Light & Engineering
Vol. 26, No. 3, pp. 29–36, 2018

Svetotekhnika
No. 1, 2018, pp. 32–38

LIGHTING OF ENGINEERING STRUCTURES AND INDUSTRIAL FACILITIES: NEW ASPECTS OF THE TOPIC

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ABSTRACT

This paper considers the fundamental problem of artificial lighting in various types and scales of industrial facilities, focusing on exterior lighting design solutions. There is a lack of interest from investors, customers and society in high-quality lighting design for industrial facilities in Russia, which in many cities are very imaginative structures, practically unused in the evening. Architectural lighting of various types of installations is illustrated with photographs. The purpose of the article is to draw attention to the aesthetic value of industrial structures, provided not only by the architectural, but also by a well-designed lighting solution.

Keywords: industrial objects, engineering structures, architecture, lighting, architectural lighting

Lighting engineering as a science emerged and developed primarily in the context of industrial production, because man has long understood that the results of his work and the quality of his life depend on the quantity and quality of light in the room where he works. For thousands of years people used natural illumination, limited by the sizes of expensive glazing in ancient times, because flame light sources in dark interiors did not produce a sufficient effect for production needs. It should be noted that the development of architecture was historically based on two objective factors: the structural construction capabilities of the covering dimensional spaces and their natural lighting. With the advent of electricity, the second factor has lost its need, but a the axiom of dependence of labour productivity on the quantity and quality of light remained. This became associated with specific content reflected in the normalisation and calculations of lighting, in improvement of evaluation criteria and design methods, in improving the quality of the light environment, significantly different from the natural light environment, in the expansion of contexts where lighting is always in demand. Interior lighting of industrial, transport and agro-industrial architecture is broad and well-researched topic, but it is constantly changing. Many industries are automated, and the role of man in them is changing constantly, but the human factor cannot be ignored under any circumstances. And this factor is primarily associated with visual perception, which depends on the quality of lighting.

Half a century ago in the USA and in other countries, controlled electric lighting drove the development of windowless shops, department stores, exhibition halls, sports and entertainment facilities, with no natural light inlets. A debate between professors V.A. Myslin and N.M. Gusev took place at the beginning of 1970s at a scientific conference in MARHI. The first posited that it was necessary to focus on creating comfortable visual conditions indoors with artificial lighting. The second argued that additional natural light is highly desirable for the psycho-physiological comfort of people in the room: the worker can look out of the window, see the natural world, the weather outside the window, the sun and the sky, the silhouettes of buildings, the crowns of trees. Today this point of view is no longer disputed. Later, Proff. G.N. Cherkasov proposed the idea of creating a favourable socio-psy-

Fig. 1 Group tour in the production hall (photo by G.N. Cherkasova)

chological environment inside industrial facilities, which could improve individuals' productivity [1, 2]. The concept comprised a set of interconnected classic and new, architectural, organisational and technical interventions in the interior and on site of the facility. This included: creating breakout spaces for short breaks on the shop floor, where they could be exhibited; establishing visual connections with the outside world through glazed openings (and today with the help of video screens); adjusting the light level and light spectrum at the beginning and end of each shift within the ranges set by health and comfort standards. New ideas for the formation of an interactive environment could be introduced in the process of work. For example: the video camera focuses on a worker at certain time intervals and the image projects onto the screens in the shop. This stimulates a level of responsibility, changes in emotional state, awareness of one's role in the production process and self-affirmation in the labour force. Changing images to other workers, creates a sense of belonging to the team, a level of personal connection within the technological space without separation from the workplace. It is

Fig. 3. "Glass manufacturing plantmanufactory" is a glowing factory of Volkswagen in Dresden

Fig.2 The glazed façade of the shop in Munich, BMW with a colour exteriorouter and interiorinner dynamic lighting in Munich

advised to use such video self-presentation briefly, selectively, at certain intervals in the shift, when there is a decline in performance, lapses in attention, fatigue before the end of the working day or a break in the work. Everything should be aimed at making people feel comfortable, getting satisfaction from their activities. The last few decades have seen the successful operation of modern industrial facilities, equipped with the latest technology, which provide tour opportunities for visitors, who can observe the production process, highly technical, and often quite beautiful equipment, the organisation and working conditions of people, the architecture and design of the environment, the effect of lighting (Fig. 1). Stained glass windows for workshops has become fashionable again (Fig.1), specifically so that the workshop and production process could be observed from the street outside even during the day-time, with intense indoor illumination, providing free workshop masterclass (Fig. 2). The industrial building extends to the red line, without a traditional fence. This is true in the case of the automobile assembly plant ("glass factory") in Dresden (Fig. 3), the winery "Protos" in Peñafiel (Spain), the brewery in Mytishchi (Russia), etc. When a group of tourists passes through the production facilities, it is advisable to use remote control "targeted" lighting, for short-term illumination of certain elements of equipment or work areas, focusing visitors' attention on the features of technological operations, safety, interior architecture and design of equipment, thus maintaining interest in the dynamic tour. The light can be controlled by a tour guide or programmed automatically. Specific solutions for light and colour, as well as sound, tactile and other sensory foci of the visitor's attention can

Fig. 4. Colour dynamic lighting of bridges:
a – Meiko East Bridge in Nagoya; b – St. Andrew walking in Moscow
(photo N. And. Shepetkov)

be applied as long as they do not interfere with the production process. The script and facilitation of such tours allows the visitor to become immersed in the atmosphere and space of production, making the industrial process a fascinating show, with the workplace as the central "hero".

The theme of lighting and lighting design of interiors of industrial buildings with different architecture and at various scales is extremely capacious, constantly relevant, structurally and technologically complex, and it is being studied continuously [3]. Another angle is the lighting design of industrial buildings as objects of the evening environment, forming part of the cityscape, historical and architectural, dominant and donor. Compared to public buildings, industrial facilities are rarely treated with artistic design, and when they are, this is often flawed. In fact, for many of these facilities, their large and original external form with proper lighting would do an honour to any city image. This is the case not only for industrial buildings, but also engineering structures – bridges (Fig. 4) and transport interchanges, CHP pipes, cooling towers and power line supports, hydroelectric dams and canals and locks, oil refineries and gas tanks, water towers and fire towers, railway depots and interchange hubs, river, sea and air ports, radar installations and TV towers, elevators, exhibition complexes (Fig. 5), etc. Many of them, especially older installations, located in residential areas, occupied by residential buildings, sports facilities, green spaces and recreational spaces, gradually are transformed into civic objects, starting a new functional and figurative life, preserved or modified in architectural form. In different cities around the world, and even beyond their borders, the architectural lighting of installations such as the Sayano-Shushenskaya and the Krasnoyarskaya hydroelectric

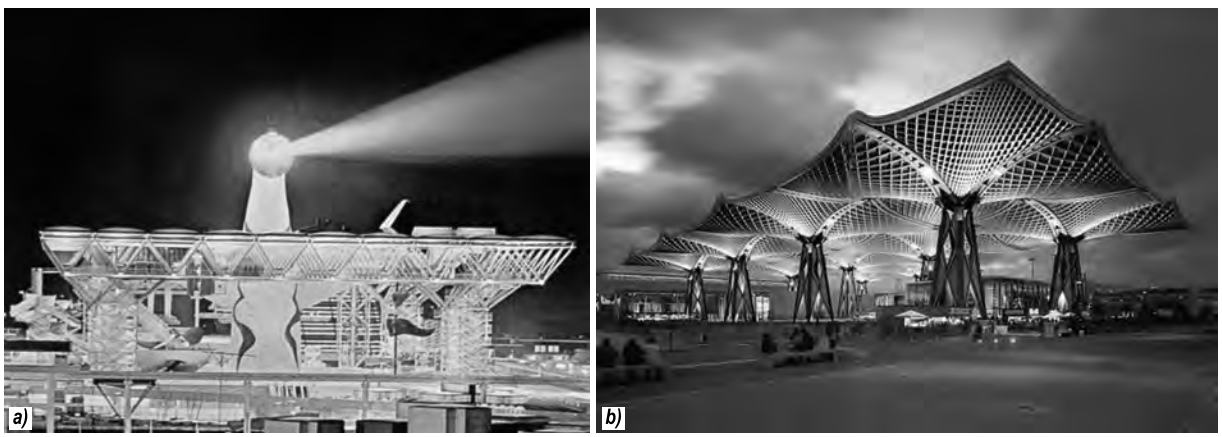

Fig. 5. Architectural lighting of exhibition facilities:
a – covering over the festival Area with the Sunsun Tower at EXPO-70 in Osaka;
b – exhibition pavilion " EXPO-200220002 in Hanover

Fig. 6. Architectural illumination of Krasnoyarskaya hydroelectric power station

power stations (Fig. 6), oil refineries, sewage treatment, and gas processing plants, become the topic of evening tours. In other cases, they appear like fantastic mirages, decorating the night landscape as seen from buses, trains, personal transport. For example: a chemical plant near the Dead Sea in Israel, is seen from afar as a bright spot of light in the darkness of the desert. The impression is enhanced by dynamically lit steam columns from the stacks. It is impossible to identify as an industrial object from afar. As you approach, it turns into a clear group of light verticals of open process equipment, reactor columns, cylindrical structures, stairs and bridges, winding pipelines. A competent system of electric lighting successfully reveals powerful architectonics, scale and energy of this 21st century (Fig. 7, (a). Even the basic mandatory technical and signal lighting of such plants make an impression on the unprepared observer. For example, driving in the evening towards Yaroslavl from the south reveals numerous electric lights and the live flames of the flared gas over the refinery stacks, which fascinate the eye. You can imagine even more powerful and sparkling complexes at night in the Tyumen

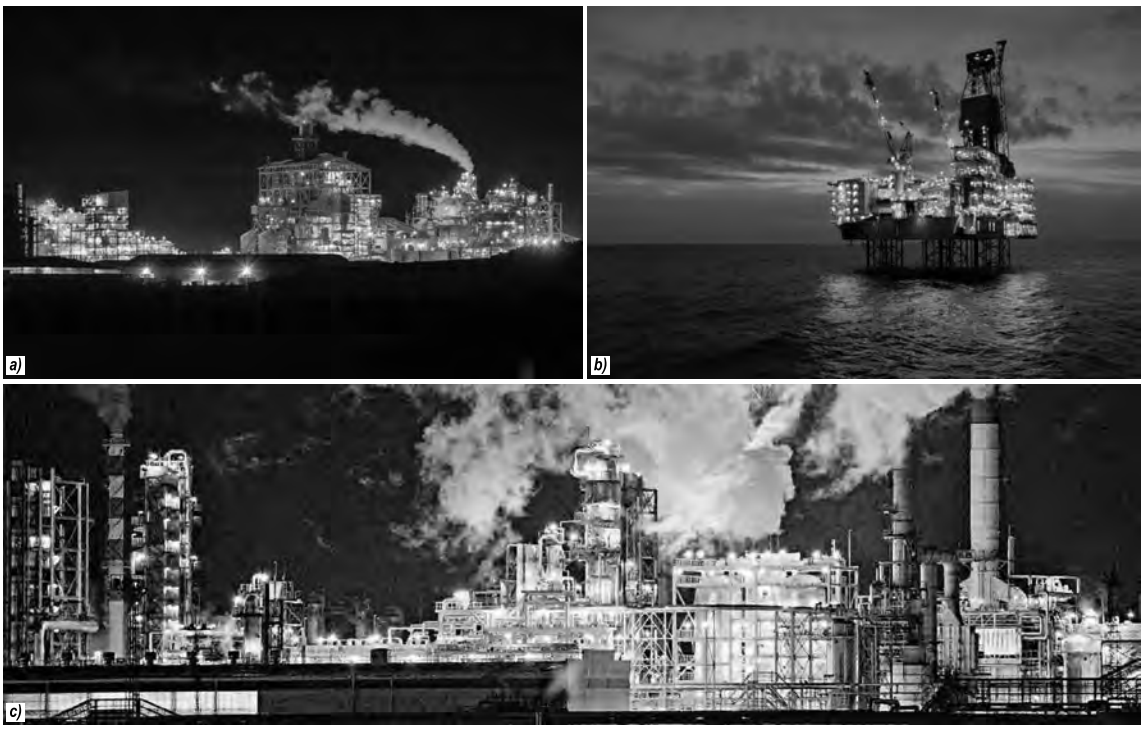

Fig. 7. Element of technological and signal lights in the night panoramic views of oil and gas, chemical and processing facilities:
a – chemical plant in the Sinai desert, Israel; b – oil platform in the North sea; c – complex of the company "Promtekhelektro" in Kstov (Nizhny Novgorod region.)

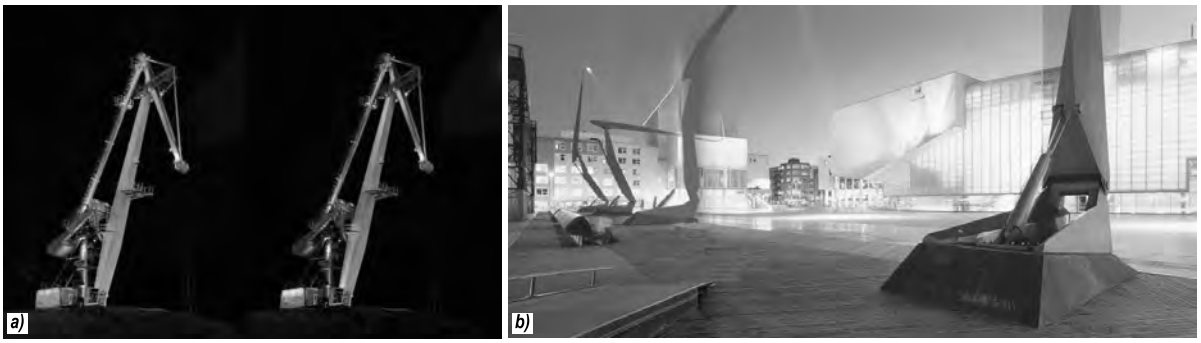

Fig. 8. Decorative lighting of port cranes as urban relics:
a – imitation of cranes at the Theatre square in Rotterdam;
b – port cranes in Murmansk, illuminated by colour light

region, in the endless tundra in the North of Russia, on oil platforms in the seas and Arctic ice (Fig. 7, b and c).

In many port cities of the world, the preferred technique of forming the light panorama was lighting, often coloured, of old port cranes, preserved as open air museum exhibits. They help people orientate themselves on embankments and the wider city space by their recognisable silhouettes and large scale. In Rotterdam, for example, the illuminated cranes in the old port inspired urban planners and designers in the 1990s to creatively interpret the image of cranes as kinetic lighting masts in the Theatre square [4]. Murmansk and other coastal cities follow the same example (Fig. 8).

The application of decorative lighting on in situ building cranes on large high-rise construction sites is increasingly used in Moscow, reviving the previously deserted and dark areas of the city territory.

Radio and television towers of different heights and designs are a known familiar silhouette of many large cities around the world. In Moscow there are two such towers – Ostankinskaya and Shabolovskaya (Shukhov). Shortly after its construction in 1967, the entire 500-metre tall Ostankinskaya tower was highlighted with searchlights and spherical discharge lamps on public holidays, according to a VNISI project. In 1996, the failed lighting system was replaced with a new one, using holiday and everyday stationary modes, metal-halogen lamps and mercury arc lamps (Fig. 9, a and b). These illumination devices were developed with our participation [4]. In 2016, "modern" designers

Fig 9. The modes of architectural illumination of Ostankino Television Tower in 1996 – 2017: fixed holidays (a) weekday and everyday (b) up to 2016, using the white light (N.I. Shchepetkov's photo); modern coloured display mode, since 2016 (c)

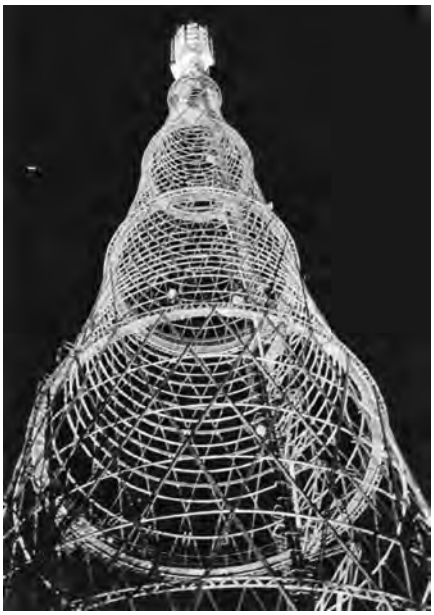

Fig. 10. Stationary two-colour floodlight lighting Shabolovskaya TV tower

added a diode mesh "stocking" onto the tower with a dynamically changing colour light pattern and temporarily preserved the unique ground system of aerial illumination made in the 1990s by Svetoservis (Fig. 9, c). The technically simple lighting of the elegant lattice of the Shukhov tower, flooded in 1997 by two-colour floodlight (Fig. 10), was often reconsidered in order to compete with the Eiffel tower in Paris; this was an initiative of Yuriy Lujkov, then Mayor of Moscow. However, all attempts to hang lighting equipment on the rusted structures of the tower were reasonably rejected by the Moscow office for the protection of monuments – we accounted for this and took it as given from the very beginning of the project [4].

Fig. 11. Light-graphic version of TV tower illumination and coloured lighting of Kantemirovsky bridge in St. Petersburg

And there are no other methods, except for intensifying the floodlight, changing its chromaticity and kinetics in this case. Perhaps the use of laser and/or narrow searchlight beams, typical for temporary (festive) light shows could be applied, because they can penetrate the tower structure without compromising its existence or creating a virtual light space around the tower, greatly increasing its scale and dominant role in the Moscow's light panorama. Illumination of unclad or monolithic structures of television towers in many cities of the world is fundamentally uniform, except that the latter allows for elements similar to the firmer: a light graphics of linear, dotted and dot colour, and dynamic patterns on their body (Figs. 11–13), as well as projection methods of video mapping.

Thermal power plant cooling towers, elevators, cylindrical oil storage tanks, cement and chemi-

Fig. 12. Lighting of the "pearl of the East" TV tower in Shanghai

Fig. 13. Lighting of a TV tower in Guangzhou

Fig.14. Lighting of the thermal power plant cooling tower in Brussels – one of the first media installation at the industrial facility

Fig. 15. Colour lighting of cooling towers CHP in Yekaterinburg

cal plants, gas tanks and water towers also large objects reflecting light in an urban context. Today, they rarely adorn the urban surroundings and industrial zones during the day, and are rather unpopular in artistic terms because of their unkept appearance, but at night they could become spectacular media screens. An example of this can be found in Brussels: an LED cord is mounted on a powerful hyperbolic-parabolic power plant cooling tower, running projections of a variety of colour animated images – flying birds, ornaments, text, etc. (Fig. 14). Our concept proposal from 2004 on the illumination of numerous cooling towers in Moscow [5] was not considered by the Moscow authorities but was implemented in Yekaterinburg and Samara (Fig. 15).

A similar story unfolded with the power lines in the area of Yaroslavl highway: in the tender for the lighting in 2011, we proposed to the Moscom-architecture and Dep-Tech to illuminate the power line supports with coloured light, forming a day silhouette panorama in the area of the platform "Severyanin" and in other areas of Moscow. The proposal has not yet been considered, although the delicate and beautiful designs of the supports deserve consideration. In the Moscow region, some power line supports in recent years have been painted with white and blue paint, which distinguishes them from the typical grey supports during the day. They can be seen from highways and from trains. Groups of such supports illuminated with coloured light, would play a powerful spatial-architectural, symbolic, informative and aesthetic role in the night space of the city.

Even more difficult for an urban solution and further adaptation to modern life are examples of the preservation and conversion of large industrial facilities, for example, metal production plants. In the West of Germany in the industrial Ruhr, many steel plants from the 19th and 20th centuries were not destroyed after the Second World War, but turned into a kind of tourist centres. One of the symbolic, attractive, accessible and effective methods of

Fig. 16. Coloured lighting technology Park in a reopened steel mill in Duisburg

this transformation was their coloured architectural lighting (Fig. 16). It is a pity, that this technique is almost unused in Russian practice, because many industrial enterprises in Moscow (and beyond) have been leaving, or are leaving the city, leaving behind the objects of historical industrial architecture. In some cases, the facades of the buildings, which have transformed into functional civic buildings, offices, museums or residential, are still illuminated, but their choice and style of lighting is very random, not referring to the functional-figurative beginning of the original architecture. Elsewhere, in the republican, regional and district cities, the situation is even worse.

Meanwhile, urban civil construction investors have long realised that good architectural lighting increases the prestige and reputation of the facility – it or its product is more expensive and quickly sold or rented. The modest cost of lighting has a relatively quick payback period. Today, it is difficult to find a small town of regional scale, and even a village where there is no shining light form private business, some advertising, windows and even facades. From our professional point of view, this light must not only be "shiny" and bright, but also informative and artistic. Lighting design in Russia in the field of architecture is clearly inferior to lighting design in the architecture of life. This is not favourable, since most of an adult's active life is devoted to work.

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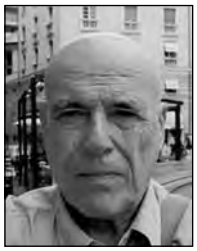

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