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THREAD QUALITY IDENTIFICATION OF 2.5 MM THICK STEEL PLATE USING IMAGE RECOGNITION

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Abstract. Currently, the image recognition systems in the industry for identifying the characteristics of manufactured parts are very diverse, but the quality of their recognition is most influenced not by the image recognition camera itself, since their operation is similar, but by the conditions of the environment in which the product is examined. Such as dust, vibration, lighting. To find out the influence of the illumination of the part under investigation on determining its quality, the image recognition camera used in the study was the "*SICK Inspector PIM60*" image recognition camera, the "*YONGNUO" LED YN-160S*" light source and the camera dome and filters of various colors: red, blue, green, transparent, and variable ND filter. The obtained results show that using a green camera filter and external illumination of the part from one side is the best way to identify the thread quality of the part. The results obtained show that using a green filter and external illumination of the test piece, it is possible to obtain ~100% recognition of the part and its holes dimensions quality if the part is always placed in the same place and the same lighting conditions are used.

Keywords: image recognition; filter; camera, quality; defect.

INTRODUCTION

Currently devices to ensure the quality of manufactured parts or other products are increasingly used. To find out the different capabilities of a standard industrial camera with image recognition software, a study comparing the quality of detail quality recognition by changing the camera filters and lighting conditions was conducted. 5 different filters were used in the study (clear, red, blue, ND and green filter). The object of research is an automatic image recognition system used to determine the quality of details. The results obtained show that using a green filter and external illumination of the test piece, it is possible to obtain ~100% recognition of the part and its holes dimensions quality if the part is always placed in the same place and the same lighting conditions are used. Quality control is the most important function of manufacturers because the product produced by the company is only on demand if it is of high quality and meets the requirements of accuracy, safety and reliability defined in the standards. Quality control can be manual (the quality of the product or its part is checked by an employee using a special device to detect and identify defects) or automatic (a product defect is detected automatically without human intervention). Automated inspection can use an image recognition system to compare the physical characteristics (dimensions, surface engravings, holes, etc.) of a quality product. Currently, in the field of industry, automatic image recognition systems are increasingly used to ensure product quality, as their price has decreased three times over the last 20 years, and the possibilities of use and quality have increased (ZANCUL et al., 2020, WEDEL et al., 2011). Unnoticed manufacturing defects can lead to the recall of the product being manufactured at the time, and ultimately result in lawsuits if the defect(s) has in any way harmed the health of the consumer or the continued quality of the product (Gasiūnas et al.,2022).

THE METHODOLOGY AND RESULTS OBTAINED IN PREVIOUS STUDIES

The physical equipment consists of: Inspector PIM60 video recognition camera manufactured by SICK, YONGNUO LED YN-160S external light source, test pieces (see Figure 1), and a computer (must have 1GB RAM or more, CPU Pentium 1 GHz or better) with a LAN connection (SOPAS 2016). The layout of the physical equipment during the research is presented in Figures 2 and 4. The camera software "SOPAS" was used in the experiments, which allows to detect the object based on its shape and identification mark (inscription, scratch, sticker, drawing, etc.) (Gasiūnas et al.,2022, SICK 2018, YONGNUO 2021).

The methodology used to detect a defect in the threads of parts using a video camera is based on the introduction of comparison settings (marking the quality features of the part under the conditions in which the properties of other parts will be studied). To capture the settings, the most suitable conditions are sought, applying various filters and lighting configurations, i.e., by selecting the best quality detection conditions for a specific detail, to which the object under study is best focused. Once a typical (reference) setting is made, the test details are compared to it (see Figures 1-2).

The first study used only the camera's factory built-in lighting with clear, red, blue, and green filters, and the subject was 90-100mm away from the camera. The layout of the equipment used in the experiments and the obtained results are presented in Figures 1-2.

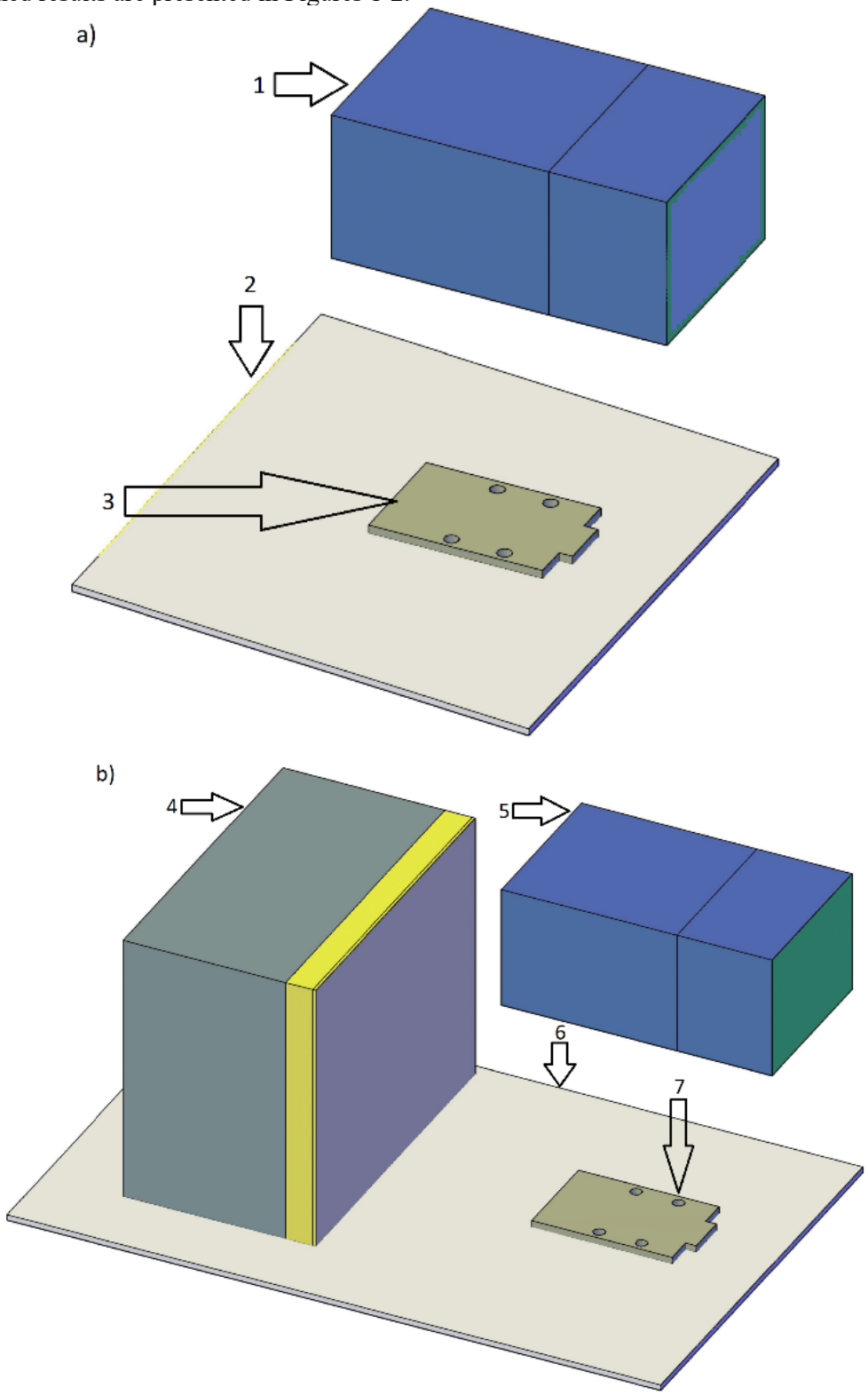
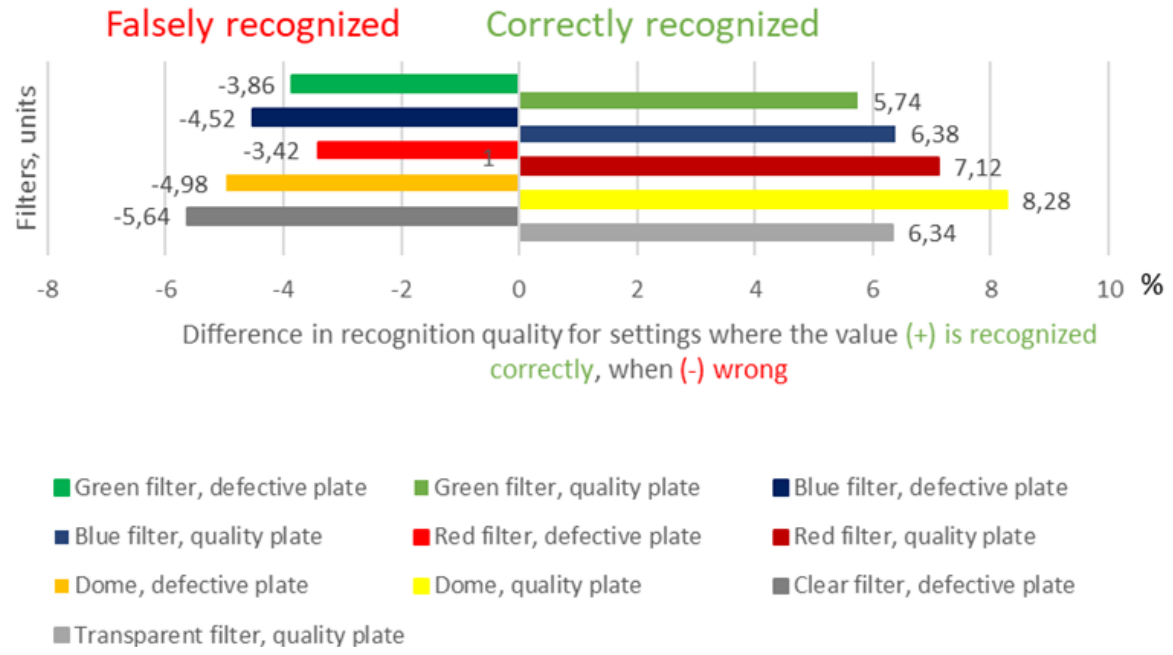


Figure 1. (a) **Layout of the physical equipment used in the study without external lighting (1'st study);** (b) **Layout of the physical equipment used in the study with external lighting (2'nd study)**
1, 5 – image recognition camera / sensor (*SICK INSPECTOR PIM 60*); 2, 6 – interchangeable base; 3, 7 – object under investigation; 4 – lighting.

The second study used additional external side illumination of the subject with clear, red, blue, and green filters, and the subject was 90-100 mm away from the camera. The layout of the equipment used in the experiments and the obtained results are presented in Figures 1 and 2.

a)



b)

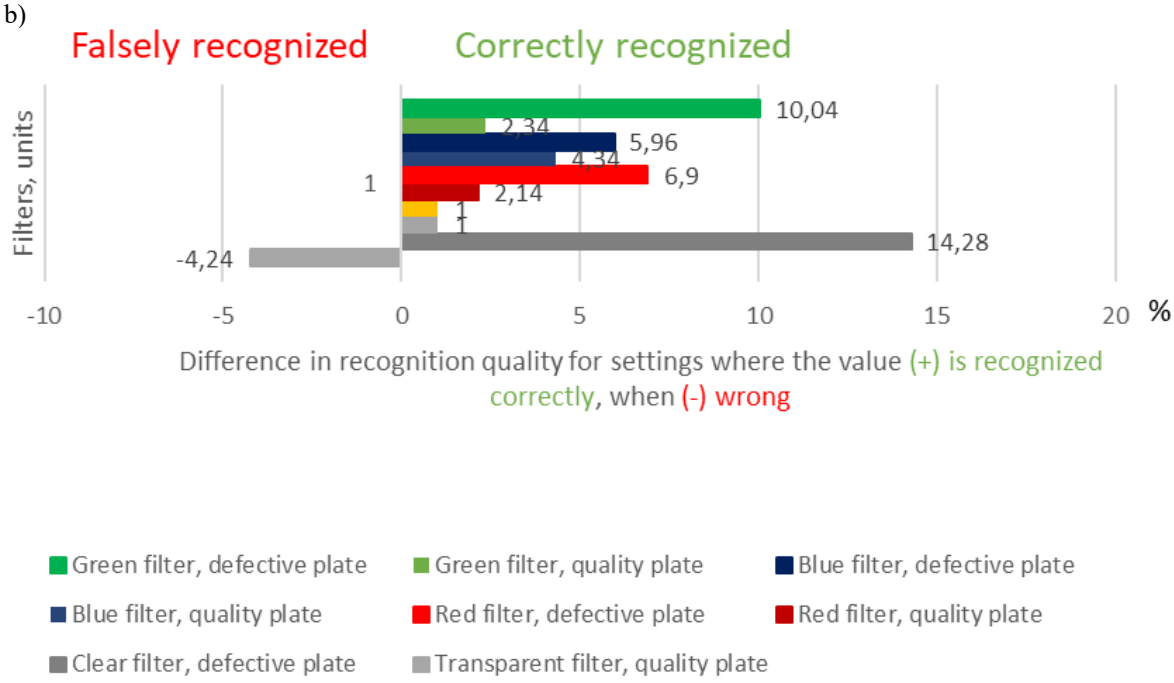


Figure 2. (a) **The first study results;** (b) **The second study results**

In the first study, the recognition of a part's dimensional inconsistency with settings using clear, red, blue, and green filters and the internal (integrated) illumination of the camera is null, i.e., the defect in details is not noticeable and all of them are 100%. cases are identified as high-quality (see Figure 2).

According to the results obtained in the second study, the recognition of the quality parts was 20% with external lighting and the clear filter, 20% with the red filter, 0% with the blue filter, and both quality and defective parts with the green filter in all tests were correctly identified, i.e., 100 percent accuracy (see Figure 2).

When using a green filter and illuminating the studied part from the side, the features of the part were correctly identified in all cases, and the recognition of a high-quality part exceeded 0.94 percent. value (≥90 percent) (see Figure 2) (Gasiūnas et al.,2022).

The third study used additional external side illumination of the subject with ND filter, and the subject was 90-100 mm away from the camera. The layout of the equipment used in the experiments and the obtained results are presented in Figures 1b), 3 and table 1.

Table 1

The third study (with ND filter)

Study	Average difference with conformance limit (conformance difference must be ≥0%), %			Comment
	Quality	*Defect*	*Results*	
ND0	-2,6	10,86	-	Recognized 5/10
ND2	-7,07	9,81	-	Recognized 5/10
ND4	-1,88	10,9	-	Recognized 5/10
ND8	-0,31	5,96	-	Recognized 5/10
ND16	-9,14	11,93	-	Recognized 5/10
ND32	-1,31	9,41	-	Recognized 5/10
ND64	0,3	19,24	+	Recognized 7/10
ND128	-0,29	12,84	-	Recognized 5/10
ND256	-4,19	21,17	-	Recognized 5/10

RESULTS

In the third study, the recognition of a defects with settings using ND (variable) filter and the external illumination of the camera is close to null, i.e., the quality details are not noticeable and 95,56%. cases are identified as defective (see Figure 4). Only when the filter is set to ND64, the camera detects the features of the parts more accurately, the recognition accuracy reaches only 7 recognitions out of 10 attempts, which is 70 % accuracy (see Figure 3) (Gasiūnas et al.,2022).

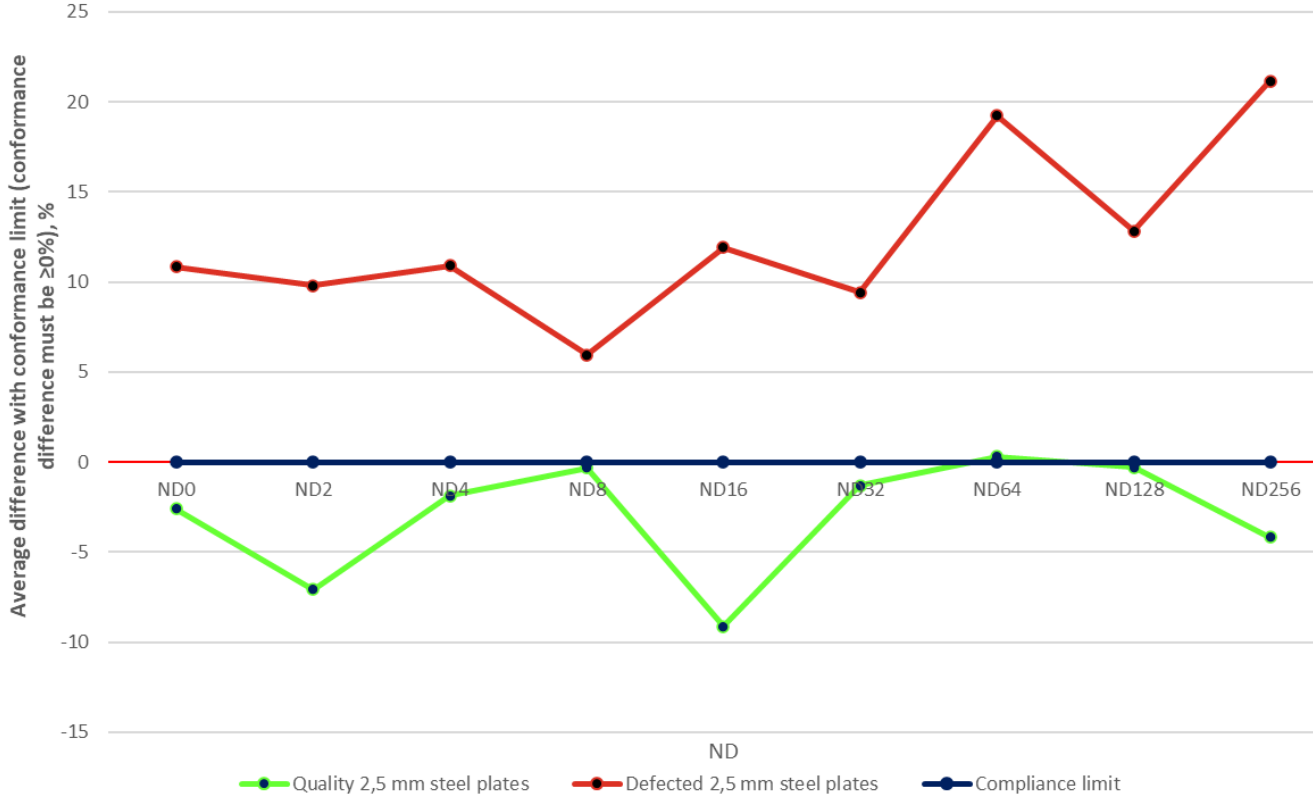


Figure 3. **The third study (with ND filter), results**

According to the results obtained in the third study, the recognition of the quality with ND filter not noticeable and still the best results are obtained with the green filter, i.e., 100 percent accuracy (see Figure 2).

CONCLUSIONS

1. After conducting research, the best quality research results with ND filter (0-256) were obtained when the filter is set to ND64, accuracy reaches only 7 recognitions out of 10 attempts, which is 70 % accuracy. So, results from previous study was better.
2. After conducting research, the best quality research results were obtained by observing the part at 90-100 mm, using a green camera filter and external lighting from one side. It was found that, when observing the part in approximately the same position (±5 mm and ±5°), even 100 percent can be obtained. recognition accuracy (quality details correspond to settings ≥90, and defective parts correspond to settings <90).

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