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QUALITY ASSURANCE IN MANUFACTURING BY WATER POLLUTION MEASUREMENT

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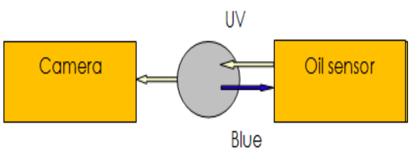
Graphical abstract



Abstract

Many products or intermediate products in industry have to be cleaned with industrial washers. For example in the metal processing industry, especially in the automotive industry, parts have to be cleaned from drilling chips and oil. For this a lot of water and chemical add ons are used. It is in the economical as well as the ecological interest of companies to use the washer liquid in an optimal way. On the one hand the washer liquid should not be changed too early, on the other hand high quality requirements in concerning the cleanness of the products have to be fulfilled. In the past, the change of the washer liquid was conducted to more or less subjective criteria. The aim of this work is the development of a sensor system, which is able to detect the optimal point in time to change the washer liquid. Depending on the application the particle pollution or oil pollution are of a higher interest. Therefore, it is necessary to measure these two kinds of pollutions independent from each other. This is realised with the help of an artificial neural network.

Keywords: Quality assurance, water pollution, neural network

1.0 INTRODUCTION

The cleaning of produced parts is necessary to ensure quality requirements and the functionality of the products. For example, in the context of car productions, all parts are cleaned between the production and assembly process. For certain parts the cleaning from particles is most important. For other parts the cleaning of oil is most important, e.g., in preparation of the coating with colour [6], [9], [11], [12]. Therefore, it is necessary to measure these two kinds of pollutions independent from each other. An application is shown in Figure 1.

Other applications are reaching from the cleaning of medical devices up to the cleaning of the chassis of railway trucks in preparation for the maintenance. Accordingly, the range of applications (Figure 2) of industrial washers is wide.

Up to now the change of the washing liquid has been carried out by the workers according to more or less subjective criteria. It is supposed that there is a correlation between the turbidity and other possible relevant parameters, like pH-value, conductance or oil content of the washing liquid. Lab investigations have been carried out to support the certain decision, but this may be expensive and it may take too much time. The definitions and the demands, when a cleaning liquid has to be changed are very different. The developed sensor system should be suitable for particle pollution as well as for pollution by oils. Thus the sensor system is applicable in all cases where the grade of pollution depends on visible pollution or recognisable oils [1], [2], [3], [4], [5]. A continuous and reproducible evaluation of the conditions of the washing liquid do need an independent measurement of particle concentration and oil concentration.

Figure 1 Industrial washer of the company BvLOberflaechentechnik GmbH, Emsbueren, Germany

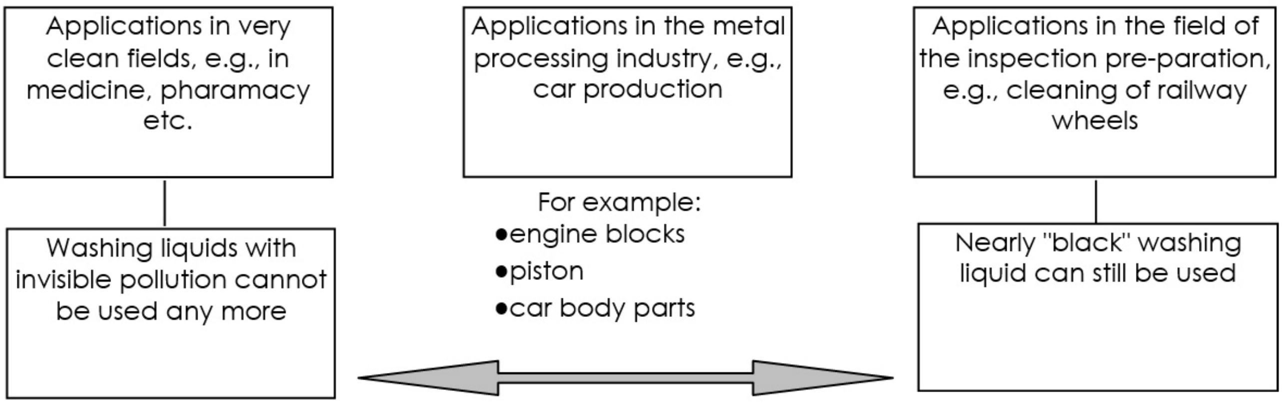


Figure 2 The range of applications of industrial washers

2.0 TWO MAIN POLLUTIONS

The two main pollutions are particles and oil [13][17]. Both have to be measured independently from each other, because different applications need different limits regarding the pollution. For the cleaning of engine blocks the particle pollution is more important as the oil pollution. Every time when parts have to be cleaned in preparation of colour coating, the oil pollution is more important.

3.0 MEASUREMENTS OF VISUALLY RECOGNISABLE POLLUTION AND OIL

Within the sensor te washing liquid is moving through a pipe of highly wear-resistant glass, where it can be observed with a camera and with an oil sensor (Figure 3). Primary measuring signals are the RGB-values, the average brightness of all pixels of the camera and the digital output signal from the oil sensor. To use the measuring range of the camera optimally regarding the turbidity an even illumination of the washing liquid is necessary. An uneven brightness distribution would limit the measurement range by points of over or undermodulation. The demands to the source of light are firstly a simultaneously cover of the whole measurement range and secondly an excellent long time behaviour to guarantee a stable calibration of the whole system.

The oil measurement is using the feature, that many oils used in industry do have the property to fluoresce in the range of blue light under the influence of ultraviolet light. The amplitude of the blue light is used as a measure of the oil concentration in the washing liquid.

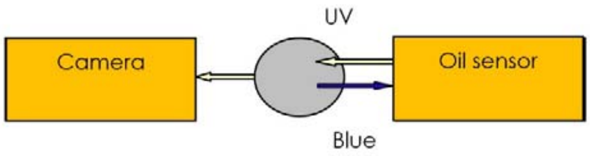


Figure 3 Arrangement of camera and oil sensor at the tube

4.0 INFLUENCE OF OIL AND PARTICLE MEASUREMENT TO EACH OTHER

The measuring results of the oil and the visually recognisable pollution should be independent of each other. Nevertheless, in practice influences takes place. The oil value is not independent of the visible pollution the colour of the pollution and the temperature. So the particles weakens the primary and secondary beam for oil measurement, the oil bubbles are detected as particles, the colours of the particles (especially blue) do have an influence to the oil measurement. It was discover, that the temperature has an influence on both measurements. A simple mathematical description of these interrelations is not possible.

5.0 THE ARTIFICIAL NEURAL NETWORK

For getting two measuring results, which are independent of each other as much as possible a neural network is used [7], [8].

Artificial Neural Networks are software tools, which are able to process input information to output information according to learnable roles (Figure 4).

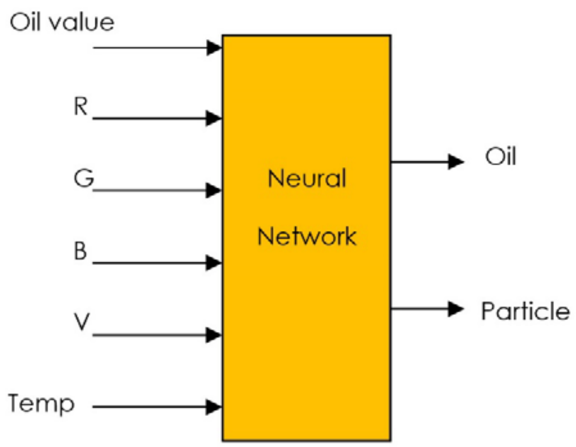


Figure 4 Artificial Neural Network with 6 input values and 2 out put values

Two steps are necessary to use neural networks. In step one the neural network has to be taught. A known oil concentration with different particle concentrations and different colours where measured. In the future we will repeat these measurements at different temperatures. The same will be done with different known oil concentration, etc. In the following the network was taught to cope with all measured data and the known oil and particle concentration. The network then developed the corresponding rules.

In step two, the neural network is used for measurement tasks. For this, the neural network gets the measured data and it uses the derived rules to calculate the oil and particle concentration.

For the development of the neural network, different software systems are available with different advantages and disadvantages. According to the answers to different questions (e.g. time to performance the task, how difficult is the handling, the price, possibilities for optimisation) the decision for the software “Data Model” was made [10].

To teach the system, it was started with five input values (measurement series C to G) and two out put values (measurement series A and B), imported from an EXCEL file (Figure 5).

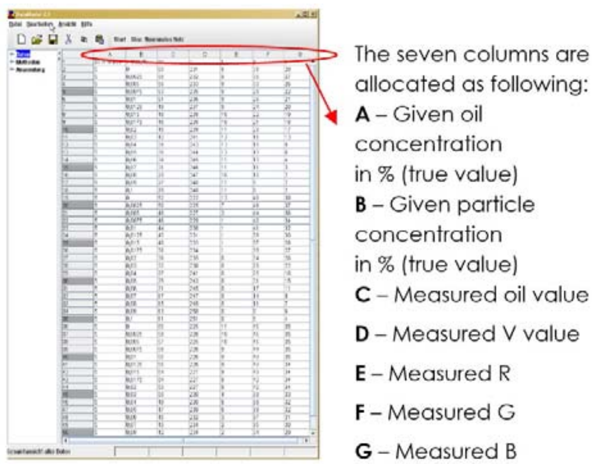


Figure 5 Given out put values and measured input values for teaching the system

After definition of input and output columns, choosing the learning method, the number of knots and the number of iterations, the systems was taught.

6.0 CHECK OF THE RESULTS

We After the teaching process, the neural network was checked with the same input values as before the teaching process. A typical result is shown in Figure 6:

A	A*	B	B*
oil in % true	oil in % true	v- true, %	v- true, %
5	5	0	0
5	5	0,0025	0,0025
5	5	0,005	0,005
5	5	0,0075	0,02
5	5	0,01	0,01
5	5	0,0125	0,0125
5	5	0,015	0,015
5	5	0,0175	0,0175
5	5	0,02	0,0025
5	5	0,03	0,03
5	5	0,04	0,04
5	5	0,05	0,05
5	5	0,06	0,06
5	5	0,07	0,015
5	5	0,08	0,06
5	5	0,09	0,06
5	5	0,1	0,06

A - true concentration of oil in %

A* - calculated concentration of oil in %

B - true concentration of particles in %

B* - calculated concentration of particles in %

Figure 6 Results of the comparison of the true values and calculated values for the oil concentration and the particle concentration

The following figures show the results of the comparison of the true and the calculated oil concentration measurement (Figure 7) and the comparison of the true and the calculated particle concentration measurement (Figure 8).

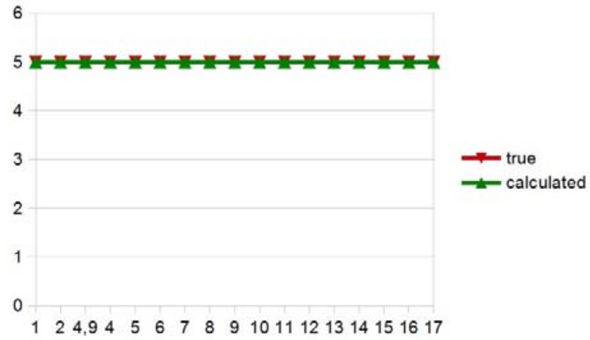


Figure 7 Comparison between true and calculated measurement of oil concentration

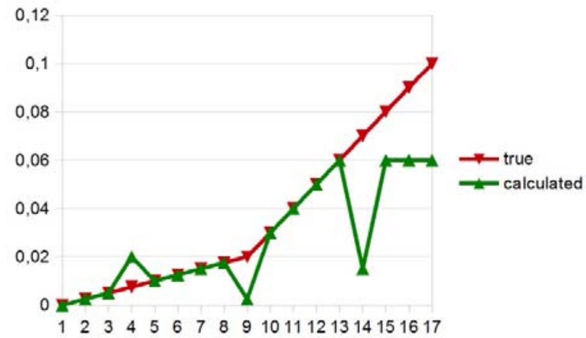


Figure 8 Comparison between true and calculated measurement of particle concentration

It can be seen that the system works excellent regarding the oil concentration measurement but regarding the particle measurement errors do exist partially.

7.0 SUMMARY

The task to calculate two independent values of the concentration of oil and particles in a liquid of industrial washers from measured values of R, G, B, V and oil can be solved with an artificial neural network [7][8][10]. The determination of the oil concentration works excellent but the calculation of the particle concentration shows partly drop outs. Therefore, the next steps will be the optimisation of the neural network to avoid outlier and to introduce the temperature as an additional input value. Furthermore the implementation of the neural network into a device will be realised.

References

[1] Hoffmann, J., Trentmann, W., Sievering, B., Decker, D. 2008. Oberflächenreinigungsvorrichtung. Europäische. Patentanmeldung zu Aktenzeichen 102007016830.8.

[2] Hoffmann, J., Trentmann, W., Sievering, B., Decker, D. 2007. Oberflächenreinigungsvorrichtung. Deutsche Zusatz-Patentanmeldung, Aktenzeichen 102007016830.8.

[3] Hoffmann, J., Trentmann, W., Sievering, B., Düker, Ch. 2006. Surface Cleaning Device. US-Patentanmeldung, Appl No 11/548,74.

[4] Hoffmann, J., Trentmann, W., Sievering, B., Düker, Ch. 2006. Oberflächenreinigungsvorrichtung. Europäische Patentanmeldung, Anmeldung Nr./Patent Nr. 06015733.6-1253.

[5] Hoffmann, J., Trentmann, W., Sievering, B., Düker, Ch. 2005. Oberflächenreinigungsvorrichtung". Deutsche Patentanmeldung, Aktenzeichen 102005049473.0-15.

[6] Hoffmann, J., Lectures about Measurement, Instrumentation and Quality Assurance. By Invitation of the ANCT, Anan, Japan. 17th February 2014 until 26th February 2014.

[7] Hoffmann, J., Trentmann, W., Kalaschnikowa, E. 2014. Quality Assurance of Cleaning Processes by Use of an Artificial Neural Network. Lecture at the International Scientific Symposium New Technologies of the Knowledge Intensive Engineering: Priorities of Development and Training at the Kasan National Technical Research University, A.N.Tupolev" (KAI), NabereschnyjeTschelny.

[8] Hoffmann, J., Trentmann, W., Kalashnikova, E. 2013. Use of an Artificial Neural Networkfor Quality Assurance of Cleaning Processes. Internationales wissenschaftliches Symposium Qualitätssteuerung. Staatliche Universität für Maschinenbau Moskau, 20–21 November. Tagungsband, S. 78–86. ISBN 978-5-94099-126-7

[9] Hoffmann, J., Trentmann, W. 2013. Monitoring of Industrial Washer Liquids. Vortrag auf deminternationalenWissenschaftlichen Symposium New Technologies of the Knowledge Intensive Engineering: Priorities of Development and Training an Der Kasan National nResearch Technical University "A.N.Tupolev" (KAI), NabereschnyjeTschelny, 16.05.-17.05. 2013. Tagungsband, S. 154 - 180. ISBN 987-5-7579-1878-5.

[10] Wasilewskaja, N., Hoffmann, J. & Trentmann, V. 2010. Optimisation of a Neural Network for the Calculation of the Content of Oil and Particles in Liquids of Industrial Washers. Lecture on Invitation of the State Technical University of Moscow (MAMI). 17 June, 2010.

[11] Hoffmann, J. & Trentmann, V. 2009. Monitoring of Industrial Washer Liquids Within the Frame of Cleaning Parts in Automotive Industry. Lecture in International Scientific Conference, Automotive Engineering–2009. Moscow, 25-26 March 2009.

[12] Hoffmann, J. 2008. Measurement of the Condition of Industrial Washer Liquids. Vortragsreihe auf Einladung der Universität von Mittelschweden, Schweden, Sundsvall.

[13] Decker, D., Hoffmann, J., Trentmann, W., 2007. Prozessanalyse und Überwachung bei industriellen Reinigungsanlagen. Vortrag auf dem wissenschaftlichen Kolloquium des Arbeitskreises Mess- und Automatisierungstechnik des VDI, Osnabrück.

[14] Decker, D., Hoffmann, J., Trentmann, W., Sievering, B. 2007. Messsystem zur Bestimmung der Badverschmutzung an Industriewaschanlagen. Proceedings, Industrielles Symposium Mechatronik (ISM), Österreich, Linz.

[15] Hoffmann, J. 2007. *Water Pollution Measurement.* Vortrag auf Einladung der Shandong Jianzhu University, China, Jinan.

[16] Hoffmann, J., Decker, D., Trentmann, W., Sievering, B. 2006. Sensor misst Verschmutzung der Reinigungsflüssigkeit. *JOT–Journal für Oberflächentechnik*. 2-5.

[17] Kirchner, B., Decker, D., Hoffmann, J. 2006. Sensor zur Bestimmung der Badverschmutzung an Industriewaschanlagen. Proceedings, workshop parts2clean 2006, Friedrichshafen.