such a tool, the German Bundesanstalt für Materialforschung und –Prüfung (hereinafter BAM), who are a state examination and attestation organisation and authority.

BAM specialists have their tool system produced individually by a German company, the system includes two video cameras, two tripods, evaluation software, a long-range Wi-Fi antenna, and Wi-Fi transceivers connected with the cameras. During measurement, cameras are placed at a preliminary calculated distance from the shooting point so that they are at 90 degree to each other. The Wi-Fi antenna is placed between the two cameras in the midpoint of the hypotenuse of the triangle formed by the cameras and the shooting point. The cameras whether have a pre-set fixed tilt angle, or based on expectable height the required minimum tilt angle is calculated, for any case the tilt angle is known.

Fig. 2. Video system camera on tripod used by Germans

4. Measurements carried out by the video system

If we have determined the plane that includes the effect parameters the effect parameters can be easily measured after specifying the size scale. From now on we can calculate in seconds the distance of any two points or even the perimeter or area of a circle. (see Fig. 3.)



Essential part of measurement made by video-based system is evaluation of recordings. Evaluation is performed logically additionally, because we perform it by such software that is not capable of real-time recording and measuring at the same time. During evaluation we must obtain from the recorded videos the frame, in which the effect parameter to be measured can be seen (e.g.: in case of bombs the largest demolition height, in case of stage pyrotechnic the largest effect width and height). Obtained pictures can be opened individually by the program.

Fig. 3. Measurement of effect parameters of 150 mm calibre fireworks bombs

6. Conclusions

Overall, we can say that the our basic hypothesis was partially confirmed. Video-based devices can almost exclusively be applied in case of momentary, small-sized effects (most part of stage pyrotechnic tools are similar) and in case of simultaneous measurement of several effect parameters. The video-based system further is more accurate, its usage is more practical, it requires less persons and time, its measurement uncertainty is much lower than in case of measurement of medium-size or complex pyrotechnic tools. In case of fireworks bombs that have large demolition height (most of professional fireworks belong here), however, the tool system based on angle measurement is satisfactory, and it has the accuracy and measurement uncertainty that are similar to those of the vide-based system, but its handling and evaluation is more practical and faster, what makes it more suitable for measurement if measurement of the obligatory (demolition height) is required only.

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