Application of Modern Technologies for Planning Improvement and Saving on Costs in the Enterprise of the Industry 4.0

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Abstract. There are many examples of successful enterprises in the market worldwide. All these successful enterprises have some specific advantages or unique techniques to survive in the market. Sustainable development is the key element to ensure survival of modern enterprises which are based on unique technologies in the Industry 4.0. Regardless of sizes and capabilities of enterprises, the availability of new technologies and correct organization allows these enterprises to respond to changing market and consumer demands immediately. In addition to this there are required well-defined methodologies and experience of employees to ensure qualified and timely feedback to improve conditions. There are suggested some technologies in this study. The objectives are to analyze and show effectiveness of these techniques to improve activities and competitive advantages of the cement factory. Additionally, these technologies resulted in significant saving on costs in the cement factory. Application of these modern methods and technologies resulted in reliable conditions for improvement of competitive advantage, adaptive management, sustainable development, planning as well as optimization of expenses in the cement factory in the Republic of Azerbaijan in the year 2020 as well as in the short and long term.

Keywords: Computerized Maintenance Management Systems (CMMS) · Recurrent Neural Network (RNN) · Condition-Based Maintenance (CBM) · Online Condition Monitoring Systems (CMS) · Sustainable development

1 Introduction

Due to high competition and global recession there are required scientific approaches for efficient management of enterprises in the Industry 4.0 in the market worldwide. Global and local economy challenges prove that the previous model of interaction has to be improved in the economy. The global recession is expected worldwide. Probably demand for crude oil will be less than supply. Actually, profits of some industries decrease along the chain. There are decreasing demand and sustainability of financial chains for small and large enterprises due to the global market shock in the year 2020.

Import and export are certainly limited because of prolongation of consequences due to COVID-19 and recession. There are trends for cost reduction to minimize expenses
in business organizations worldwide. There are risks of possible low sales of ready products of the cement plant. There are also additional risks of late and complicated managerial decisions because of uncertainty, fast changing conditions, the huge amount of dynamic data, lack of experience and skills due to COVID-19. These risks result in loss of the time and investment due to outdated existing tools, procedures and control in the processing of technical and commercial data when procurement and delivery of raw materials, equipment and spare parts for the cement factory.

In order to minimize the consequences of recession there is required accurate and qualified management on the example of the cement factory. Therefore, when uncertainty conditions the timely decision making becomes critical for management. Competitive advantage also depends on correct organization, balanced planning and application of state-of-the-art technologies like RNN, CMMS, CBM and online CMS in comparison with preventive maintenance routines on the example of the cement factory. Actually, the prediction technique which is based on the RNN allows to get reliable results on the basis of preceding and current macroeconomic statistics [1]. The RNN prediction technique provides conditions for qualified, effective and balanced planning of raw materials and spare parts as well as optimization of expenses or even direct saving on costs on the example of the cement industry. The concept, principles of operation and training of fuzzy neural networks and technologies of recurrent fuzzy neural networks were given in the works of many researchers, in particular in the research of the internationally recognized scientist Doctor of Technical Sciences Professor Aliev, R.A. [1]. Tested and recognized prediction results and trends for the cement market of the Republic of Azerbaijan were considered in the work [2]. There are specific requirements to apply CMMS and online CMS in view of return on equipment. When purchasing these software and technologies a balanced solution is advised due to the relatively high costs. Application of the above-mentioned technologies provide reliable conditions for improvement of quantitative and qualitative results. These robust results also can create conditions for efficient management, maintenance, planning, saving on costs as well as valid and qualified decision making for the planned production of cement in the Republic of Azerbaijan.

The paper is structured as follows. The Sect. 2 is devoted to general description of technologies in the modern cement industry. The Sect. 2.1 is devoted to description of the RNN structure, functioning principles and application results of modern prediction technologies in the cement industry. The Sect. 2.2 is devoted to description of modern online CMS technologies in the cement industry. The Sect. 2.3 is devoted to description of modern CMMS and planning principles in the cement industry.

2 Application of Modern Technologies in the Cement Industry

Actually, there are some criteria of successful application of modern technologies via adaptive management, first mover advantage, efficiency, feedback, reasonable simplification and rejection of complicated methods on the example of the cement factory.

One of the main conditions of successful implementation is to apply modern marketing analysis and planning via CMMS in the cement factory. This approach is useful for the decision making by management timely. The prediction technique which is based
on RNN allows getting reliable results on the basis of historical and current macroeconomic statistics. These computation, analysis and planning can be implemented taking into consideration of macroeconomic statistics on the example of the cement industry. Therefore, this RNN prediction technique can contribute to optimization of expenses or even direct saving on costs on the example of the cement industry. This approach has resulted in the sustainable development and efficiency via timely, sound decision-making on priorities and balanced planning. RNN, CMMS, CBM and online CMS are suitable technologies due to efficient operations when the huge amount of dynamic fast changing technical and commercial data and tasks on the example of the cement factory in the Industry 4.0.

2.1 Modern Prediction Technologies in the Cement Industry

Actually, the accurate qualitative prediction of the cost of cement and the cement market research resulted in confirmation of the increased cost during the years 2017–2018 [2]. The work [2] used fuzzy neural network to do cost forecasting. The results of prediction provided in the work [2] were confirmed to be reliable and accurate in the cement market [2]. The system [2] provided qualitative prediction for years 2017 and 2018. Application of recurrent neural networks is a further step to improve the quality of forecasting due to their inherent dynamic system modeling characteristics. A three-layer recurrent neural network RNN [1, 3] with five inputs, seven hidden neurons and one output was created to predict volumes of cement production for the year 2020.

The architecture (Fig. 1) and working principles of RNN were described in the work [4] as below.

The network uses a no-activation (only-distribution neurons) input (1st) layer, sigmoidal activation function based hidden (2nd) layer, and linear activation function-based output (3rd layer) layer. Three layers of neurons in perceptron networks are proven to be enough for approximation of most of input-output numerical mappings with any desired accuracy [4].

The neurons in the 1st (input) layer only distribute the input signals without modifying their values:

$$\tilde{y}^{(1)}_i(t) = \tilde{x}^{(1)}_i(t)$$  \hspace{1cm} (1)

The neurons in 2nd (hidden) layer compute their output signals as follows:

$$\tilde{y}^{(2)}_i(t) = F\left(\tilde{\theta}^{(2)}_i + \sum_j \tilde{x}^{(2)}_j(t)\tilde{w}^{(2)}_{ij} + \sum_j \tilde{y}^{(2)}_j(t-1)\tilde{v}^{(2)}_{ij}\right)$$  \hspace{1cm} (2)

where

$$F(s) = \frac{s}{1 + |s|}$$

The neurons in the 3rd (output) layer are linear and their outputs are calculated as:

$$y^{(3)}_i(t) = \theta^{(3)}_i + \sum_j x^{(3)}_j(t)w^{(3)}_{ij} + \sum_j y^{(3)}_j(t-1)v^{(3)}_{ij}.$$
Formally, all signals and parameters (weights and thresholds) of the considered neural network can be arbitrary fuzzy numbers (e.g. triangular fuzzy numbers) or ordinary crisp numbers [4].

Taking into account the macroeconomic statistics, Table 1 and [5–7], the RNN was trained using the data, a segment of which is given below.

Inputs: cement production $X_1(t)$; ready concrete production $X_2(t-2)$; building bricks production $X_3(t-2)$; Inflation for consumer prices $X_4(t)$; Oil price average $X_5(t)$. Output: Cement production (sales) $X_1(t+1)$.

After one thousand training iterations on the basis of the evolutionary (DE) algorithm, $\text{RMSE} = 1.57 \times 10^{-10}$ was achieved. The neural network was trained to predict cement production (sales) in the year 2020. The main prediction results were made by RNN and confirmed $X_1(2020) = 2746.5$ [8].

Training data were described in the Table 2. The inputs and outputs to the RNN are provided below and shown in the Fig. 2.

- $X_1(2018) = 3444.7$
- $X_1(2019) = 3132.9$

The results produced for older years (2017, 2018) are comparable with the work [2]. To check the better performance of the suggested prediction technique, the data were processed with other well-known prediction methods, such as regression analysis and ordinary neural networks (provided in Microsoft Excel XLMINER Platform). RNN was significantly better due to the ability to remember dynamics in historical data.
Table 1. Macroeconomic statistics for RNN inputs [5–8]

| Year | Cement production (thousands tons) | Concrete production (thousands tons) | Production of building bricks (thousand cubic meters) | Inflation, consumer prices (annual%) | Average oil price (USD) |
|------|-----------------------------------|--------------------------------------|-----------------------------------------------|--------------------------------|---------------------|
| 2005 | 1538.0                            | 1916.0                               | 161.0                                         | 9.6                             | 48.89               |
| ……   | ……                               | ……                                  | ……                                           | ……                             | ……                |
| 2017 | 2879.8                            | –                                   | –                                             | 12.9                            | 48.73              |

Table 2. Actual and predicted data resulted applying RNN [8]

| Inputs          | Output        |
|-----------------|---------------|
| X1(t)           | X1(t + 1)     |
| X2(t − 2)       |               |
| X3(t − 2)       |               |
| X4(t)           |               |
| X5(t)           |               |
| 1538.0          | 1622.0        |
| ……              | ……            |
| 2306.9          | 426.1         |
| 2879.8          | 280.6         |
| 942.1           | 12.9          |
| 2879.8          | 48.73         |

Fig. 2. Actual and predicted results of cement production in the year 2020 [8].

2.2 Modern Online CMS Technologies in the Cement Industry

On the basis of the example of former Garadagh Cement (at present Holcim (Azerbaijan)) there were introduced modern online technologies and condition monitoring program which was encouraged using online CMS of PRÜFTECHNIK GmbH. Prevention of interruptions of production process allowed to ensure successful performance. Therefore, early analysis allowed a planned repair which significantly decreased production and maintenance costs [9]. Therefore Holcim (Azerbaijan) also confirmed application of the online CMS like a modern technology to increase equipment reliability, ensure production availability, decrease maintenance costs. Actually, before installation of the
online CMS the maintenance costs were €51803 in total for the monitored production equipment during five months.

The goal was to decrease the costs to €14500 that was a decreasing factor of 3.6. Actually, the sum of the maintenance costs reached €2134 that was a total maintenance costs reduction by a decreasing factor of 24.3 during the next five months. As a result, the maintenance costs were reduced to 4% in comparison with initial status [9].

Additional improvements were made by decreasing of the costs for unplanned stops for the monitored production equipment lines. The frequency and duration were decreased for unplanned stops and unplanned works significantly [9].

### 2.3 Modern CMMS Technologies and Planning in the Cement Industry

Actually, CMMS ensured conditions for qualified, effective and balanced production and maintenance planning of raw materials, spare parts as well as qualified optimization and scheduling. The planning process required the feedback to ensure the reporting and statistics (Fig. 3). CMMS technology ensured timely decision-making on priorities as well as accurate and balanced planning. Principles and implementing SAP business planning and consolidation were described in [10, 11]. One of the best examples of CMMS is the advanced SAP software platform which was described and applied in many enterprises worldwide [10, 11]. CMMS is the perfect technology due to capability of efficient operations in presence of large data flows and fast changing dynamic process of updating of technical and commercial data and tasks on the example of the cement factory in the Industry 4.0.

![Fig. 3. General planning and scheduling steps.](image-url)
3 Conclusion

Application of these modern technologies resulted in improvement of the planning and significant costs saving on the maintenance on the example of the cement factory. These modern RNN, CMMS, CMB and online CMS methods and technologies ensured improvement of competitive advantage, adaptive management, sustainable development as well as optimization of expenses in the cement factory in the Republic of Azerbaijan in the year 2020. Application of these advanced technologies confirmed timely adaptation of the cement factory to various changes and its competitive advantage in the market in the Republic of Azerbaijan. On the basis of new challenges of the modern market, results of application helped in decision making for short-term and long-term planning efficiently. Taking into account application of RNN with evolutionary training, these technologies ensured qualified prediction of production volumes in the example of the cement industry X1 (2020), which could be confirmed by the direct links of macro-economic and digital indicators. In addition to this there were analyzed advantages and practical implementation of CBM and online CMS in comparison with preventive maintenance routines in the cement factory. As a result, the above-mentioned CBM and online CMS implementation ensured prevention of unplanned stops and failures over a long period of time. Efficiency of modern RNN, CMMS, CMB and online CMS technologies can be confirmed for the long-term planning regardless of a type of production and enterprise in the Republic of Azerbaijan and worldwide.

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