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Development Directions of Fire-Fighting Equipment Using Aircraft Engines Abroad

In the last century, outstanding fire-fighting technology developments have occurred in Hungary. Mobile, quickly deployable, efficient, environmentally friendly tools and technologies with optimal fire extinguishing material use have come to the fore. This included equipment using exhaust gas from internal combustion engines and combustion products from aircraft engines for fire-fighting. The developers' goal is to reduce environmental and secondary damage during fire-fighting, and at the same time, they sought to increase the efficiency of fire-fighting processes by using measurably less fire-fighting material. In our article, we present the foreign developments of fire-extinguishing equipment that uses aircraft engines with a unique operating principle and is suitable for applying multiple types of fire-extinguishing materials, thus also for implementing complex fire-fighting. We review the design and construction of the equipment, their operating principle, examine their practical application possibilities, and present directions for future development.

***Keywords**: internal combustion engine, aircraft engine, exhaust gas, turbo-reactive fire extinguishing, fire extinguishing agent use, fire extinguishing efficiency*

Introduction

Considering environmental and safety conscious aspects when investigating even fire cases, different road and industrial accidents can be stated to severely affect air, soil, water, and the built human environment.[4] There is great effort for research, development, and practical implementation of new fire-fighting technologies to decrease environmental damage. Thus quick, effective, and favorable fire extinguishing material consumption are important.

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[4] Földi–Padányi 2021.

More and more research deals with fire-fighting activities, studies were published about new fire-fighting and fire extinguishing materials, techniques, and the experiences of intervention tactics. Aircraft engines were applied, during which operation exhaust gas was used for fire-fighting. Along with fire-fighting methods using different chemicals,[5] water, which is the longest used and most environmentally friendly, has started to come to the fore again. Researchers have perfected several extinguisher devices based on the unique usage of water and water-mist production. Such devices are turbo reactive fire extinguishers, in the development of which Hungarian engineers acquired imprescriptible merit. The application of aircraft engines for fire-fighting, using the exhaust gas as inert gas coming from the engine to be fire extinguishing material was realised by Kornél Szilvay – firefighter colonel, mechanical engineer and inventor. In the description of Szilvay's patented dry extinguisher machine, an aircraft engine producing exhaust gas used as fire extinguisher is present. This device first cools down then compresses the exhaust gas to a proper pressure level. During fire-fighting, compressed gas transports powder from a reservoir and blows it into the fire. Szilvay, after whom this dry extinguisher was named, patented[6] it in the USA and in Germany in 1924. His results ensured a proper base for further developments in fire-fighting techniques with exhaust gas. Several studies have dealt with the domestic developments of fire-fighting devices that apply aircraft engines and examined their practical implementation possibilities.[7] In this article, we represent foreign developments and examine the structure, design, and application options of devices.

International development directions

Using aircraft engines in fire-fighting was dealt with internationally, inside the so-called *Comecon* countries, besides Hungary, in the Soviet Union. In the 1960s, experiments were conducted on jet engines to be applied for fire-fighting purposes.[8] Researchers and experts from Novosibirsk were striving to create a device that is capable of extinguishing the ray-type fires of petroleum and natural gas wells. The aircraft jet engine was built on a lorry, thus it was mobilised. This fire extinguisher was created so that MIG–15 fighter aircraft provided the Klimow VK–107 type centrifugal compressor jet engine, and it was mounted on a Zil–157 off-road lorry. Hungary received two pieces of that vehicle for experimental purposes. Originally, the device only produced gas jets, and the introduction of water jets was a Hungarian development.[9] Figure 1 represents the extinguisher device with the mounted water-jet pipes (marked with red).

[5] Nagy 2023.
[6] Hadnagy 2008.
[7] Kuti 2023.
[8] Демидов 1976.
[9] Biczó 1977.

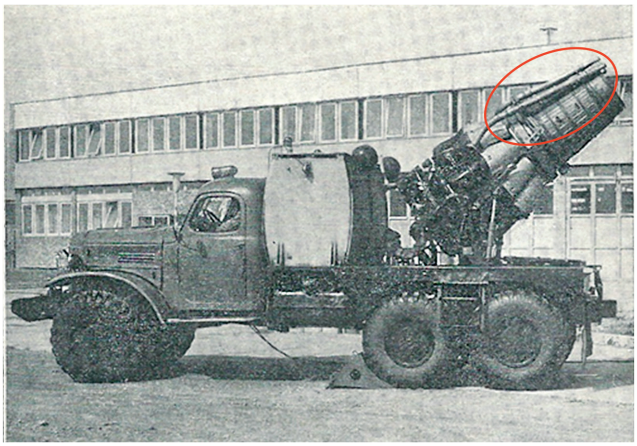

Figure 1: Aircraft engine mounted on a Zil–157 vehicle
Source: KUTI 2009

Soviet developments, which went on in the socialist era, only covered those devices that were appropriate for the extinguishing of hydrocarbon fires occurring during mining; apart from some special applications, pictures from the previously mentioned ones are not available. After the fall of the Soviet Union, Russia had already manufactured fire-fighting devices, which were represented in Germany at the Intersutz exhibition. Figure 2 represents a tracked turbo-reactive extinguisher from 2010.

Figure 2: Turbo-reactive extinguisher manufactured by Russian Pozhtechnika
Source: BLAULICHT 2010

It is visible from the picture that the device itself is mounted on the chassis of a tracked rotary lift and a Klimow type engine is used. Two water jets are driven in the outlet extinguishers on each side. Besides Hungary, experiments were conducted in the socialist era also in the German Democratic Republic (GDR), regarding the development of turbo-reactive extinguishers and their possible applications. The engineers of GDR started to design a device in 1982, which was produced in 1984.[10] The self-manufactured IFA W–50 L/LA all-wheel drive truck was chosen as a carrier vehicle, a type that is made to carry a crane with a specially designed bogie. A Klimow WK–1 type jet was built on it from a MIG–17 Soviet fighter. The device got AGLF[11] as its name. Its unique design made it possible to create horizontally 80–100 and vertically 30–35 metres long extinguisher jets. In the outlet, two ray tubes are fixed through which 3000 litres of water per minute could be shot in ray flow from external water source. Extinguisher range is 0–180° horizontally and 75° vertically. Two pieces were produced from this vehicle, which were in service in the power plant of Vattenfall Europe Mining AG Schwarze Pumpe in Germany, Spremberg,[12] until 1993. These devices can be seen in Figure 3.

Figure 3: IFA AGLF
Source: Biemer 2008

The extinguishers were successfully deployed in several fire cases; thus, they were updated in 1993. In order to have more excellent operational safety and better deployment, changes were made in the jet engine as well. As a result, the ray distance increased to 150 metres. Operators were modified, and a separate cab was mounted on the chassis. Carrier vehicles were changed to MAN brand, thus, reliability and movement speed increased. These vehicles were effectively applied several times in fire cases involving technological devices at the power plant.[13] These extinguishers are deployable till nowadays, they are presented in Figure 4.

[10] Gihl 2000.
[11] AGLF, Abgaslöschfahrzeug, vehicle with exhaust gas extinguisher.
[12] Kuti 2009.
[13] Schneider 2006.

Figure 4: MAN AGLF
Source: Heizler 1997

Following the BIG WIND turbo-reactive extinguisher made in Hungary, engineers from GDR started to design a track vehicle on which an extinguisher was mounted with greater power output at the end of the 1980's, regarding the soviet technique. The device was actually not built due to the fall of GDR, but its plans remained. Following the great success of the Hungarian explosion-prevention unit managed to put out fires in Kuwait between 1991 and 1993, the tracked turbo-reactive extinguisher was built in the already-unified Germany, from which only one was made, and it is still recorded as operable and can be found in the German Fire Fighting Museum, Fulda. A T–55 combat tank was used as chassis on which a tower rotator on a manipulator arm, an R–13–300 type Soviet-made MIG–21 MF supersonic fighter aircraft engine was mounted. The device was called "Hurricane", and several successful practices were conducted with it, but real operation was not done. This device is presented in Figure 5.

Figure 5: Hurricane AGLF
Forrás: https://dfm-fulda.de

Further development was conducted by Zikun corporation in Germany, and in one of the world's biggest chemical plant, in BASF[14] in Ludwigshafen, by the plant institutional fire brigade, the newest developed turbo-reactive extinguisher was applied in 1996.[15] Since the device created water-mist aerosol, it was named ALF.[16] It was invented to extinguish fires occurring in the chemical industry exactly. On a MAN three-axle, specially designed carrier, 2 pieces of Turbumeca Larzac 04 jet engines were mounted. Engines were operable and controllable independently from each other. Turbines drove two water jets by engines in ray flow, and the summarised water consumption was 6000 litres/minute, so 3000 litre/minute by turbines. The available maximum jet distance was 120 metres, and the maximum width of the extinguisher jet was 40 metres. Water jets were driven through special jet pipes before they were driven into deflection jets. The water jet figure, therefore, could be modified. Its role in water-mist creation, thus its efficiency in extinguishing, became obvious.[17] Regarding closed and opened space interventions, several experiments were conducted in the enormous factory of Ludwigshafen by Germans before the device was applied. For instance, leak fires, warehouse fires and fires of technological devices were put out, and reservoirs were cooled down. It is remarkable that a liquid fire with a 270 m^2 surface was put out. The device can be seen in Figure 6 on standby and during operation.

Figure 6: Turbo-reactive extinguisher applied in 1996 by BASF
Forrás: BASF 2023

In 2005, a newer, so-called second-generation turbo-reactive extinguisher was systematised. A Mercedes Actros with three axles is the carrier vehicle, jet engines are the same type as in case of the previous one. The device is presented below, on the right-hand side during operation.

Considering the experiences of these devices during intervention and operation, Zikun Corporation made continuous developments about extinguishers. In the third generation of devices, a high-performance water pump was built in the carrier vehicle, thus, their ability to intervene is quicker, and their service is simpler. Higher-performance water jet pipes were

[14] BASF – Badische Anilin und Soda Fabrik.
[15] Heizler 1997.
[16] ALF: Aerosollöschfahrzeug, firefighter with aerosol.
[17] Gihl 2000.

built in; as a consequence, water consumption increased to 8,000 litre/minute, so 4,000 litre/minute by engines. These devices also got ALF as their name. Due to developments usage, application possibilities have expanded besides the so-called classic fire-fighting tasks. These are capable of extinguishing burning reservoirs, safety digs, cooling neighbouring reservoirs, bathing dangerous compounds entering the environment, putting out technological devices, cooling them down, extinguishing closed space, tunnel fires, cooling down built infrastructure, and also can be used as a pressurised ventilation system. Different possible applications are represented in Figure 8.

Figure 7: Turbo-reactive extinguisher applied in 2005 by BASF

Forrás: www.basf.com/global/de/who-we-are/organization/locations/europe/german-sites/ludwigshafen/neighbor-basf/environment-and-safety/fire-department/about_us/fleet.html

Figure 8: Application possibilities of turbo-reactive extinguishers

Forrás: Zikun 2010

Multiple practical application opportunities increased extinguishing efficiency further, also, due to continuous interest, the fourth generation of the devices is developed, which are assembled with a foam generator system besides a water pump and an extinguisher reservoir; these are produced by Zikun corporation. The built-in extinguisher reservoir and pumping system shortened the installation time; thus, fire-fighting tasks could have been started earlier. In industrial plants, until the intake is assembled, the extinguisher carried by the vehicle is perfect enough. The devices are continuously produced and applied in several chemical plants and industrial parks all over the world. Most of the time, MAN and Mercedes brands are chosen to be carriers, but in Belgium, Volvo chassis was used. In the US it was similarly a Mack chassis that served as a firefighter vehicle.[18] In our western neighbourhood in Austria, institutional fire brigades in the Industrial Park of Schwechat received a fourth-generation Zikun turbo-reactive extinguisher in 2012, and this can be seen in Figure 9.

Figure 9: ALF applied in the Industrial Park of Schwechat
Forrás: www.btf-ipsw.at/loeschfahrzeuge.html

The fifth generation of turbo-reactive extinguishers is manufactured by the German Dicosy corporation. The fire-fighting device is the Turbo Hydro Jet Box (THJBoy), which is liftable from the structure of the carrier vehicle. One of its novelties is that the engine is operable with Diesel, which is less flammable than kerosene. The device, which was exhibited in Germany at the Interschutz Exhibition in 2015, can be seen in Figure 10.

[18] Zikun 2010.

Figure 10: THJ 4000 during operation
Forrás: Ruhdorf et al. 2021

The lifted extinguisher can be operated at 210° horizontally and between –10 and +60° vertically. Its water consumption is 4,000 litres per minute. Water pumps and a foam generator supply are built into the structure. The length of the extinguisher jet is 120 metres horizontally and 90 metres vertically. This device is used by the company Evonik on the site of Reinfeld.

Conclusion

We derived conclusions that fire-fighting devices using aircraft engines are further developed by foreign engineers based on the results and practical experiences of the Hungarians, and technology as well, thus, they designed better devices capable of putting out industrial fires and carrying out special tasks. One of the Hungarian results, which was taken into consideration by foreign researchers during the development of turbo-reactive extinguishers, was the inlet of extinguishing water into the gas flow, practically the application of dual flow method to create water-mist, which on the one hand cools down the exhaust gas coming from the jet engine and the environment of the fire as well. Another Hungarian development was the application of two jet engines on one platform, which made it possible to extinguish great-extent fires. German developers considered both Hungarian results as base, and they continued their work. The inlet of extinguishing water to gas flow was realised with the help of jet pipes, whose consequence was that the jet figure and size of water drops could be changed in order to increase the efficiency of extinguishing. The significance of unique jet pipe applications is that during their usage, the created water mist can perform more extinguishing effects at one time at optimal conditions. To increase the deployment efficiency and mobility of new generation turbo-reactive extinguishers, which were mentioned in our article, developers apply rubber-made tires instead of continuous track as carriers. Along with the two jet-engine structures, which enable combined fire-fighting and the application of the flame liftoff method,

the jet engine mounted on a liftable platform appeared as further development, and this also widened the usage opportunities. Available literature resources and deployment experiences were investigated; thus, it can be stated that the presented devices are quickly deployable as a result of the extinguisher reservoir built into the carrier vehicle. Until the inlet is not assembled, the extinguisher is enough, consequently, deployment time is shorter, resulting in decreased damages caused by fires. It can be stated that due to continuous developments, not only the efficiency, but also the the maximum of their extinguishing performance are increased, and their extinguisher consumption became more optimal. We concluded that during the operation of turbo-reactive extinguishers, water-mist production is achievable with measurably less extinguishing water, fire-fighting is still effective, and fewer damages are caused to the environment.

Summary

As a summary, it can be stated that due to foreign developments, turbo-reactive extinguisher devices are capable of choking oil well explosions, putting out different industrial fires, also dumping poisonous gases, intensive cooling with water mist, and working as positive pressure pumps. In our article, we presented how turbo-reactive fire-fighting devices went through continuous, practical, experience-based developments and what developments are in progress. Regarding their industrial use, it can be stated that future developments will ensure increasing combined extinguishing abilities and extinguishing efficiency. An important task is to decrease the installation time of devices, thus extinguishing may begin earlier.

The range of uses expands, and their fire-fighting efficiency continuously increases, resulting in more environmentally friendly fire-fighting. Nowadays, it is exceptional that aircraft engines are used in a wide range of industrial areas; moreover, Hungarian research and developments have served as a strong base for successful practical application.

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