Modern Sensor Technology for Alphanumeric Recognition in Metallurgy Industry

M. Mikolajek[1], Z. Machacek[1], J. Koziorek[1]
[1]*Department of Cybernetics and Biomedical Engineering, VSB TU Ostrava, 17. listopadu 15, 708 33, Ostrava, Czech Republic*
martin.mikolajek@vsb.cz

***Abstract*—This paper presents the possibilities of modern sensor technology enables measurements of non-electrical physical values by using advanced technology to automatic recognition of alphanumeric marking. Research focuses on analyzing the usefulness of modern sensor technology for special cases in industrial automation for the steel industry. Development of alphanumeric marking recognition system is described with the sensor elements implementation especially the optical scanner for surface differences recognition and the thermo camera surface temperatures recognition. The described research is specialized for various methods that can be used for alphanumeric marks recognizing instead of the standard industrial cameras usage. Verification and Recognition of alphanumeric marking with regard to the applicability in industrial applications for segments detection is very important for actual research orientation.**

***Index Terms*—Alphanumeric marking recognition, optical scanner, thermo camera, metallurgy industry, measurement methods.**

I. INTRODUCTION

There is presented a summary of various special sensor types for the alphanumeric marking recognition in metallurgy industry, which should give data about the type and other parameters of the tested product. Identification of the product is a topic research interest, which is necessary in today's manufacturing processes. For this purpose, There is used a wide variety of sensors, such as ultrasonic, optical, inductive sensors and others sensor types. The practical part describes the use of a special sensor technology in specific problematic case of alphanumeric marking recognition. There are presented tested methods and possibility of reading embossed metal digits which are affected by dust or a considerably high temperature. Specifically, the results are applicable for cases where it is necessary to identify the figures or marks in metal products produced in industrial automation [1].

Developing applications with the sensor data acquisition technology need the firmware implementation of a communication library. There is necessary to obtain for PLC applications development program with support of GSD files, guaranteeing the possibility of sensor communication networks by PROFIBUS and ETHERNET. However, the developed program on PC or embedded control system is possible by SDK communication libraries. The innovation of embossed alphanumeric marks recognition sensor methods is very needful especially for marking machine in metallurgy industry because of dust faults [2].

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II. IDENTIFICATION ASPECTS OF EMBOSSED ALPHANUMERIC MARKING IN METALLURGY INDUSTRY

There is provided more information about the selection of the sensor technology type in order to achieve the expected optimal results. Marked data in the metal material also contain information about the type and quality of the metal slab which is recorded to database information system. The marking process realizes marking of alphanumeric characters in the material form of the embossed depth of 0.5 mm- 1 mm. The size of embossed alphanumeric characters is representing by 15 mm × 10 mm surface. The width of embossed alphanumeric figures is 0.5 mm to 1 mm size. The hole's diameter is about 1 mm in case of using the stamping holes.

Embossed alphanumeric characters may be contaminated by dust or other impurity; therefore we tried testing another method for recognition instead of camera techniques. This problem can be resolved for example by using scanner method for material surfaces detection.

Another problem may be the high temperature of measured product which depends on the location of the sensing device in the industrial technology. The measured metal product can be measured in temperature up to about 800 °C [3], [4].

A. Alphanumeric Marking Recognition Immediately After Embossing Heating Process

This process type is usable to ensure proper readability of embossing alphanumeric data. Thus it is executed for ensuring that the embossing is done correctly for other automatic identification of product. Incorrect elements in alphanumeric marking are usually carried out immediately after the thermal processing of metallurgical materials. The advantage is the fact that immediately after punching alphanumeric markings are recognized, which can guarantee the reliability of reading accuracy of characters. There could be very useful thermal camera for identification of embossing alphanumeric markers. There is not guaranteed enough precision with surface optical sensors usage because of high temperature of marked product.

B. Alphanumeric Marking Recognition for Cold Material State Especially for Automated System

This process type is loaded with deterioration due and oxidation progress and dusty contamination of the applied material. Thus dirty material is not possible to identify with the standard industry camera. Therefore, there is another possibility for identification by a scanner for measuring surfaces of materials.

Fig. 1. Example of embossed alphanumeric marking characters.

The verification of useful sensor type was focused to ensure proper data capturing, such as a scanning resolution, range, sensitivity, operating temperature, mechanical strength etc. The example of embossing alphanumeric marker characters is shown in Fig. 1.

III. SENSOR METHODS DESCRIPTION FOR ALPHANUMERIC MARKS RECOGNIZING IN METALLURGY INDUSTRY

There is presented a selection of the available types of sensing devices for measuring surface. It discusses the available scanners that are suitable for measuring the metal surface so that it is possible to analyse the embossed alphanumeric characters. The possible marking numbers measuring can be performed using accurate laser scanners allow full scanning of surface of a desired object with a great precision. Selecting the type of measuring device must be a compromise between price and value of the measuring device [5].

A. Scanner Type Description Based on Method of Optical Principle

This type of scanners is designed primarily for their use in the laboratory and the clean environment. Scanned slabs are exposed in the environment which it is not intended for, and it would be necessary to use the sensor element with the protection solution. The required resolution for the measurement of embossed characters is 0.5 mm – 1 mm which is suitable only for scanners with EVA series Artec - Eva Lite, Eva or Spider. These types of scanners are generally designed for fast 3D digitization of image objects with a wide range of technology fields for medicine, engineering, archaeology etc. Other types of scanners are not suitable because of lower resolution for embossed alphanumerical characters.

These optical 3D scanners so unlike the laser ones need no reference marks and they are highly portable and lightweight. Scanners allow capturing of large field of view. Scanning occurs in real time and the user sees on the computer monitor that the part of the model has already been scanned. The 3D scanner price is lower than it is for example in laser technology.

There are shown suitable scanners based on the optical principle in Table I.

TABLE I. SCANNER TYPE BASED ON METHOD OF OPTICAL PRINCIPLE.

SCANNERS specifications	**Artec Eva Lite**	**Artec Eva**	**Artec Spiders**
Ability to capture texture	-	Yes	Yes
3D resolution, up to	0.1 mm		
3D point accuracy, up to	0.5 mm		0.03 mm
3D accuracy over distance, up to	0.03% over 100 cm		
Texture resolution	-	1.3 mp	

B. Scanner Type Description Based on Method of Laser Light Principle

The available laser scanners are suitable for use in many industrial applications. This is not a 3D scanner type but it is only line scanner type. There is necessary to realize the moving of the material under the scanner and to assign Y coordinates by using trigger or CMM counters.

These types of scanners must operate in relatively small measuring distances of tens of millimetres. Their advantage is the high precision measurement of the surface in the rank of micrometres. The evaluation of the distance is performed by using the triangulation method. Movement of incidence point of the laser beam is detected by the sensor according to the change in distance between the measured material and the sensor. Triangulation method description composed of laser generator and laser sensor is shown in Fig. 2. [6].

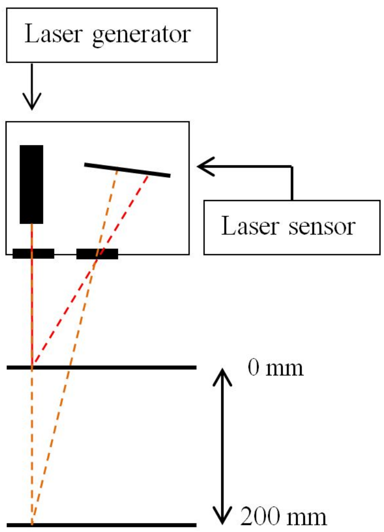

Fig. 2. Triangulation method description composed of laser generator and laser sensor.

TABLE II. SCANNER TYPES BASED ON METHOD OF LASER LIGHT PRINCIPLE.

Parameter	Value
Measuring range X axis	to 143.1 mm
Measuring range Y axis	by moving
Measuring range Z axis	to 265 mm
Measuring speed	from 0.2 to 4 kHz
Maximum measurement accuracy	from 2 to 12 μm
Samples point per measure link	640 to 1280 points

Table II shows only the basic parameters characterizing the laser scanners. The types of scanners with higher measuring range in the Z axis means the less accurate measurements. The accuracy of 2 micron applies to the type that has a measuring range of only 26 mm. At the highest range then the accuracy is 12 microns [7].

C. Infra-Camera Type Description Based on High Temperature Detection

The purpose of the Infra-camera is a non-contact surface temperature measurement of the elements. Choosing the type of camera is always a compromise between practical value of thermo camera and its price which depends on the elementary parameters such as the working temperature, the dpi resolution, the sampling frequency, the temperature sensitivity of camera, the quality of the camera optics etc. Furthermore, it is possible to take into account the parameters which can be the resistance of mechanical design, communication options and the support software. For comparison, there were the variations of uncooled thermal cameras tested there. Typical spacing for uncooled cameras is 38 microns. Therefore to use the same lens of 500 mm the effective detection distance is up to 0.8 km. An important aspect, however, is also The impracticable usage of 500 mm lens to uncooled camera lens is other important aspect because it has the maximum aperture of f/1.6 and low lens diameter of 313 mm and therefore this solution is very expensive compared with the effectiveness of deployment. The resolution affects the price of the camera. The most common resolution of thermal camera is around 160 × 120 pixels or 382 × 288 pixels. These are the lowest price category which is widely used.

IV. TESTING OF SENSOR METHODS FOR ALPHANUMERIC MARKS RECOGNIZING IN METALLURGY

There are presented testing processes and results of chosen possible sensor methods for embossed alphanumeric marks especially for metallurgy industry. The verification of sensor methods applicability is executed for scanner type based on the method of optical principle, the scanner type based on method of laser light principle, the thermo-camera type description based on the high temperature detection. The both types of scanners were tested for reading the alphanumeric characters placed on the cold metal product in the laboratory. The thermo camera was tested for reading alphanumeric characters placed on the hot metal product in metallurgy [8].

The image recognition quality was significantly affected by the type of surface of given material from the metallurgical process. The measurement of embossed alphanumeric characters through the use of thermal camera was divided into three basic types of measurement given by unwanted flakes contamination quantity on the analysed material with approximately 0, 30, 60 percentage in the area of the alphanumeric characters. The measurement of 20 samples was carried out for individual types of surfaces. The analysed results of low level contaminated characters were satisfied for the measured samples by the standard image camera. There was evaluated about 3 percentage improvement of recognition by surface scanner usage. The readability is decreasing with higher level of contaminated characters especially for standard image camera, therefore the thermal camera measurement efforts about 12–15 percentage higher reliability of measurement. The higher reliability of measurements of embossed characters via the thermal camera happens due to the possibility to monitor the thermal differences of surface of embossed characters and own material. The reading of embossed characters must be carried out immediately after embossing itself before the temperature is balanced out. The other advantage is that the thermal camera for reading of characters can be placed at the greater distance from the hot measured material.

A. Verification of Scanner Sensor Method Based on Optical Principle

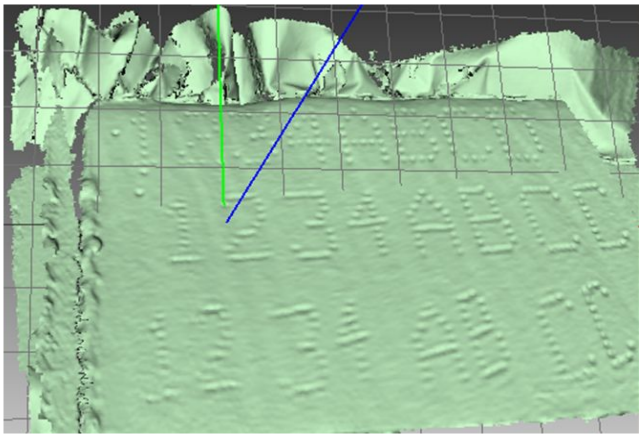

Fig. 3. Verification of scanner sensor method based on optical principle.

The verification was performed with 3D optical scanner EVA series Artec [8]. This type of scanner was used for test measuring at the laboratory. There was necessary to place around the measured metal surface the non-flat paper for connectivity of optical methodology algorithms. There is implemented the special software application for PC which gives computed result image shown in Fig. 3. The problem for implementation is SDK library unavailability for own application software developing. The embossed alphanumeric points are readable for image recognition algorithm which is shown in Fig. 3.

B. Verification of Scanner Sensor Method Based on Laser Light Principle

The verification was performed with Microepsilon 2750-100 scanner sensor. This type of scanner was used for test measuring at laboratory for 2D surface differences measurement. Compared to previous scanner sensor method the measured product is shifted toward the scanner in one direction. Measurement speed is set to 250 frames per second. The measured results are presented graphically in the following Fig. 4. There is not assured the ideal constant velocity motion of sensor above the measured product, reading characters can be not clearly readable.

The other laboratory measurement of Microepsilon 2750-100 scanner sensor was performed with the linear unit for moving the sensor over the steel plate shown in Fig. 5. The surface movement speed was 9 mm/s and the profile frequency was of 160 profiles per second. The maximal possible movement speed to scan over the surface is about 60 mm per second. If this isn't enough either there is possible to reduce the measured points per scan from 1280 pixel resolution to 640 pixel resolution.

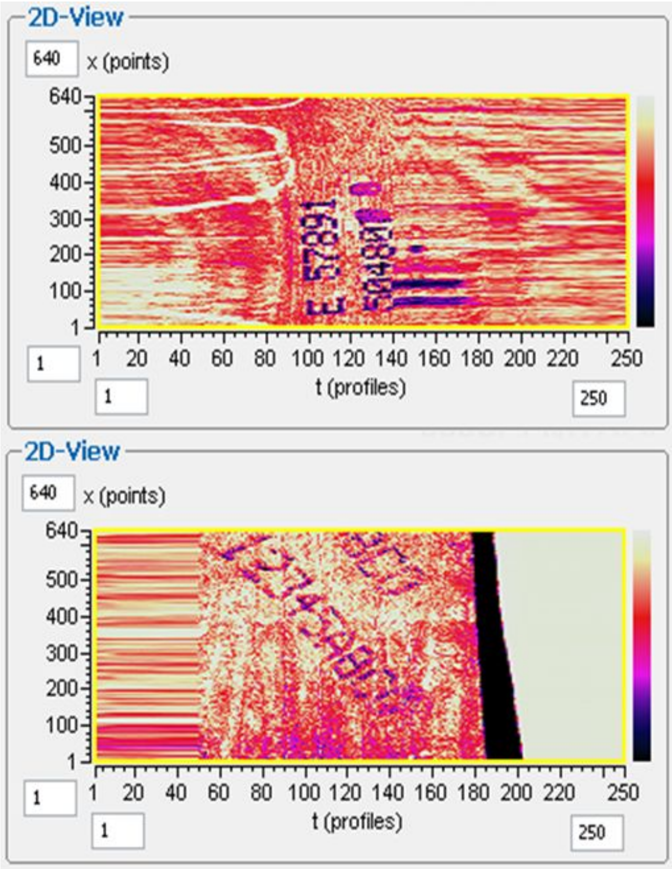

Fig. 4. Verification result of scanner sensor method based on laser light principle with non-constant movement.

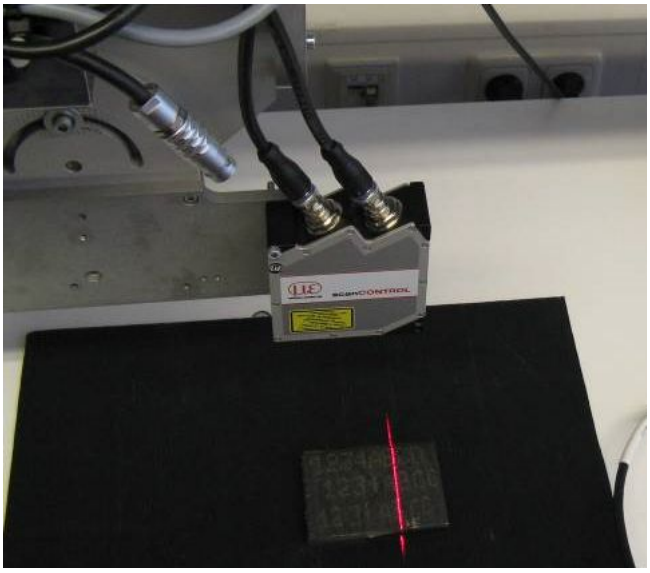

Fig. 5. Laboratory measurement of scanner sensor method based on laser light principle with constant movement.

It increases possibility of movement speed to 120 mm per second, but it has to be proved if the dots in the metallurgy material will still be detected. The measured results are presented graphically in Fig. 6.

Fig. 6. Verification result of scanner sensor method based on laser light principle with constant movement.

A. Verification of Infra-Camera Type Based on High Temperature Detection

The verification was performed with infra-camera Micro -

Epsilon TIM 200. This type of infra-camera has the resolution of 160 × 120 pixels with the possibility of 1500 Celsius degree measuring.

Fig. 7. Verification result of thermo-camera type based on high temperature detection.

Compared to the previous methods this measurement is usable for the high temperature surfaces especially immediately after embossing of marking characters because there is for a short time different temperature in the embossed places. There is problem with different temperature field on the others places not only where embossed characters are. The measured result by infra-camera is presented in Fig. 7.

V. CONCLUSIONS

The purpose of the paper was to realize the verification of the possible special sensor technology methods in the specific problematic case of embossed alphanumeric marking recognition for the metallurgy industry. These method types are verified in laboratory as well as in industry implementation. The measured metal product can be measured in cold temperature or in high temperature up to about 800 Celsius degree.

There are presented processes and results for the scanner type based on the method of optical principle, the scanner type based on the method of laser light principle, and the infra-camera type description based on the high temperature detection. The paper analysed the possibility and limits of usage of these special sensor methods for precise image recognition of embossed alphanumeric characters in the metallurgy material.

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