60 Years of the First in the World Mobile Machine for Flash-Butt Welding of Rails in the Field Conditions

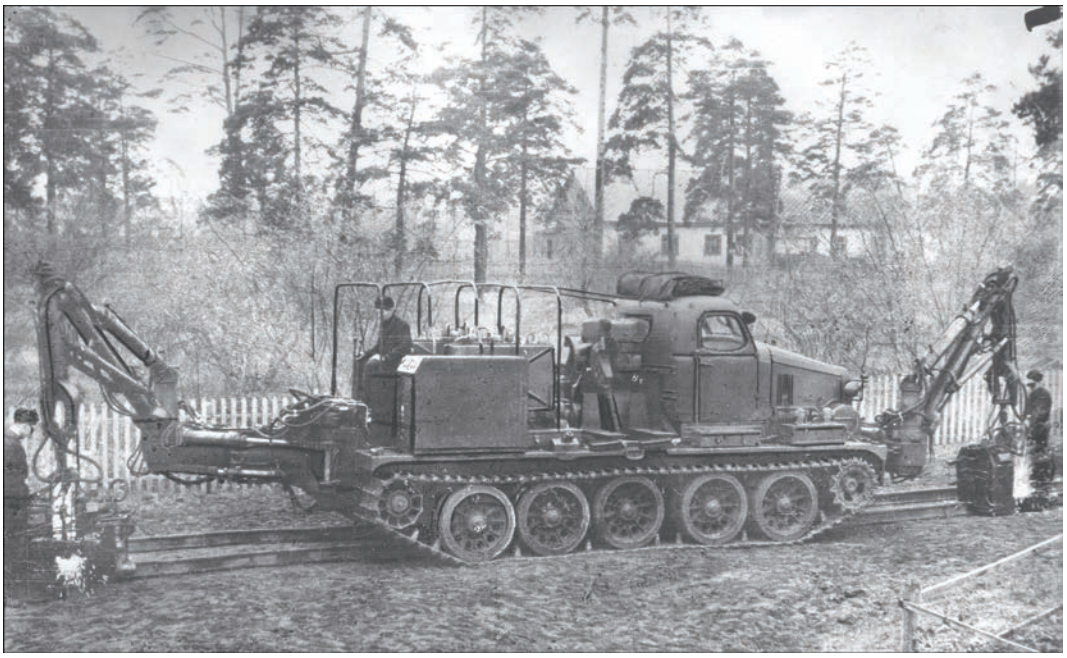
In the post-war years the tens of thousands of kilometers of railway tracks, damaged by war and quite unsuitable for any traffic on them, were available at the most part of the former USSR territory. The situation was redoubled also by the absence of production of new rails at that period. The way out of the situation was the only one: to start the restoration of railway tracks by using the remained undamaged rails to recommence the delivery of necessary cargoes along them. Moreover, even at this stage of reconstruction the task was to pass to the most progressive technology, namely to provide the continuous track (without double-sided cover plates), which will allow developing high speeds of traffic and being more reliable in maintenance.

The primary task was the searching for a reliable permanent joining of rail ends. Methods of welding, thermit and electric arc ones, known at those years, were characterized by a very low efficiency (1–2 butt joints per hour), and required to use a large amount of welding consumables and highly-qualified operators. At the same time the noted methods of welding did not provide the mechanical properties of joints, meeting high requirements to the continuous track joints (close to properties of the rail base metal).

Such requirements were satisfied by the flash-butt welding of rails, which was used at the factories abroad, equipped by stationary rail-welding machines. Using these machines the rail sections of 200–400 m length were welded in them and transported to the laying sites by special trains. Such machines consumed power of 400–500 kV·A, and their mass exceeded 200 tons. This circumstance allowed their application only in specialized rail welding shops, having the sufficient power supply (600–800 kV·A). The construction of similar enterprises at the USSR territory at that time was not possible.

In the middle of the 1950s the governmental task was put forward to the Electric Welding Institute: to design equipment for flash-butt welding of rails directly in operating track at its reconstruction and repair. Moreover, the welding process should be realized completely in the automatic mode and with account for minimized requirements to accuracy of cutting the rail ends as compared to the requirements under the factory shop conditions. The latter was specified by the fact that it is difficult to use the equipment for high-accuracy treatment of rail ends in the field conditions.

The development of the new technology and equipment for rail welding in the field conditions was carried out at the Electric Welding Institute integrally. Together with searching for welding technology, providing the required quality



Mobile complex K355 during tests at Kiev rail road tracks (1960)

Mobile rail welding complex on railway platform

of joints at a minimum power consumption, the control systems, providing its stable reproduction, independently of changing the service conditions, as well as equipment, having much less weight and dimensions, were developed. It was assumed to apply the equipment being designed as a tool, mounted on the rails being welded. It was found, that the significant decrease in welding process power, consumed in flash-butt welding of rails, can be achieved when using the power for welding with a continuous flashing for basic heating instead of used heating by resistance in stationary machines of the shops. Exciting by the continuous flashing at low specific powers became possible due to applying the controllers of flashing rate and high reduction (by 2–3 times) in resistance of welding circuit of the machines.

To produce the required heating in welding, a programmed reduction of voltage during flashing was suggested for the first time. Such technology, named as the continuous flashing with a programmed reduction in voltage, was used as a basis for the development of modes for welding of different rail types. For all the mentioned innovations, the International patents were obtained in the leading countries of the world. With their application, the first in the world mobile welding machine K355 was designed for continuous flash-butt welding of rails in the field conditions. It was characterized by a low weight (2.3 tons), allowed its application for mounting on rails using standard hoisting mechanisms. The welding machine power was 150 kW, it was enough to use the standard diesel-generating electric stations of 200 kV·A for its power supply. The first rail welding machines were mounted on all-terrain vehicles of a high trafficability, equipped with the hydraulic jacks and used in excavators. The electric supply of two welding machines, operating simultaneously, was realized from

generator, connected with a shaft of power take-off of all-terrain vehicle. Several tens of such mobile welding complexes were successfully used for restoration of railway tracks in hard-to-reach regions of the former USSR railroads.

During restoration of the railroads the main volume of welding works was connected with their reconstruction and laying of new sections of rails with sleepers. For these purposes, the mobile complexes were developed on the base of self-propelled railway platforms (PRSM) with a gantry hoisting devices. To increase the efficiency, the simultaneous welding of two butt welds by separate machines was provided.

In 1960, in accordance with documentation, worked out at the PWI, the Kakhovka plant of electric welding equipment (KPEWE) started production of the machine K355. By the middle of the 1960s about hundreds of such machines were in service in the USSR. Their design was continuously improved with account for needs of consumers. Since the middle of the 1970s the export of such machines to different countries of world started. They were bought by the USA, Great Britain, Austria, China and other countries. In total, from the data of KPEWE, 80 % of the world park of mobile welding machines is the machines, manufactured in Ukraine.

At the modern stage, the development of the new types of welding machines at PWI is continued. This is caused by the tendency of applying the high-strength rails of a new generation at the railway tracks.

In the recent decade the developments in the direction of updating the equipment for welding rails in the field conditions are continued. Here, the real tasks are taken into consideration for applying these machines in different regions of the world.

The application of the new technology of welding of high-strength rails, combined with their tension, required the creation of new generations of rail welding machines, characterized by much higher upsetting forces, equipped with built-in mechanisms for removal of weld reinforcement in a hot state. The above-given peculiarities of the new technology of welding of high-strength rails and systems of multifactorial control were used as a basis for the design of a new generation of mobile rail welding machines. Modern systems of computing technology, quick-response hydraulic drives and powerful systems of electron control of welding parameters are used in them. Such machines allow performing welding of long-length rail sections, combined with their tension.

The first machine K921 for welding rails by a pulsating flashing with tension was designed at the PWI in 2001 and manufactured by KPEWE in cooperation with the Norfolk Southern Company (USA). Its implementation and final testing of the technology of rail welding were carried out with the PWI participation on rail roads, which belong to this Company. For the first time in the world practice the flash-butt welding of rail sections of an infinite length, being up to several hundreds of kilometers without bolted joints, was performed. From the available data the total length of continuous tracks of infinite length, welded by the Company, exceeds 10 thou km.

In 2001–2005 the machines of K920 and K922 types of two modifications were designed. The parameters of these machines (forces of upsetting and clamping, machine dimensions) were optimized with account for applied technologies of repair and construction and available mobile rail welding complexes. In particular, it was possible to decrease greatly (by 1.5 times) the weight and dimensions of the machines as compared to the first experimental-industrial model K921.

In 2010–2012, according to the license agreement with Holland Company (USA) the PWI designed machines K930 and K945, which have an enlarged travel of movable clamp of up to 450 m at upsetting force of 120 tons. This allows welding of long rail sections of large length in reconstruction of railway tracks. The mobile complexes for operation with such machines were designed, respectively. Ten such complexes are operating since 2014 at the rail roads of Great Britain. They use the machines K945, designed at the PWI and manufactured at KPEWE.

The modern mobile rail welding complexes, manufactured by KPEWE, represent self-propelled units, which are provided with a rail travel or a combined travel, allowing moving both on rails, and also on high-way and earthen roads.

A qualitatively new level of mobile rail welding equipment was achieved as a result of the cooperation of PWI with the Progress Rail Services Corporation Company (USA). In 2014–2018, in accordance with the license agreement, the machines K960 and K1045 were designed and manufactured, which made it possible to significantly expand the fields of FBW application.

The machine K960 (upsetting force of 200 tons) is the most powerful among the production line of mobile machines for welding rails with tension, created by PWI and in present it is successfully operated in the reconstruction and repair of railways in the USA.

A unique arrangement of the suspended single-rod rail welding machine K1045 provided the ability to perform works in hard-to-reach places (in the underground, in welding rail endings of crossing pieces), which is a significant competitive advantage as compared to the known rail welding complexes.

On the mobile complexes, except the rail welding machines, the diesel-generator units of 200–300 kW capacity, hydraulic jacks, auxiliary equipment for rail preparation for welding, system of nondestructive testing are mounted. Mobile complexes of similar type, where machines K920, K922, K930, K950 are applied, are used at the rail roads of Europe, by Holland Company in the USA, Network Rail Company in Great Britain, in China, Australia, Taiwan, Malaysia, India, Turkey, Saudi Arabia and Thailand.

Prof. S.I. Kuchuk-Yatsenko