To the 80th anniversary of the Victory in the Great patriotic war

Production and consumption of the most important kinds of ammunition during the Great patriotic war (1941–1945)

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The provision of high-performance ammunition in the required quantity has played and is playing a key role in achieving victory in military conflicts. During the Great patriotic war, the industry of ammunition production was often called the «front line of the homefront», because «without ammunition, guns and rifles do not fire, mortars and katyushas are silent, ships, tanks, planes become unarmed and defenseless ...» [1, p. 3]. The successful suppression of the enemy, the capture of fortified positions, and the support of the advancing troops directly depended on the sufficiency of ammunition supplies. The article discusses some issues of the production and consumption of ammunition (primarily land artillery) at various stages of the Great patriotic war (1941–1945). Special attention is paid to the role of ferrous metallurgy, which supplied the main raw materials and semiproducts for the manufacture of blanks for shells and weapons. Extensive statistical data are provided. As an illustrative material, the article contains samples of visual products from the Great patriotic war (photographs, posters, postcards) related to the production of ammunition. During the war years, they symbolized the unity of the front and rear, recorded the process of hard work, and showed the importance of the contribution of each industry employee to the common victory.

Key words: the Great patriotic war, the Battle of Moscow, the Urals, the People's Commissariat of Ammunition, defense factories, shells, mines, «shell famine», rolled products, steel, steely cast iron.
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Ammunition is technical devices used for direct affecting on the aim during execution of a combat mission. Ammunition include artillery and mortar shots, grenades, reactive missiles, unguided drop and antisubmarine bombs, aviation cassettes, engineering and marine mines, engineering explosives, cartridges for small arms. In military science, the term "shot" means both the process of shell (mine, grenade, bullet) shooting out of gun bore of an artillery gun, mortar, grenade launcher, small arms and ammunition itself for shooting from an artillery gun (artillery shot), mortar (mortar shot), grenade launcher (grenade shot). Ammunition is classified according to its ranking to any military branch or component, method of its delivery to the aim, destination and technical-engineering features as well as to its ranking to armament complexes [2, pp. 4, 20].

I. I. Vernidub, the prominent specialist in the field of ammunition production and well-known researcher of this industry, has noted that "ammunition production is the most widely distributed and most metal-consuming, the most expensive and also most dangerous industrial branch of the military industry" [1, p. 3].

During the pre-war period, the USSR defense industry has developed with accelerated speed. Ammunition production also increased, the state order for ammunition enlarges every year. In January 1939, several specialized People's Commissariats were selected from the People's Commissariat of Defense Industry, i.e. the People's Commissariat of Ammunition (PCA). The main directions of PCA activity were devoted to manufacture of shells, drop bombs, explosives, primer caps, exploders, powders, shell cases for marine and overland artillery as well as mines.

Until the beginning of 1941, USSR produced almost all kinds of ammunition with high ballistic properties [3, p. 253]. Production of the main kinds of ammunition increased every month during 1939–1940. In 1940, more than 43 mln. pieces of artillery shells, mines and drop bombs were manufactured (830,000 t of ferrous metals were used for this production) [4, p. 284]. During the first six months of 1941, this production volume rose by 66.4 %, i.e. more than by 1.5 times. Nevertheless, the defense industry of ammunition could not reach the planned indicators from year to year. The rate of ammunition production was not satisfactory tot the country's leadership, because the potential enemies were ahead of the USSR substantially: Germany and Japan manufactured approximately 300 mln. artillery shells during the first war year [5, p. 217], while Germany produced 27 mln. artillery shells only of 75 mm caliber in 1940 [6, p. 387].

Since the beginning of the Great patriotic war, it was possible to meet the enormous requirements of the army in ammunition only based on the complete national industrial power, providing interaction of many industrial branches participating in the processes of ammunition production. However, 303 enterprises manufacturing ammunition were quit the ranks owing to occupation and evacuation from the frontline regions. The monthly production volume of these enterprises was 8,4 mln. shell cases, 2.7 mln. mine cases, 2 mln. drop bombs cases, i.e. over 13 mln. ammunition cases [4, p. 284; 7, p. 42]. The USSR territory occupied in

1941 provided 68 % of ironmaking, 58 % of steel making, 63 % of coal mining for metallurgical works (relating to the pre-war indicators) [7, p. 42].

Artillery remained the main remedy of fire damage of an enemy during battles, it was confirmed by the local war conflicts between world wars. In April 1940, Iosif Stalin, the General Secretary of the Central Committee of All-Union Communist Party of Bolsheviks (VKPb), spoke at the meeting of the Red Army commanders, which was dedicated to accumulation of the experience of military operations against Finland. He named artillery "a God of modern war" and repeated several times that it is artillery who is solving war fates at present time [8, p. 278]. In the meantime, ammunition reserves of the main artillery calibers were almost spent during the second part of 1941, while the industry was able to manufacture only 26 mln. artillery shells, what was only a half of the planned order approved by the State Defense Committee (GKO) [9, p. 293]. The hard state with production of artillery shell cases, which were the main carrying and/or destructing components of artillery shells, took place in the end of 1941 – beginning of 1942. Indeed, situation of sharp "shell hunger" occurred in the autumn 1941 in the conditions of wide range and high intensity of military operations. Red Army required enormous amount of ammunition and it was necessary to spend them in economic mode, according to the strict limits of consumption. The fronts which operated in the most important directions were supplied according to the following standards: four ammunition allowances, including two of them for battle consumption and other two – for minimum supply level. Nobody could use store reserves without permission of the Supreme High Command General Headquarters. Supplying the armies of Zapadny (Western), Reserve and Bryansky fronts in September and following months of 1941 was implemented according to the preset limits of consumption [10, p. 459].

Owing to the fact, that just in 1939 technological documentation for manufacturing shell cases in the conditions of civil non-specialized works has been developed, USSR industry succeeded in rather quick putting into practice production of shell cases at non-military enterprises [4, p. 276]. During the Moscow battle (30.09.1941 – 20.04.1942), shells and other required ammunition from the former civil works were supplied to the frontline directly from the Moscow municipal and regional plants (**Fig. 1**).

However, situation with ammunition supply in the Western front remained difficult. Defending period of the Moscow battle since the end of September to the beginning of December was its most hard stage. In October 1941, the resources were 5.5 ammunition allowances of artillery and mortar shots, while only 1.8 ammunition allowances were spent during this month. In November 1941, the Western front received ammunition less by 2.5 times in comparison with the front request to the Main Artillery Directorate. Totally 1,042 railway cars with ammunition were sent in October, while only 724 railway cars – in November.

As soon as consumption of ammunition was strictly limited, ammunition feed (2.1 ammunition allowances) was almost equal to its consumption (2.3 ammunition allowances).

Fig. 1. Participants of pre-October socialistic competition, the followers of Stakhanovism at one of the military works in Moscow: comrades Petrukhina, Zanegina, Vorobieva, Vasilieva *(from left to right) are working to supply the Red Army with the shells of excellent quality (picture made by S. N. Strunnikov, the press photographer of "Pravda" newspaper, 02.11.1941)*

Until the beginning of the counteroffensive of the Soviet troops near Moscow (December 6, 1941), they had from 1 to 2 ammunition allowances for 120 mm mines, 37 mm and 85 mm anti-aircraft, 76 mm division, 122 mm howitzer and cannon, and 152 mm howitzer-cannon shots, as well as from 2 to 4 shots of other calibers [10, pp. 461, 469]. At the height of this offensive near Moscow, consumption limits of artillery ammunition constituted often less than 10 shots for a cannon per day [11, p. 162].

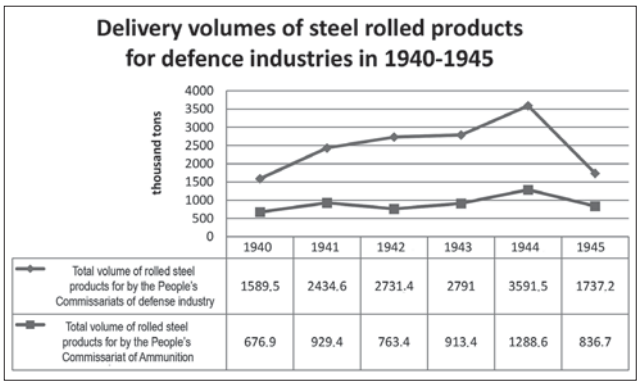
Just in this very difficult period, in the middle of February 1942, Boris Vannikov, one of the outstanding managers of the USSR defense industry, was appointed to head the People's Commissariat of Ammunition. Yuliy Khariton was acquainted with Boris Vannikov during their joint work for the nuclear project and characterized him as a brilliant engineer and excellent manager, who succeeded to transform this industrial branch in the industrial mechanism with smooth and uninterrupted operation.

Production of artillery shells was the most labour-intensive operation in ammunition manufacture, because they are complicated products consisting of non-ferrous metals, special allots and (first of all) high-strength steels. Rolled sections are considered as the main initial material for production of a billet for shell components and destruction means: cases, sectors, rotating bands, stabilizers, blades, cumulative cones [12, p. 7, 8].

The level of production of ferrous metals was the lowest in the second half of 1941 and in the first quarter of 1942, while enormous amount of cast iron, steel and rolled products were required. It was necessary to provide the most deep reconstruction in the iron and steel industry in the direction of military production (in comparison with other industrial branches). At the same time, the requirements for grade and dimension ranges of metals changed principally, in addition to essential increase of demand for amounts of manufacturing metal. Manufacture of special metal grades for military products required more time, than manufacture of

usual commercial metal products. And metallurgical works should completely and very quickly satisfy the demands of tank producers in armoured steel, organize manufacture of wide range of pipes for mortars, drop bombs, cases and motors of airplanes. Ferrous metals were required for manufacture of products, which were used as components for the most important assemblies of military machines, arms and ammunition – ropes, springs, steel band as well as shell and mine cases [13, pp. 254, 256]. An artillery shot means essential metal consumption. E.g., fragmentation and demolition shells with weight exceeding 6 kg and cumulative shells with weight about 4 kg were used for the 75 mm gun ZIS-3, which was the most widely distributed and efficient cannon during WW2. 160 mm mortar MT-13 threw a mine with weight 40 kg to the distance up to 5,100 m. Reactive shells M13 for legendary katyushas weighed 42 kg. High-power 203 mm howitzer B-4, named as "Stalin's hammer", used shells with weight 100 kg.

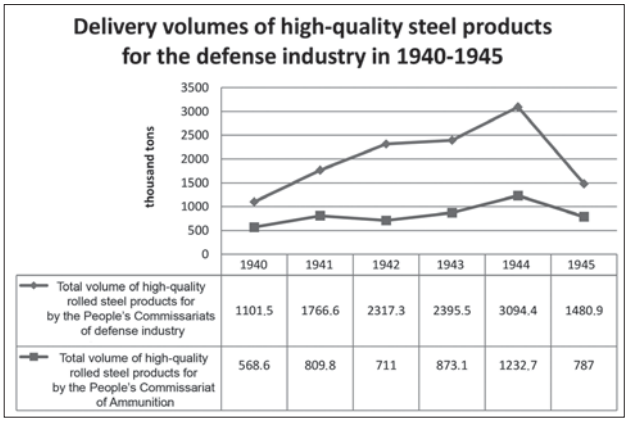
Rolled steel products were the base of military production. It was used by the People's Commissariats of Aircraft Industry, Ammunition, Armament, Tank Industry, Mortar Armament. The following diagrams, based on the official statistic data [14, pp. 46, 50], illustrate this metal consumption. Delivery volumes of rolled steel products to the People's Commissariat of Ammunition in comparison with total deliveries to all five defense People's Commissariats are presented in the following diagram.



	1940	1941	1942	1943	1944	1945
Total volume of rolled steel products for by the People's Commissariats of defense industry	1589.5	2434.6	2731.4	2791	3591.5	1737.2
Total volume of rolled steel products for by the People's Commissariat of Ammunition	676.9	929.4	763.4	913.4	1288.6	836.7

It was evident that continuous growth of deliveries of rolled steel products for defense industry was observed since the beginning of the war till 1944, while the People's Commissariat of Ammunition displayed significant reduction in 1942. At the same time, the People's Commissariat of Ammunition was one of the main consumers of rolled steel products. Its relative part in total consumption of rolled steel products varies as follows: 42.6 % (1940), 38.2 % (1941), 27.9 % (1942), 32.7 % (1943), 35.9 % (1944) and 48.1 % (1945). During 1942 and 1943, only the People's Commissariat of Tank Industry had larger consumption of metallurgical products: 38.8 % in 1942 and 34.5 % in 1943.

Dramatic increase of importance of high-quality rolled steel products was also observed during the war. Such products were used for manufacture of shell billets, armoured plates, flat bars for bimetals, steels for helmets. Delivery volumes of high-quality rolled steel products for the People's Commissariats of defense industry are compared in the following diagram.



	1940	1941	1942	1943	1944	1945
Total volume of high-quality rolled steel products for by the People's Commissariats of defense industry	1101.5	1766.6	2317.3	2395.5	3094.4	1480.9
Total volume of high-quality rolled steel products for by the People's Commissariat of Ammunition	568.6	809.8	711	873.1	1232.7	787

This graph is quite similar to the graph in the previous diagram. Reduction of deliveries in 1942 is also noted. However, the part of high-quality rolled steel products in deliveries to the People's Commissariat of Ammunition increased permanently from 84 % in pre-war 1940 to 95.8 % in 1944. This tendency changes only in 1945, when the part of high-quality rolled steel products slightly decrease by about 2 % in comparison with the 1944 indicator.

Especially significant growth of manufacture of high-quality rolled steel products was achieved in the works of the eastern regions: it was 66 % in 1944 in comparison with 26 % in 1940. Metallurgists in the Ural and Siberia regions manufactures high-quality rolled steel products more than the whole Soviet Union metallurgy during 1940 by 30 % [13, p. 252]. In the end of the war, each fifth shell was produced of Chelyabinsk steel. The new steel grades and additives increasing strength of materials, as well as titanium alloys were developed during the war years.

During the Great patriotic war, Ural transformed in the main metallurgical base of the USSR, the main supplier of steel grades and rolled products requires for the defense industry. Chelyabinsk plant No. 78 named after Sergo Ordzhonikidze (at present time "Stankomash") has started mass production of ammunition cases, including armour-piercing projectiles; only in 1944 in produced 2 mln. cases for ammunition of various kinds and calibers. Machine-building plant named after V. I. Lenin in Zlatoust (Chelyabinsk region) increased manufacture of shells for ground artillery in the 2nd part of 1941 by 3.8 times, while in the USSR in general this indicator made only 2.5 times. This plant mastered and manufactured during 1941–1944 42 kinds of shells, components for cumulative shells and shell cases; it produced more than 3.8 mln. of 45 mm armour-piercing projectiles, more than 4.2 mln. of 122 mm shells, more than 2.1 mln. of 45 mm sub-caliber shells, more than 1.0 mln. of 76 mm shells. The People's Commissariat of Ammunition awarded Kyshtym machine-building plant six times with the first place in the industry; this enterprise mastered production of shells and mines during tight timelines.

Each 33rd shell for the frontline was delivered from storehouses of Magnitogorsk Iron and Steel Works (Chelyabinsk region), where production of 45 mm and 76 mm artillery shells, bombs and mines was initially organized and dimension range of manufactured ammunition was dramatically

Fig. 2. Finished products of Chelyabinsk defense plant (picture made by I. N. Shagin, the press photographer of "Komsomolskaya Pravda" newspaper)

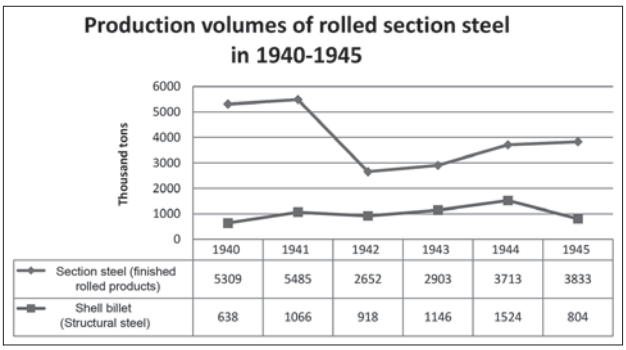
Fig. 3. Stored shells at Chelyabinsk defense plant (picture made by I. N. Shagin, the press photographer of "Komsomolskaya Pravda" newspaper)

increased till 1944. This enterprises started deliveries of reactive shells M-13, cumulative shells (able to pierce any tank armour), demolition bombs etc. to the frontline [15, p. 439] (**Fig. 2, 3**).

Metallurgical works named after A. K. Serov (at present time Nadezhdinsky metallurgical works) in Serov (Sverdlovsk region) was one of the few producers of cold-drawn steel. In 1944, it delivered 25 % of its production volume to the People's Commissariat of Ammunition, what exceeded the parts of the People's Commissariats of Ferrous Metallurgy (21 %), of Tank Industry (20 %), of Aircraft Industry (15 %) etc. [16, p. 131]. The plant No. 72 in the small Ural town Verkhnyaya Tura (Sverdlovsk region) manufactured more than 600,000 shells in 1941 (outstripping the targeted annual plan by 143 %) and more than1.3 mln. shells and mines in 1943. The monthly program of this plant was about 70,000 of 152 mm fragmentation and demolition shells and more than 120,000 of 76 mm shell cases. As for cases for 82 mm mines, their daily production reached 6,000 pieces [17].

Production of ammunition became also a key direction in operation of the defense works in the Eastern Siberia; practically all plants and workshops were included in this process (except specialized ones). Thus, the plant No. 863 of the People's Commissariat of Forest in Krasnoyarsk manufactures cases for 122 mm shells. Production volume of this plant in the end of 1942 increased this indicator of pre-war period almost by six times. The target plan to manufacture 240,000 cases for 122 mm shells was outstripped by 133.4 % [18, p. 51].

The following diagram illustrates the quantitative parameters of manufacture of section steel products in the shape and dimension range of rolled steel, including steel products used for production of ammunition. So, in 1941 one fifth of manufactured domestic section steel was used for production of shell billets. In 1942 this indicator was already one third, taking into account that production of shell billets was in this year smaller than in 1941 only by 14 % despite total collapse in rolled section steel production (more than by two times). The pre-war level of rolled section steel production was not achieved, however, the part of shell billet exceeded the level of 1940 by 2.4 times and constituted about 40 % of total domestic production of rolled steel sections.



	1940	1941	1942	1943	1944	1945
Section steel (finished rolled products)	5309	5485	2652	2903	3713	3833
Shell billet (Structural steel)	638	1066	918	1146	1524	804

The breakthrough in operation of the ammunition industry started in 1942 and was fixed in the following 1943. Totally 1.838 mln. tons of ferrous metals was directed for ammunition production in 1942, while in 1943 this indicators grew to 2.437 mln. tons [7, p. 80]. As a result of increase of this production volume, the Red Army has got ammunition more by 18 % that was spared during the same period [4, p. 296]. In the beginning of 1944, the Soviet defense industry could provide uninterrupted supply of the fighting armies. The dynamics of ammunition production growth, including artillery shells, is reflecting in the **Tables 1** and **2** and in the following diagram.

The data of the Table 1 can be considered as lowered, because they include just not all positions, in particular small caliber shots (25, 27, 45 and 57 mm) for ground and marine artillery etc.

Growth of steel production became possible owing to putting into practice evacuated and newly built plants, locating of ammunition production facilities at civil works, attracting additional material resources and labour resources (**Fig. 4**).

Comprehensive improvement of technological processes, putting the most efficient technologies into operation, optimization of production management are considered as the main reserves for further increase of manufacturing these products [9, p. 307].

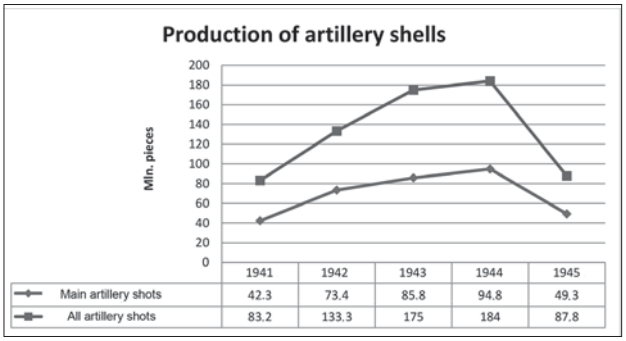
During pre-war period, high-strength steel cases could be manufactured mainly only at several specialized enterprises with high-productive presses and other equipment for complicated heat treatment. In 1930-ies the scientists tried to find out the ways to replace expensive high-quality steel

Table 1. Ammunition production in the USSR during the Great patriotic war (mln. pieces) [19, p. 11]					
Kind of ammunition	1941	1942	1943	1944	1945
Artillery shots	**42.3**	**73.4**	**85.8**	**94.8**	**49.3**
Mortar shots	24.9	53.9	75.7	78.6	35.2
Drop bombs	16.0	8.1	10.3	10.4	3.7
Reactive shells	0.81	3.9	3.9	4.0	1.7

Table 2. Production of artillery shells in the USSR during the Great patriotic war (mln. pieces) [20, p. 173]					
Quarters / Years	1941	1942	1943	1944	1945
I quarter	11.5	19.0	37.0	44.5	46.4
II quarter	15.8	29.2	44.1	46.4	35.7
III quarter	29.7	41.0	46.5	47.3	5.7
IV quarter	26.2	44.1	47.4	45.8	–
Totally	83.2	133.3	175	184	87.8

Fig. 4. Female annealers G. Okhotnikova and E. Sharikova, members of All-Union Lenin Communist Youth League, at the N plant; they replaced men who went to fight (according to mobilization in February 1942 of the persons older than 16 to the defense industry) and executed the working tasks on 250–300 % (picture made by I. N. Shagin, the press photographer of "Komsomolskaya Pravda" newspaper, 07.10.1942)

with less deficient material in order to solve the problem of widely distributed and accelerated production of shell cases. As a result, steely cast iron was chosen as this material. Being not as strong as steel, it provided more killing shrapnel, though without any good demolition effect [21, pp. 128, 130]. When working with this alloy, productivity increased essentially and cost decreased. It resulted in saving about 2 mln. tons of deficient steel shell billet owing to transition of production of 120 mm mines and 76 mm shells to casting of steely cast iron [9, p. 308].



Elimination of "shell hunger" allowed the Red Army to use artillery successfully in offensive operations, starting from Stalingrad counteroffensive. It has begun on November 19, 1942 with 80 minutes of artillery softening-up of unprecedented force. Only at Donskoy front, during the first artillery attack, 5–6 thousand shots were implemented, plowing the enemy defense. Totally more than half million of shells and mines were shot by artillery at Donskoy front during 12 day counteroffensive, it was equal to more than 5.5 thousand tons of metal and explosives. The neighboring South-West and Stalingrad fronts had even more artillery [11, pp. 167–168]. Next year, during Kursk battle (05.07–23.08.1943), allowance of ammunition only for front cannon artillery was about 1.2 mln. shells and mines [11, p. 177].

To provide realization of "Bagration" operation (23.06–29.08.1944), one of the largest military operations during WW2, up to 400,000 tons of ammunition were required according to preliminary calculations of the General Staff. 2.832 mln. mines (1,700 carriages), 478 thousand shots of anti-aircraft artillery (115 carriages), more than 3.434 thousand shots of ground artillery (3,656 carriages) were spared during the operation for Belorussia liberation [22, p. 23]. Such high provision of front armies with ammunition was not observed ever before during any other strategic offensive operations.

It was calculated how average daily flow of ammunition increased from battle to battle. If we accept ammunition consumption during Stalingrad battle as 100 %, during Kursk battle it made 306 %, during Vistula-Oder operation – 498 % and during Berlin operation – 668 % [19, pp. 9–10; 23,

Fig. 5. The postcard with poster «To make the way to the victory more quick, a worker, please send more shells!» (poster made by graphical painter L. F. Golovanov)

p, 14]. German specialists noted that "often it was difficult to determine the direction of the main strike of Russian forces, because shooting was fired with equal intensity along the whole front" [24, p. 247].

During the war years, placing the images on postcards became wide distribution. The letters and postcards received from frontline underlined once more responsibility of rear workers for providing soldiers with required arms and demonstrated direct link between efforts of workers in the rear and successes of troops at the battlefields (**Fig. 5**).

The ferrous metallurgy bore colossal responsibility since the beginning of the Great patriotic war for manufacture of ammunition – the most metal-intensive industry of military production. The Soviet industry succeeded to organize wide-range and continuous production of ammunition just in 1942, despite total decrease of ironmaking and steel making (USSR reached the 1940 level of steel melting only in 1948). It allowed to cut significantly production costs, to increase production volumes, to save dozens of tons of deficient metal. USSR did not reach even in 1944 the indicators of the 5-year plan for production of ammunition, which had been preset in 1938, though 1944 was characterized by the highest level of productivity of shell plants [20, p. 173], but it succeeded to provide stable and uninterrupted supply of ammunition to Red Army. It was accompanied by simplification of production technologies, first of all in production of ammunition cases, what led inevitably to prevailing quantitative indicators before qualitative ones. However, there was no other way to solve this problem in the USSR at that time [21, p. 130].

The Soviet ammunition industry has manufactured and supplied to Red Army during the war totally more than 10 mln. t of ammunition, while Soviet artillery has obtained 775.6 mln. artillery and mortar shots [4, p. 296]. Iron and steel industry played one of the main roles in this success. CIS

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