Efficiency of innovative technology in construction industry

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Abstract. The need for sustainability increasingly influences the development of new technologies, business processes and working practices. Innovations are an important part of all business processes. The aim of innovation is, in particular, to reduce the burden on the environment. The current trend in the construction industry is diamond rope cutting. The aim of the paper is to evaluate the most advanced technology for cutting and removing concrete structures in terms of efficiency.

1. Introduction
The concept of sustainable development is associated with environmental problems, particularly with the issue of natural resource management, economic challenges and global climate changes or the transformation of post-industrial society. The basic aspects of achieving or maintaining the competitiveness of the economy and sustainable development include the advanced knowledge industry, especially the adaptation to the changes brought by the so-called Fourth Industrial Revolution. The cornerstone of this period is the knowledge society and the innovation. The sustainable economic development has been chosen as one of the key areas for the competitiveness of the national economy. The main microeconomic priorities lie in the improvement of science and research, innovation, the business environment, the modernization and the development of information technologies and also the development of technical infrastructure and sustainable consumption of natural resources.

The principles of sustainable development are based on the belief that the needs of the present generation must be fulfilled in such a way that the possibilities of future generations are not weakened. Their part is the promotion of life in its diversity, based on the principles of democracy, the gender equality, the solidarity, the respect for the rule of law and human rights, including the peace and equal opportunities for all.

The need for sustainability increasingly influences the development of new technologies, business processes, business organization and working practices. The innovation is an important part of all business activities. The innovation is characterized as a transfer of the idea of a new or improved business process used in industry or in business. The technical innovation is characterized by the emergence of new products, processes and significant technical changes in manufacturing processes.

The aim of the innovation is especially the reduction of the burden on the environment. Nowadays, the new technologies are at the forefront of ecology, economy, and efficiency. The current trend in the construction industry is the diamond rope cutting. The construction structures, whether
administrative buildings, bridge constructions, hall buildings, multifunctional units and others, are built mainly of reinforced concrete. The aim of this paper is to evaluate the most advanced technology for the cutting and the removing of the concrete structures in terms of efficiency.

2. Innovation and the sustainable development

The innovation represents a key element from the point of view of the enterprise for its further development and the increased competitiveness within the current globalized market. In compliance with the international terminology, these types of the innovation are distinguished [5]:

- The innovation of the product, which mainly involves the introduction of new or significantly improved products or services, especially in the field of technical parameters or user-friendliness;
- The process innovations that are aimed at introducing new or significantly changed production, process change, or supply methods;
- The marketing innovations that are focused on new marketing methods in product support, valuation, design and other areas;
- The organizational innovations which are focused on new organizational methods, changes in organizational arrangements or external relations.

In the manufacturing industry, there prevails the product and the process innovation, or the technical innovations; in the services, there is a higher share of the innovative activities in terms of marketing and organizational innovation. Non-technical innovations make it possible to create the new and effective ways to promote new products and services, or introduce the flexible changes in organization management to respond to new market trends and customer demands. The ecological innovation, according to Eurostat methodology [5], is not considered as a separate innovation. It is a group of environmental benefits of innovations that are considered to be the by-products of other named innovation groups (especially in product and in process).

Since 2008, the overall innovation activity in the Czech Republic has been decreasing, mainly due to the lower intensity of the innovation efforts in the area of non-technical innovation. From the international point of view, enterprises in the Czech Republic innovate less than the average of the EU28 countries, but in the area of the technical innovation, the Czech Republic is close to the EU average. The business ownership and the size of an enterprise affect the intensity of innovation activities. The most intensively innovating are the large enterprises with more than 250 employees [5,3,7].

The business entities in the business sector are innovating in their products, internal processes, or business strategies and try to accommodate the existing market or technological conditions or anticipate their development. The successful innovation activities are a key prerequisite for the business growth and survival in a globalizing market. The sustainable development involves not only an environmental protection and the efficient use of natural resources, but also aspects of the economic growth and social cohesion. There is a predominant view that the principles of sustainable development should also be reflected in decision-making processes at all levels. A capacity for mobilizing and using science and technology (S&T) is increasingly recognized as an essential component of strategies for promoting sustainable development [6,8].

The accuracy of the fulfillment of sub-parts of the construction phase is the key to an effective outcome. The diamond cutting and the drilling is currently a highly efficient and fast way to dismantle reinforced concrete structures, concrete products, masonry and other natural and man-made building materials. The unique technology of cutting concrete using a rope with a diamond surface allows for dismantling even under the most demanding conditions: the cutting walls with a thickness of more than 70 centimeters, dismantling of monolithic foundations and structures, the work on coastal objects (pier, docks, and girders), and the arc cutting and cutting with tilting in hard-to-reach places. Also, the diamond drilling technology is widely used in construction for drilling technological holes in hard materials such as concrete, reinforced concrete, bricks, stone and other [2,4]. Thanks to this no-break
method, the gap drilling takes place without a noise and a vibration, and the process technology allows the drilling gaps of ideal shapes and exact dimensions in any position and at different angles. In the case of the core drilling, it is mainly the production of passages for water, hot water, air-conditioning, etc. Unlike the manual cutting using the drill hammers and pneumatic hammers, it is possible to achieve the core drilling of concrete and reinforced concrete, 10-20 times more work efficiency is achieved thanks to the diamond segments ensuring an easy penetration into the structure. This method is used, for example, for drilling gaps for piping, anchoring, drilling wells and perforation boreholes for the removal of concrete and the reinforced concrete.

3. Diamond cutting efficiency

The benefits of the diamond cutting have been analyzed with 15 experts from the special field, using the QFD methodology, more in [1] and the results are demonstrated in the following table 1.

| Importance                              | Frequency |
|-----------------------------------------|-----------|
| Very precise gaps without the need for further structural modifications | 2 13 123 |
| Fast, accurate and efficient work       | 4 11 111 |
| Saving the time and financial cost vs. classical cutting | 10 4 1 31 |
| Possible cutting even in heavily armored constructions | 1 14 129 |
| Work without vibrations and so without damage of other constructions | 15 135 |
| The possibility of carving large openings, which are divided into manipulated pieces | 2 13 123 |
| Reduction of a noise and dust to a minimum | 13 2 57 |
| Maximum environmental friendliness      | 4 8 3 55 |

Source: own elaboration

From the point of view of specialists, this is an advantage in terms of statics - work without vibrations and so without damage of the other constructions, the second most advantageous is the suitability for use in heavily reinforced constructions, and the last two most important aspects are the possibility of cutting large gaps, which are divided into manipulated pieces as well as precise gaps without the need for further structural modifications. The professionals also evaluate the diamond cutting as a benefit in terms of accuracy and efficiency. The weakest aspect is the saving the time and financial costs versus the classic cutting. In terms of time, it would be possible to talk about the time saving, but on the economic aspect – not the financial costs. The use of diamond technology is costlier than the classic cutting.

For the evaluation of the effectiveness of the most advanced technology for cutting and removing concrete structures, is given an example of practical experiences. The diamond rope can cut the building gaps from 0.5m thick the concrete, the reinforced concrete, the concrete pipes, and the brick masonry. The diamond rope also commonly cuts a wall of 4m thickness. At the highest performance, the engagement of the diamond rope is within 10m. The other use of the diamond rope is cutting the small square gaps, and for measurements below 0.6 x 0.6m of different thickness is a suitable diamond rope system.

The concrete and the reinforced concrete are possible to cut by diamond wheel to 1m of the masonry or the monolith. This process can only be used for long cuts (over 10m of the cut length). In the case of smaller gaps cutting, this technology cannot be used as the masonry cuts of 1m in length - more half the diameter of the disk. This presents a problem in terms of pillars, pipe bells and beams, there may come their disturbance.
The work with the diamond rope has a slightly lower performance than the diamond wheel cutting. The sections of diamond rope in the steel reinforcements are not as accurate as the diamond disks. The explanation is in the diamond rope slip, which are at an angle of up to about 60°, there is a grinding of the steel reinforcement and not the pruning (instead of 1 cm cut is there 3 cm cut, the rope vibrates gently and there is a curl of the cut). The diamond disk cuts the steel reinforcement continuously. With the reinforcing concrete or the steel reinforced brick masonry, the large vibrations occur, the steel reinforcements are released and thus their adhesion and the reduction of the strength of the reinforced concrete are impaired. The use of diamond rope appears to be problematic, especially for poorly made steel reinforcements (curl or bend when assembling), this causes the cut to be cut even in a place that cannot be seen from the outside. Because of this, it is impossible to carry out any manipulation with the concrete scraper (carved block) and the diamond rope system is then inefficient.

Nowadays, the so-called banked diamonds are used, which have better work performance and are of better quality. The diamond ropes are driven mainly by a hydraulic saw, but there are also diamond rope self-tensioning saws. The disadvantage of the diamond rope system cutting at higher cutting thicknesses is the flatting down the rope. Also, due to lack of space in the rope stack when performing longer cuts, the rope must be shortened. Therefore the rope is re-routed to the desired length by cardan joints or fixed ones, which - when are new - have a larger diameter than the diameter of the worn rope, and this creates a problem by tearing the rope often and re-connecting.

The diamond rope is now able to cut round gaps. The diamond rope usually cuts from the diameter of 1.2m, up to 1.2m diameter is usually used a core drilling with crowns.

4. Conclusion
While diamond rope cutting technology has been known to demolition of large structures for decades, its use in other sector is growing slowly. The process has many advantages including minimal vibration or damage to any structural element, low noise or high accuracy of cuts and large depth of cuts. The diamond rope cutting, diamond wheel and core drilling are gradually being discovered in the construction industry and despite the higher price; it is being used more often in practice.

References
[1] Blecharz P and Štverková H 2011 Product Quality and Customer Benefit App. Econ., Busin. and Devel. Inter. Symp. p 382 - 388
[2] Cash D W, et Al. 2003 Knowledge systems for sustainable development Natl. Acad. Sci. 100 pp 8086–8091
[3] Chytilova L. 2013 Rating prediction using neural networks VI. mezinárodní vědecká konference doktorandů a mladých vědeckých pracovníků (Karviná: Slezská univerzita v Opavě)
[4] RYLES D Q 2017 Diamantové řezání
[5] EUROSTAT 2012 The Oslo Manual is one of the central documents providing an overview of the basic definitions and practices in measuring innovative business activities
[6] Ruttan V W 2001 Technology, Growth, and Development. NY Oxf. Univ. P.
[7] Vymetal D, Hucka M, Hunka F and Kasík J 2008 Production planning model using REA ontology E & M EKONOMIE A MANAGEMENT 11 p 93-102
[8] World Bank 1999 World Development Report