Mine-clearing System for Use in International Peacekeeping

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OVERVIEW: The laying of landmines during the wars and civil conflicts of the 20th century has left somewhere between 60 and 110 million of these devices buried in the ground in different parts of the world (according to figures from a FY1998 U.S. Department of State report), and even now they result in injuries to around 20,000 people each year. It was against this background that Yamanashi Hitachi Construction Machinery Co., Ltd. established a project team to contribute to international peace through humanitarian aid, and in 1995 set about developing demining equipment based on functions from hydraulic excavators. This development got underway in earnest after the Japanese government signed the Ottawa Treaty in 1997. Currently 86 machines are being used for landmine clearance in nine different countries (as of April 2012), and Hitachi is actively working to develop and supply demining equipment that is even more efficient and easy to use. To supply equipment to the Japan Ministry of Defense for use in international aid, Hitachi, Ltd. has also used demining equipment as a base for developing a landmine clearance machine with a remote control function that can withstand anti-tank mines. A prototype was delivered in 2010.

INTRODUCTION

WITH the aim of contributing to the international community, Hitachi's demining business supplies an anti-personnel landmine removal machine that commenced development at Yamanashi Hitachi Construction Machinery Co., Ltd. in 1995.

When the situation in the Kingdom of Cambodia was discussed with staff from the Cambodian Mine Action Centre (CMAC), which is supported by the United Nations agency and the Cambodian government to undertake landmine clearance, they reported that the biggest problem was the clearance of reeds, bamboo, and other brush, and that this took up 70% of the time spent on landmine clearance. In response, Hitachi embarked on the development of a combined brush clearance and anti-personnel landmine removal machine that would be capable of dealing efficiently with this type of vegetation.

Although anti-personnel landmine removal machines were still subject to export controls at that time, Hitachi decided on humanitarian grounds to start the development anyway. Subsequently, development was spurred on by the Japanese government signing the Ottawa Treaty (officially known as the Convention on the Prohibition of the Use, Stockpiling, Production and Transfer of Anti-Personnel Mines and on their Destruction) in 1997, followed by the exclusion of anti-personnel landmine removal and detection machines from the "Three Principles on Arms Exports."

This article describes a landmine removal machine that is intended to help promote international peace.

DIFFERENT TECHNIQUES DEPENDING ON MINEFIELD CONDITIONS

At the time development first started, approximately 54% of the world's minefields were in the Middle East or North Africa, 21% in Asia, 18% in Central Africa, and 5% in Central or South America.

Removal methods differ depending on circumstances in each region, including the soil type, how the mines have been laid, the types of mines, and the presence of other unexploded ordnance. Cambodia and other Southeast Asian nations have a high proportion of anti-personnel mines that can be difficult to locate because of the tendency for buried landmines to be carried to different positions during the rainy season. It is also common for minefields to be overgrown with grass or brush, which impedes the removal of anti-personnel mines. In contrast, while minefields in places like the Middle East or North Africa commonly have little vegetation that needs to be cleared first, they often contain large numbers of anti-tank mines and unexploded ordnance. Mines can be broadly divided into anti-tank mines (containing 6 to 10 kg of explosive) designed to damage tanks,

Fig. 1—Swing Type Anti-personnel Landmine Removal Machine Able to Deal with Brush Efficiently Using Rotary Cutter.
The rotary cutter is used to clear the brush to make the landmines easier to find. The unit can swing backwards and forwards to follow the lie of the land and perform clearance work even on sloped or other uneven terrain.

and anti-personnel mines (containing 50 to 250 g of explosive) designed to injure human beings. Some minefields also contain unexploded ordnance.

Amid all these different considerations, the major issue was the development of a cutter able to deal with the brush that grows on Southeast Asian minefields.

PRODUCT DEVELOPMENT

The two types of anti-personnel landmine removal machines in current use are the swing type based on hydraulic excavators and the newly developed self-propelled push flail type based on past research and development. The removal methods are the rotary cutter type and the more explosion-resistant flail hammer type.

Swing Type Anti-personnel Landmine Removal Machine

In surveys of Cambodian minefields since 1995, what the people on the ground have requested has been machinery capable of efficiently clearing brush prior to mine removal, a task that consumes 70% of the time required for demining. Products on the market at that time included a Canadian-made brushcutter and locally produced grass cutters, but none had the capacity to cut the type of brush found in Cambodia. Hitachi decided that it needed to develop its own combined brush clearance and anti-personnel landmine removal machine to overcome this problem, and that it was also necessary to be able to clean up the brush after cutting. With operator safety and machine durability obviously being the overriding requirements, the first prototype anti-personnel landmine removal machine based on a hydraulic excavator was completed in 1998.

Minefields in Cambodia have reverted to jungle. In addition to the potential for landmine explosion, cutting and removing this jungle brush by hand also puts people at risk of poisonous snakes and mosquito-borne diseases such as malaria and dengue fever.

Rotary cutter machines are one solution to this problem. The cutters rotate at high speed to pull out brush by its roots, and these same cutters can be used to explode any mines in the soil. An advantage of swing type machines based on hydraulic excavators is that they can cope with the different terrains in which landmines are buried. In addition to the hill-climbing capabilities of a hydraulic excavator, the end of the arm can follow the topography in situations such as steep or rugged terrain with severe undulations. The machine can also be used for digging by changing the attachment at the end of the arm to a bucket, for example. A swing-type combined brush clearance and anti-personnel landmine removal machine was supplied in 2000 following explosion resistance testing in Cambodia that confirmed the safety and explosion resistance of the cab, the durability and explosion resistance of the rotary cutter, and the blade strength. This machine is still in active service (see Fig. 1).

Flail Hammer Type Demining Equipment

The way landmines are buried in minefields varies widely, and these fields often also contain unexploded ordnance and anti-tank mines. Because of the risk of encountering these, it is essential that equipment development place a priority on maintaining the safety of the operator and machine. With the aim of developing demining equipment with better explosion resistance, and with support from the New Energy and Industrial Technology Development Organization (NEDO), Hitachi started developing flail hammer type demining equipment in 2002 based on research and development conducted between 1995 and 2000. Unlike rotary cutter machines, flail hammer type demining equipment has a slimmer rotating shaft and works by rotating a chain with a hammer (weight) on the end at high speed to destroy the mines by blowing them up. The machines are more blast resistant because of the large number of gaps in the rotating flail.

This problematic explosion resistance testing was conducted in cooperation with the Japan Ministry of Defense. Hitachi also participated in practical trials in places such as the Islamic Republic of Afghanistan and

Fig. 2—Explosion Resistance Testing in the Islamic Republic of Afghanistan.
Stringent explosion resistance testing is conducted, with the safety of the operator having top priority.

Cambodia in cooperation with the Ministry of Foreign Affairs of Japan prior to the machine entering practical use in February 2007 (see Fig. 2). It is currently used in Cambodia and the Republic of Angola.

In 2006, Hitachi started developing new demining equipment that will be better suited to clearing flat land. Equipped with a flail hammer at the front that covers a width of 3 m (twice that of the previous machine), the machine uses chains with 90 hammers attached to pummel the surface of the ground, and moves forward under its own power detonating mines as it goes. It is also fitted with nine large rippers at the rear of the machine that can plow the soil and help restore it to agricultural use. The machine provides an efficient way to clearing landmines with a capability of 1,700 m^2 per hour, which is more than 100 times faster than using manual labor.

The main features of the machine are as follows (see Fig. 3 and Fig. 4).

(1) Level plates (which function like sleds) fitted to the bottom of both flail hammer units provide an automatic control mechanism that can adjust the flail depth based on the terrain and detonates anti-personnel mines by reacting to uneven ground and keeping the excavation depth constant.

(2) Rippers are fitted to the rear of the machine to help rehabilitate the land for agricultural use.

(3) The cab is located at the rear of the machine to improve safety. Use of a slide type elevated cab also improves visibility.

(4) The shape and material of the hammers and chains were developed through repeated testing. To reduce maintenance costs, they are designed to allow refurbishment by local technicians.

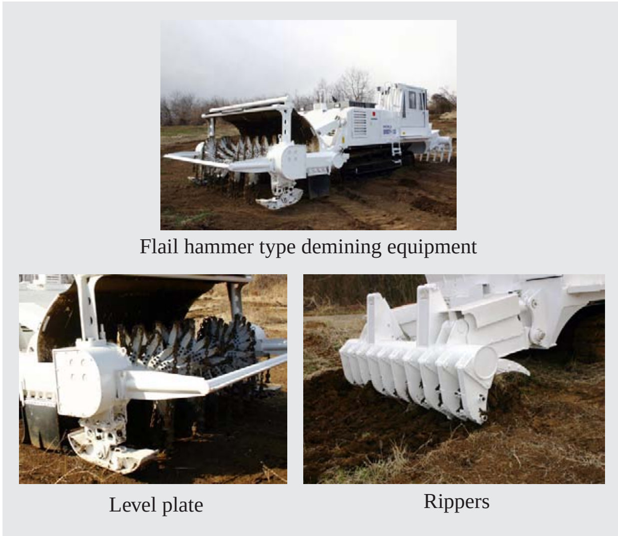

Fig. 3—Flail Hammer Type Demining Equipment.
After landmines are cleared by the highly explosion-resistant flail hammer fitted to the front of the machine, the soil is plowed by rippers fitted to the rear to help restore it to agricultural use.

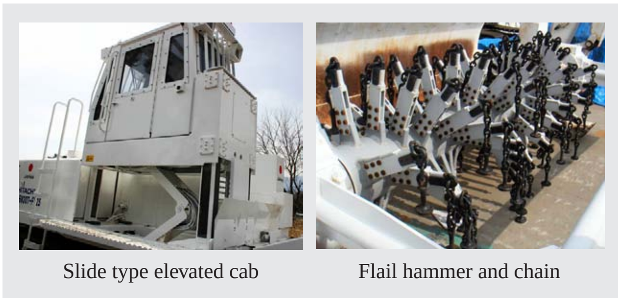

Fig. 4—Slide Type Elevated Cab, and Hammer and Chain.
The cab is located at the rear of the machine for safety, and the hammers and chains are designed to allow refurbishment by local technicians to repair any wear or damage.

LANDMINE CLEARANCE MACHINE BUILT USING TECHNOLOGY FROM DEMINING EQUIPMENT

In 2010, Hitachi, Ltd. supplied a prototype landmine clearance machine that used the rotary cutter and flail hammer technology from the swing type anti-personnel landmine removal machine based on a hydraulic excavator. The main features of the machine are as follows (see Fig. 5).

(1) The attachment mechanism allows the machine to swap between the rotary cutter, flail hammer, and landmine detector. This means that the same machine can perform each of the steps required for landmine removal, with the rotary cutter used to clear and pile up the brush, the landmine detector used to detect landmines and unexploded ordnance, and the flail hammer used to clear the landmines.

Flail hammer

Landmine detector

Rotary cutter

Photo courtesy of Japan Ministry of Defense

Fig. 5—Prototype Landmine Clearance Machines.
The attachment mechanism allows the machine to swap between the rotary cutter, flail hammer, and landmine detector.

(2) By using different materials and thicker plate to improve its strength, the machine has been made capable of withstanding anti-tank landmines as well as anti-personnel landmines.

(3) For safety, a remote control function has been provided to allow work to proceed without an operator on-board. In this case, a camera is fitted in the cab where the operator's head would be and the images from this camera are used to operate the landmine clearance machine and perform landmine detection and removal work remotely. A camera is also fitted on the rear to check the safety of the area behind the machine.
(4) The machine is designed to allow disassembly so that it can be shipped by air as well as by land or sea.

CONCLUSIONS

This article has described a landmine removal machine that is intended to help promote international peace.

Landmine clearing does not end when the mines are removed from the minefield. The actual benefits are realized when the land from which the mines have been removed is reused for a school or farm, for example, so that the local people can become more independent and self-reliant. In the Republic of Nicaragua, land from which mines had been cleared is now used to grow oranges, producing 600,000 cases a year and about 1.5 million dollars in exports. Other crops included coffee and highland vegetables.

In Cambodia, two schools have been built on former minefields to provide the infrastructure for children's education. Working through a non-profit organization, "Good Earth Japan," Hitachi is also actively participating in measures that support self-reliance, including providing local people with agricultural education, the construction of wells and reservoirs, and the provision of roads. For safe and secure communities, Hitachi's aim is to contribute to international peace by restoring land to peace and prosperity so that children can play barefoot.

REFERENCES

(1) K. Amemiya, "Development of Demining Equipment for the International Contribution," Hitachi Hyoron **89**, pp. 208–214 (Feb. 2007) in Japanese.
(2) K. Amemiya, "Landmine Clearance," Shogakko Jiho (Mar. 2009) in Japanese.
(3) K. Amemiya et al., "Contributing to the International Community through Monozukuri," Hitachi Review **62**, pp. 142–146 (Mar. 2013).
(4) "Hitachi Demining Machine," TIERRA+ **102**, pp. 16–17, Hitachi Construction Machinery (Oct. 2011) in Japanese.
(5) Hitachi Construction Machinery Co., Ltd., "Activities for Demining," http://www.hitachi-c-m.com/global/company/csr/contribution/mine/index.html

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