LEAN MANUFACTURING TECHNOLOGY AND MINIMIZATION OF LOSSES FROM ACCIDENTS

Krasikov, Nickolay Y., *PJSC Rostelecom, St. Petersburg, Russia.*

ABSTRACT

In railway sector there are many dangerous destabilizing factors. One of the most common problems is collision of a train with a vehicle which is stuck on or entered out of driver's negligence into a railway crossing. In the article methods of minimization of losses from this type of accidents are considered. They comprise construction of tunnels and overpasses at the intersections of the railway and the road, use of a 3D-laser radar to warn the locomotive crew about the stuck transport. In addition, it is possible to use web cameras, the image from which, using a router installed within 4–5 km far from the crossing, is transferred to the train driver's cab on a separate display in advance to see the stuck vehicle and to have time to take emergency braking measures.

Keywords: lean manufacturing, safety factors, railway crossing, emergency situation, visual perception, 3D-laser radar, web camera.

Background. *According to the definition of the Cambridge Business English Dictionary [1], lean manufacturing is a business focused on producing goods in large volumes and using methods that avoid the occurrence of waste and reduce the time spent on production.*

The exhaustion of natural resources, global warming, the food crisis lead to a rise in the cost of production and the need to save all types of resources [2]. Therefore, development and implementation of resource-saving technologies, use of effective marketing and pricing strategies, which allow to reduce costs at all stages of the product life cycle, became topical.

Objective. *The objective of the author is to consider lean manufacturing technology and minimization of losses from accidents.*

Methods. *The author uses general scientific methods, economic assessment, psychological theories, comparative analysis.*

Results.

The loss reduction dominant

LEAN technology – «lean manufacturing» (from English lean –without fat, slender) is a logistics management concept focused on optimizing business processes with maximum market orientation [2].

The ideas of lean manufacturing stem from the Toyota cost reduction philosophy, according to which the prices for the products of the enterprise are dictated by the market and buyers, and the company's management objects can only be the cost of production and the profit from sales. At the same time, the focus is on reducing the company's internal costs.

Based on the idea of reducing the cost of production, it is necessary first to determine the price for which buyers agree to purchase the proposed product, and then subtract from it the cost of its manufacturing to estimate the expected profit. The main way to maximize profits, therefore, is to reduce losses in the manufacture of products.

The losses in LEAN are generally divided into seven main varieties [3]:

1) Overproduction. This is the production of excess quantities of products or its premature appearance before the emergence of real demand.

2) Expectation. Any expectation – people, documents, equipment or information.

3) Excessive processing. Superfluous are those operations that are not needed by consumers who do not want to overpay money for their implementation.

4) Excessive reserves. Storage of such reserves requires additional areas, they can adversely affect safety, cluttering the aisles and production areas.

5) Superfluous movements. Any movement that is not required for successful execution of the operation in question becomes a loss. Often ineffective organization of the work process and incorrect layout of workplaces are the causes of unnecessary movements of performers – walking, reaching, bending.

6) Losses from defects, or reworking. The costs of reworking, re-performing operations when defects

Pic. 1. Collision of KamAZ and the passenger train at the railway crossing in 2015 in Belgorod region [4].

Pic. 2. Collision of a train and a passenger car at the railway crossing in Kyuong (Australia) in 2014. Photo by Bruce Magilton [5].

are detected, are classified as losses, since any work beyond the necessary is superfluous.

7) Transportation. Transportation to distances large, or creation of temporary places of accommodation, storage, unnecessary movement of materials, people, information or documents from place to place – all this leads to time and energy losses.

Analysis of collisions at crossings

One of the serious losses for railway enterprises is idle hours of trains due to blocking of traffic caused by the collision of the train with vehicles for one or another reason located at the railway crossing when the train approached (see Pic. 1, 2).

To stop, a freight train moving at a speed of 88,5 km/h requires not less than 1,61 kilometers (according to the National Security Council of the United States). And often there is no direct visibility to the intersection of the railway track, and the train driver simply does not have time to brake.

According to A. A. Platov [6], the total amount of time lost for restoration of traffic after a road accident at railway crossings in Russia was at least 100 hours from 1994 to 2003 (Pic. 3). That is, the losses in time reduced the possibility of using the railway track and making a profit.

In accordance with the ecological approach to visual perception of the known scientist-experimenter J. Gibson [7] during passive driving in transport, the musculo-articular sensations of the position and movement of individual parts of the body are absent. The only reliable information about displacement is provided by visual sensations. This is especially true now, when the technology of the seamless, «velvet track» is actively developing and the movement of the train becomes extraordinarily smooth. Therefore, the only reliable source of information for the train driver is the instrument's readings.

According to D. L. Petrovich [8], the success of the «complex» reading of the instrumental information depends on the cognitive-style characteristics of the operators. The high degree of field independence corresponds to higher performance indicators of such a reading, and the high degree of impulsivity corresponds to the lower scores of instrument scales.

Field independence characterizes a person's ability to find a simple relevant detail in a complex perceptual image. Field independent people overcome the most complex context easily. Field-dependent persons, on the contrary, barely overcome a complex task (they need time to see the detail in a complex whole).

Impulsivity and reflectivity appear when people need to make a right choice from many alternatives. Impulsive subjects tend to quickly respond to a problem, quickly make a decision without a thorough analysis of the situation. Reflective – are characterized by a slow response rate, the decision is made by them on the basis of careful consideration [9].

Ways to prevent accidents

In accordance with the principles of LEAN work to prevent collisions of trains with vehicles as adding value to the consumer – safety of transportation – should be expanded if railway companies want to profit, not bear image losses, and be competitive in the future.

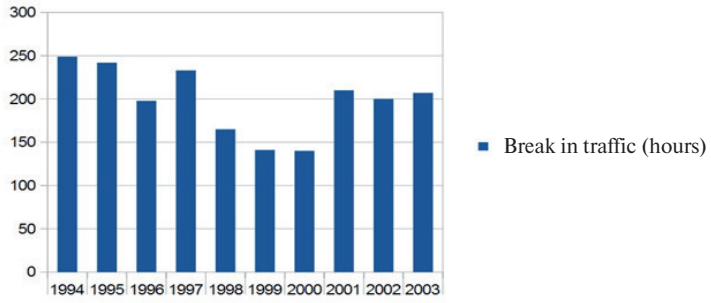
There are several ways to do this.

One of them is construction of tunnels and overpasses at the intersection of the railway tracks and the road. However, according to the specialists of the Institute of Natural Monopolies Problems such an overpass can cost from one billion to even two and a half billion rubles.

Another way is to use the invention of Boyji Rajaram from India (RF patent 2333860) – a collision avoidance device (CAD) for trains and similar transport vehicles, based on a microprocessor with a radio transceiver operating at a given distance, for example 2 km, and having an independent power source. When installed on a locomotive, braking car, crossing, railway or any other station the device automatically generates signals for initiating various security measures. For example, such a measure can be switching on of the braking system of a moving train to reduce its speed to a safe limit, or a complete stop of the train at a safe distance. At the same time, the collisions are prevented by the switching on of sirens at the crossings, to which drivers of road transport shall react, and the train driver or the crossing's operator on duty get information about approaching trains, their location, speed through communication channels.

Another method of preventing collisions of vehicles can be installation of crossing's barrier devices (CBD), which blocks the roadway by lifting the hinged lid.

In Japan, on the East Japanese Railway Company [10], a 3D-laser scanner is used on more than 200 level crossings, which scans the space above the railway crossing in the vertical and horizontal plane twice per second. The signal that is reflected from the object is processed as a certain set of points, then the software makes a conclusion that this set of points is a vehicle located at a railway crossing. If at this moment the train is approaching, its driver receives an alarm signal.



Pic. 3. Indicators of losses in time due to road accidents at railway crossings in Russia for the period 1994–2003 [6].

In modern traction rolling stock, many processes for controlling the operation of units and assemblies, maintaining the speed of the engine set by the train driver and reducing it are performed automatically. The automation of routine operations to drive a high-speed train increases the safety of traffic, so the task of facilitating the work of a train driver with the replacement of his actions by automatic execution, especially in high-speed traffic, is still relevant. Although, even when auto-driving, about 10 % of the path is traversed by a train in the manual control mode [11], and it means that such method of eliminating the losses from collisions of trains with vehicles as web cameras on especially busy railway crossings remains in demand.

Web cameras should be resistant to vibration, rain, snow, wind and other unfavorable weather conditions. The image from the web camera using a router installed 4–5 km far from the crossing is transferred to the driver's cab on a separate display, so that he sees the vehicle in advance and could take emergency braking measures. Visual representation of the image from the nearest crossing on the display as a means of displaying information should simplify the process of reading and quick categorization of the image from the display.

Conclusion. *In accordance with the principles of LEAN, the losses from train delays caused by collisions of trains with vehicles at railway crossings should be eliminated taking into account aggregate costs and minimization of waste.*

Which of the methods is more preferable depends on the particular conditions. This issue requires further research and pilot testing of each method, as well as comparative analysis depending on traffic density, the economic possibilities of the railway company and other factors, which relate to application of lean manufacturing technologies.

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Information about the author:
Krasikov, Nickolay Y. – sales agent of PJSC Rostelecom, St. Petersburg, Russia, krussikov@mail.ru.

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