The Cobra fire suppression system as a mobile application of a high pressure water jet

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Abstract

This article presents one of the applications of an industrial usage of high pressure water jets to extinguish fires. Such a technical solution was installed on a certain type of fire extinguishing vehicles, allowing full mobility. The article encompasses pictures which graphically illustrate the given topic.

Keywords: high pressure water jet, fire extinguishing, Cobra system, fire trucks.

Introduction

High-pressure water jet or water jet with the addition of a medium are used virtually in all sectors of industry, technology and economy [6,7]. The following particles can be used as a medium in such case:
- metallic, e.g. steel shots, aluminum granulate,
- mineral, e.g. corundum grains, grains (balls) of glass, grains of slag,
- from synthetics, e.g. polyamides, polymers,
- from plant products, e.g. fruit seeds, corn grains,
- special ones, e.g. grains of dry ice.

The basic areas in which the following technology is used are e.g.:
- cleaning sheet metals, sides of ship hulls,
- cleaning forgings, molds, plastic holdings,
- cutting, deburring, surface processing of materials which are difficult to work, e.g. composites, titanium, industrial ceramics, and in any shape,
- cutting and working on synthetics, glass, ceramics, paper,
- cleaning places which are difficult to access, e.g. rotors and airplane turbines,
- cleaning boilers in sugar-refineries,
- cleaning kilns, cutting reinforced and concrete elements in the calcium-construction industry,
- removing explosives from ammunition,
- working on parts, cleaning steel sheets, cutting profiles, e.g. of doors, bumpers in the car industry,
- extinguishing fires.

The examples given above allow to familiarize oneself with the diversity of usage of the discussed technology. This article presents one of the possibilities of using the water jet in a mobile variant on a fire truck.

1. The division and characteristics of fire trucks

In Poland, the most often used designations are still those in accordance with the norm [2], even though this norm was substituted by the European Union norms [3,4,5].

The basic designations of fire trucks are as follows:
- **Fire truck**: this is a car used for extinguishing fires and/or rescue.
- **Brush truck**: this is a car adjusted to carrying people and technical means used to carry out an independent fire extinguishing action.
- **Special car**: this is a car used for carrying people and equipment necessary for performing special tasks during rescue operations.
- **Rescue-brush truck**: this is a combination of a brush truck with a special car.
- **Exchangeable container**: this is a special purpose container, which can be put on and taken off a given vehicle.

1.1. Categories of rescue-extinguishing cars

Depending on the real maximum weight of a vehicle, in accordance with the previously mentioned norm [2], one can distinguish the following:
- light class: up to 7,5 tons,
- medium class: from 7,5 to 14 tons,
- heavy class: above 14 tons.

Depending on the ability to move on certain surfaces, one can distinguish the following:
- category 1 – city – these are vehicles with the purpose of travelling on roads with a hard surface,
- category 2 – cross-country vehicles – these are vehicles able to travel through hard surface roads and, in a limited scope, on other types of roads,
- category 3 – all-terrain vehicles – these are vehicles which are able to travel through all types of roads and unbeaten tracks.

2. Fire truck marking

2.1. Traditional marking [2]

Rescue-extinguishing car *GCBA 5/32*. The marking is as follows: G – rescue-extinguishing car, C – heavy, B – with a water tank, A – with an automatic pump, 5 – a water tank of a capacity of 5m³, 32 – the nominal efficiency of the automatic pump of 32 hl/min (3200 l/min).

Rescue-extinguishing car *GCBA 5/24*. The marking is as follows: G – rescue-extinguishing car, C – heavy, B – with a water tank, A – with an automatic pump, 5 – a water tank of a
capacity of 5m³, 24 – the nominal efficiency of the automatic pump of 24 hl/min (2400 l/min).

2.2. European Union marking [3]

Rescue-extinguishing car S – 2 – 3 – 5000 – 8/3200 – 1. Marking of a rescue-extinguishing car of a heavy class (S), of the cross-country vehicle category (2), with a 3-person crew, with a water tank of a capacity of 5000 dm³, with a pump with an efficiency of 3200 dm³/min under the pressure of 8 bar, with a light mast (1).

Car with a mechanical ladder M – 1 – 3 – 30/10 – 1 – 1. Marking of a mechanical ladder, medium class (M), city category (1), with a 3-person crew cabin, lifting height of 30 m, range of overhang 10 m, with a pump (1) and (special equipment) at the expense of (1).

2.3. Letter marking of fire trucks

G – extinguishing
C – heavy (above 12 tons)
L – light (up to 3.5 tons)
M – autopump [hl/min]
A – autopump [hl/min]
B – water tank [m³]
Pr – powder [kg]
Sn – snow [kg CO₂]
S – special:
D – ladder [m]
H – hydraulic jack [m]
W – hose [m]
Z – tank [m³]
Dz – crane [t]

On - lighting [kW]
Kn - container
Kw – quartermaster’s
Op - operational
Df – command and communication
San - sanitary
Wys - height
Wf – with workplace
T – with equipment for construction and other catastrophes
P-gaz, P-dym – with anti-gas and antismoke devices
Rd, Rt, Rch, Rw – road rescue, technical rescue, chemical rescue, water rescue
R – recognition

e.g. GCBA – a heavy extinguishing car with a water tank of a capacity of 5m³ with an autopump of an efficiency of 24 hl/min, frother 10% of tank capacity.

3. Examples of technical solutions in chosen fire trucks [4, 5, 8, 9, 10]

3.1. 301 [T]52 - SH 42 Volvo FM9 fire truck with lift

The tactical-technical specifications

Make: Volvo, model FM9, horsepower: 330 HP, drive: 4x2, maximum working height: 42.0 m, maximum working overhang: 19.2 m, maximum basket load: 0.365 t, length in transport position: 10.5 m, width in transport position: 2.5 m, height in transport position: 3.7 m, turn angle: 360°.

3.2. Light extinguishing-rescue GLBA 1/1 car on an IVECO DAILY 65C15 chassis (with the function of technical rescue) [4, 5, 8, 9, 10]

The tactical-technical specifications

Drive: 4x2. Crew: 5 people, Allowed mass 6.23 t. Extinguishant tanks (water/frother): 1000/100 dm³, extinguishing high pressure unit: Kappa 100, frother dispenser: 3% and 6%. Initial attack firefighting line: 60 m, high pressure, light Mast: 2x1000 W, winch: electric, maximum allowed weight: 4 t.

Equipment: technical rescue equipment (e.g. hydraulic tool set, pneumatic low and high pressure winch set, wood saw, steel and concrete saw), electric power generator 2.2 KVA. Other equipment optional.
3.3. Heavy rescue-extinguishing GCBA 8,5/50 car on a Mercedes Actros 3340 chassis [4,5,8,9,10]

The tactical-technical specifications
Drive: 6x6, Crew: 3 people, Maximum real weight: 25,9 t., Engine (maximum power): 290 kW.
Autopump: Volkan type 6000 N, Frother dispenser: 3% and 6%, Initial attack firefighting line: length 60 m, low pressure, Light mast: 2x1000 W, Winch: Power Winch.
Equipment: suction hoses 110-2500-L (x6), delivery hoses: W-52-20-LA (x8), W-75-20-LA (x10), W-110-20-LA (x8), 9000 l (composite) water tank, 900 l (composite) extinguisher tank, automatic valve for hydrant filling, two-scale autopump type A 50/8 – 4/40, water-foam cannon type DWP 50, sound generator BOS200 200W, radio communication equipment (Motorola GM 360), electric winch, compressed air foam PWP System (CAFS), LED light.
Other equipment optional.

4. The essence and basic advantages of the processing

High pressure water jet processing is done by working with a water jet in a nozzle on the processed material, therefore the process is about transmitting high power into the object, which causes tearing off micro molecules of the material from its basic mass. Due to the high concentration of the water jet (even despite a high density), small working forces are in operation.

On the other hand, the essence of water-abrasive jet processing lies in adding to the jet (to the water jet) an abrasive medium in order to increase its processing ability, since one cannot process e.g. all metals, ceramics, hard rocks etc. with a water jet. As, in order to acquire an appropriate jet speed, one has to produce too much power to achieve this. In addition to this, sometimes delamination occurs after processing with the water jet only. A schematic presentation of this process is presented on fig. 1 [7].

The basic advantages of processing with a high-pressure water jet are e.g. [7]:
- the possibility of making a large number of operations, changing the jet’s direction with automatic NC, CAD/CAM steering,
- no wearing of the device,
- high efficiency of the process, acquiring the required quality, tolerance and shape indicators,
- simple setting of the object, very small processing strength,
- no deformations and low thermal strain within the structure of the processed soft or hard material, which does not influence the structure and quality of the processed area,
- saving the material due to the precise processing, and, due to this, a minimal amount of waste, as well as the lack of final processing (lack of finishing touches),
- no significant dangers and negative influence on the natural environment and on the human organism,
- the possibility of cutting complicated touches, in a multi-directional system and with great speed,
- efficiency.

The processing possibilities of a high-pressure water jet depend on: the composition of the jet, the direction of processing, the type of processed material, the method of influencing the processed material.

4.1. The influence of the structure and shape of the water jet on the efficiency of the processing

The basic requirement when using a water jet to process different materials is the condition of obtaining on the nozzle a jet which is coherent, therefore one which is able keep its cohesion (the so-called not falling apart during movement) and keeps its kinetic energy as far as possible from the nozzle. After leaving the nozzle, the jet meets air, which is approximately 800 times less thick than water and which starts to part, in external layers, from the center. Sometimes the air also influences the inside of the jet layers. This causes quick exchange of mass between the water jet, as well as the loss of its cylinder shape, which transforms into a cone. This is illustrated in fig. 2 [7].

When steering pressure, one may force a jet’s shape up to a certain distance from the nozzle, also due to e.g. the intensity of the water flow which increases together with the pressure, and also due to the increase in its aeration, i.e. saturating the jet with air. The increasing aeration and instabilities and pulsations within the jet cause dropping, decrease in the jet’s speed, increasing in diameter. This is shown on fig. 3 [7].
Fig. 2. Speed in a high-pressure water jet

Fig. 3. The structure of a high-pressure water stream
1 - Beginning area
2 - Main area
3 - Ending area
4 - Tied stream
5 - Drop stream
6 - Stream disintegration
7 - Transition zone
8 - Water spray cone
9 - Nozzle
10 - Stream core (constant)
11 - Spray type (discontinuous)
12 - Drop spray cone

The processing possibilities of a high-pressure water jet depend on e.g. [7]:
- the physical properties of the liquid,
- the pressure of the water jet,
- the water flow rate,
- the addition of abrasivates,
- the diameter and length of the nozzle,
- the direction in which the surface (material) is processed
  and the way of this processing, e.g. the angle of incidence of the jet,
- the type of material and its properties,
- the type of the technological process (processing).

5. Using the water jet for fire extinguishing

The Cobra cutting and firefighting system [1] was developed in 1997 by the CCS company together with the Swedish Rescue Services Agency and the Bronto Skylift company in order to allow safe and efficient fire extinguishing with the function of water jet cutting, which is able to pierce various construction and building materials, e.g. concrete, wood, glass.

The method used by the device (cutting cold) allows to cut various materials without producing hot sparks, which enables working in conditions where there is a risk of fire or explosion. The water, which is directed into a special nozzle under 30 MPa pressure, makes a water fog, due to which the device can efficiently extinguish fires.

Water and the abradant are supplied into the Cobra system with the assistance of a hose, which allows to work even up to 300 meters from hydraulic and power devices without weakening the cutting force and the extinguishing possibilities. This is a significant advantage during rescue operations and fire extinguishing in high buildings and on areas in which cutting and extinguishing devices are difficult to access.

5.1. The Diajet (direct injection abrasive jet) system

This is a method of directly creating an AWSJ (abrasive water suspension jet), which is about mixing in a pressure tank water with an abradant in a given concentration and delivering this mixture with one elastic cable into the work head with a nozzle, forming the cutting jet [6].

An important feature of this method, in comparison to the direct production of the AWJ jet (in which water and the abradant are put into the work head separately), is the much more effective way of mixing the abradant grains within the created jet. Due to this, it is possible to use a working pressure of approximately 70 MPa, which is enough to give the jet a speed of over 300 m/s, making the cutting device highly efficient.

5.2. Cutting properties

The patented nozzle creates a jet of water and abradant [1]. It uses the pressure created by the pump to give the jet cutting properties. Its strength allows to cut through construction materials of any kind – fig. 4 [10], e.g. steel or concrete. The high-pressure water pump uses a hydraulic Bronto drive. The working pressure of the water jet cutting system is approximately 35 MPa, with the flow of 50 liters per minute. The water and the abradant are transported via a standard 12.5 mm thick hydraulic hose.

Phot. 4. Cutting a circular section post

5.3. The cutting frame
The cutting frame \([1]\) is an element of the water cutting fire extinguishing device named Cobra and it is directly attached to the power system. It is a hydraulic cutting head system with a nozzle moving along a track. The standard size of the track is 500 x 500 mm, optionally other sizes and shapes of the track can be made, depending on the customer’s needs, fig. 5 \([10]\).

The cutting speed and direction are operated with a remote control, which can be placed within an appropriate and safe distance. The cutting frame is used e.g. for making evacuation tunnels from ships and planes, cutting out manholes and evacuation holes and evacuation exits, or for emptying silos etc.

**Phot. 5. A view of a cutting frame with equipment**

### 5.4. Extinguishing properties

The Diajet jet, in combination with 35 MPa pressure, creates a water fog from microscopic drops, which makes the Cobra system \([1]\) an effective firefighting device. The high-pressure water pump, Dynaset, fig. 6 \([10]\), is powered hydraulically, and its efficiency is 60 liters per minute under the pressure of 35 MPa.

The water pump is powered by the hydraulic driver of the fire truck. The equipment in the Cobra system is e.g. an abradant bottle, hose drum 115 m long and 12.5 mm thick and special cutting and fire extinguishing lances, phot. 7 \([10]\).

In comparison with other fire extinguishing systems, e.g. water-foam systems using regular generators, when using the Cobra system, one really achieves a significant reduction of damage due to the excess of water, since most micro-drops are vaporized in the sphere of hot fire gases.

**Phot. 6. A view of a Dynaset water pump**

A standard Jet type generator generates much bigger water fog drops than Cobra, thus often flooding with water and damaging buildings, objects, and other property which is supposed to be saved from the fire. Using standard systems, approximately 4-10% of the water used evaporates, and when using the Cobra system, approximately 95-97% of water used evaporates \([1]\).

As it was mentioned previously, water poured under high pressure, after leaving the nozzle turns into microscopic drops, creating the so-called water fog, which efficiently extinguishes fire since a big reaction area of the created fog absorbs heat – due to its big surface, the water fog evaporates quickly and cuts off oxygen, thus extinguishing the flames.

It is very important that small rescue units (light cars) equipped with the discussed system may quickly begin a professional rescue operation, even with a two-people crew.

A crew operating the Cobra device should consist of one person operating the lance and one person monitoring the burning object, e.g. with a thermographic camera. The system is easy to operate and the lance and hose used are not heavy.

The Cobra devices \([1]\) can be installed in various fire trucks, phot. 8-9 \([10]\): heavy, medium, and small of the Pickup or Van type. The hose has an optimal diameter of 0.5 inch and can be made longer up to 80% of a standard hose without using any of the device’s parameters.

**Phot. 7. A Mercedes fire truck with equipment and lance**

**Phot. 8. A Volvo FL 240 fire truck**
5.5. The advantages of the COBRA system

The basic advantages of the system presented in this article are [1,10]:
- efficient extinguishing of fire with the usage of a limited amount of water which allows to minimize the damage of the objects on fire due to flooding them with water,
- being environmentally friendly and ecological,
- ensuring safety to the user due to remote control,
- the possibility of quick and safe fire extinguishing in closed rooms, without the risk of a back draft,
- efficiency during quick interventions,
- using the safe cold cutting method, allowing for cutting and making holes in conditions in which there is a risk of explosion,
- high usefulness during actions in high buildings and in situations requiring the usage of long hoses,
- low pressure drops and not losing efficiency on the distance of up to and beyond 300 meters.

6. Conclusions

The fire extinguishing system presented in this article is based on a high-pressure water jet and its practical application allows to track the effectiveness of such a solution in fire extinguishing in general. It has to be emphasized that it can be used as a basic solution – or as an additional support to the equipment and fire extinguishing capabilities of fire trucks.

Such systems are very often used for extinguishing buildings, cars – or in the mobile variation – in rescue operations on burning ships.

Bibliography
1. Training materials of the Central School of the State Fire Service in Czestochowa.
2. PN-79/M-51300. Fire trucks. The division and marking.
10. The authors’ private pictures and archives

System gaśniczy Cobra - jako mobilna aplikacja wysokociśnieniowej strugi cieczy

Streszczenie

W artykule przedstawiono jedną z aplikacji przemysłowego wykorzystania wysokociśnieniowej strugi cieczy do gaszenia pożarów. Tego typu rozwiązanie techniczne zabudowano na określonym typie pojazdów gaśniczych zapewniając pełną mobilność. W skład artykułu wchodzą zdjęcia, które ilustrują graficznie przedstawione zagadnienie.

Słowa kluczowe: wysokociśnieniowa struga cieczy, gaszenie pożarów, system Cobra, samochody pożarnicze.

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