STUDY OF PUNCH-DIE MISALIGNMENT USING MACHINE VISION SYSTEM

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DECLARATION

This work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree.

Signed.............................. (Mohd Fairdaous bin Basir)

Date.................................

STATEMENT 1

This journal paper is the result of my own investigation, except where otherwise stated. Other sources are acknowledged by giving explicit references. Bibliography/references are appended.

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STATEMENT 2

I hereby give consent for my journal paper, if accepted, to be available for photocopying and for interlibrary loan, and for the title and summary to be made available outside organizations.

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TABLE OF CONTENTS

LIST OF FIGURES

ABSTRAK

Salah jajaran adalah salah satu sumber utama kecacatan dalam proses penebukan. Ini akan melambatkan keseluruhan proses dalam garis pengeluaran, membawa kepada pelbagai masalah seperti kelewatan penghantaran produk. Kajian ini menyiasat salah jajaran penebuk-dai menggunakan sistem pemprosesan imej dan sistem penglihatan mesin. Salah jajaran penebuk-dai yang diperolehi dengan menganalisis imej yang ditangkap menggunakan sistem pemprosesan imej. penebuk-dai diletakkan pada mesin tekanan hidraulik. Lampu kelajuan dan lampu LED telah diletakkan di belakang spesimen bagi menghasilkan imej berkualiti untuk diproses pada MATLAB. Imej yang ditangkap telah dianalisis dengan menggunakan pemprosesan imej. Berbanding dengan cara-cara yang biasa mengesan kesalahan jajaran digabungkan dengan sistem pemprosesan imej mempunyai potensi yang besar untuk mengurangkan penggunaan masa untuk memperbaiki salah jajaran.

ABSTRACT

Misalignment is one of the main sources of defect in deep drawing process. This will delay the whole process in a production line, lead to many problem such as late of product delivery. This study investigate the punch-die misalignment using image processing system and machine vision system. The misalignment of the punch-die are obtained by analyzing the image captured using image processing system. The punch-die was placed on hydraulic press machine. Speed lights and LED lights were placed behind the specimen to capture a good quality image to be processed on MATLAB. The captured images were analyzed using image processing. Compared with the usual ways of detecting misalignment combined with the purposed image processing system has significant potential for decreasing the time consumption on fixing the misalignment.

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Index Terms—misalignment, image processing

1.0 INTRODUCTION

The accuracy of product geometries such as angle and flange length is more important than ever in today's manufacturing environment. Misalignment is one of the main sources of defect in deep drawing process and main causes of die failure. Misalignment comes from various sources including fabrication error e.g. machining and grinding and assembly error. Die-punch misalignment can be caused by four conditions, out-of-round punch, axial imbalance, tilting of the punch, and tilting of the die. The out-of-round punch is typically due to the machining error, whereas the remaining types are commonly due to the assembly error presence of any unintended object. Checking tooling alignment is a simple way to confirm that application will turn out the way expected. Nowadays, forming simulations are widely used in a trial and error scheme to develop a forming process which produces reliable parts. However the increment in complexity of the part thus optimization techniques have been developed to obtain the best result.

Generally, tool monitoring is divided into two categories, namely, direct and indirect methods. The direct method measures the actual quantity of measured variable such as volume of lost material for tool wear, while the indirect method measures auxiliary quantities and obtains the actual quantity through empirical correlation (Byrne et al., 1995). The indirect method uses sensor data to detect the machine condition. This method is more practical to implement in the industry because it enables monitoring the process online without the necessity to stop the process. Many methods have been developed for tool monitoring in the machining process.

However, there are few studies that focus on tool monitoring in sheet metal working such as stamping and punching/blanking process. For stamping monitoring, most literatures use tonnage and/or strain signal (Sari et al., 2016). These signals provide information about changes in process variables and are widely used for tooling protection from overload, controlling part quality and detecting forming faults such as misfeeds and scrap in the die. In the punching process, the cutting process is performed by a punch and die. As the wear state of these tools is different, tool wear monitoring becomes more complicated because it should involve the wear progress of different tools. However, these tools' wear state concurrently influences the burr formation during the cutting process. As burr formation is one of the important keys in quality control and it indicates the tool condition, online monitoring in the punching process can be directed to monitor the burr formation. Vibration-based monitoring method is developed for the punching process where the vibration signal is measured vertically at the upper tool and lower tool (Sari et al., 2016). There are three types of failures frequently exist in deep drawing process which are wrinkling, earing, and fracture (Wifi et al., 2007). Any misalignment of the die may cause severe damage. If the punch is not aligned to the hole in the die, non-uniform clearance will occur. If the clearance is too large, then large burrs and parts with poor quality will be produced (Husson et al., 2008). However, if the clearance is too tight, parts with poor edge quality may be produced, thus reducing tools life, showed that die-punch misalignment changes the maximum force by up to 4% (Slavic et al., 2004). To improve the quality of sheared edge, ultra-high strength steel sheets were punched under slight clearance between a punch and die. By the slight clearance, the tensile stress during the punching is reduced (Mori et al., 2013). In addition, a cold punching process of die-quenched steel sheets having high strength and low ductility was developed. A slight clearance punching process of ultra-high strength steel sheets with a moving die was developed to correct the eccentricity between the punch and die automatically. By setting a gap between the moving die and holder, the die is shifted by imbalanced force, and the punch and die become concentric after several strikes (Jaafar et al., 2014).

Furthermore, misalignment may exacerbate the stress produced during the operation of the die and punch, thus leading to premature tool wear, breakage, and part quality (Guo, and Tam, et al., 2012). Misalignment is one of the main causes of die failure (Fox et al., 2008). The effect of tooling on wrinkling and found that the tilting of the blank is an important parameter and that small tilting causes large wrinkling (Hematian, and Wild, et al., 2001). (Broomfield et al. 2009) suggested the use of the die set to avoid the misalignment of the punch and die. Similarly, a stripper was designed that may guide the punch tip to minimize the possible of misalignment (Joo et al., 2001). Utilized the drain cavity channel to ensure correct positioning and alignment (Modi, and Kumar, et al., 2013), and applied the blank-holder-gap profile approach to achieve minimal thinning (Hosseini, and Kadkhodayan, et al., 2014).

Die-punch misalignment can be caused by four conditions, namely, out-of-round punch, axial imbalance, tilting of the punch, and tilting of the die (Vairan, and Abdullah, et al., 2017). A slight clearance punching process of ultra-high strength steel sheets using a punch having a small round edge to improve the quality of the sheared edge has been developed (Mori et al., 2013). In this process, setting of tools is not easy in practical punching operations due to the small clearance between the punch and die. In application, for example an automatic visual inspection (AVI) system for detecting stamping defects in leadframes manufacturing were developed (Zamani et al., 2003). Their system requires that images be captured without the presence of any misalignment and thus the leadframe must be aligned accurately with the camera during the image capture.

Know that any misalignment of the die may cause severe damage. The objective of this study is to propose an assessment of puncher-die alignment utilizing image processing technique. For the case study, a simple blanking tooling had been used.

2.0 METHODOLOGY

The study conducted in four steps methodology;

2.1 Specimen set up position

The punch-die set were prepared on hydraulic press machine. For this study, a simple blanking tooling for a tensile specimen shape had been used. There were two types of set up for this investigation which is front and side of the die set. The camera was set up to the position in front and side of the punch-die set. For the front view, the camera was placed 30cm from the puncher-die set. While for the side view, the camera distance from the puncher-die set is 25cm. The camera was set up to f/7 aperture, 100 ISO, 1/160 s shutter speed, 32mm focal length. The lighting set was set to 100% white intensity and placed behind the punch-die set as shown in Figure 1(a), Figure 1(b), Figure 2(a), and Figure 2(b). The camera was linked to the MATLAB software.

Figure 1(a) Front view image camera set up

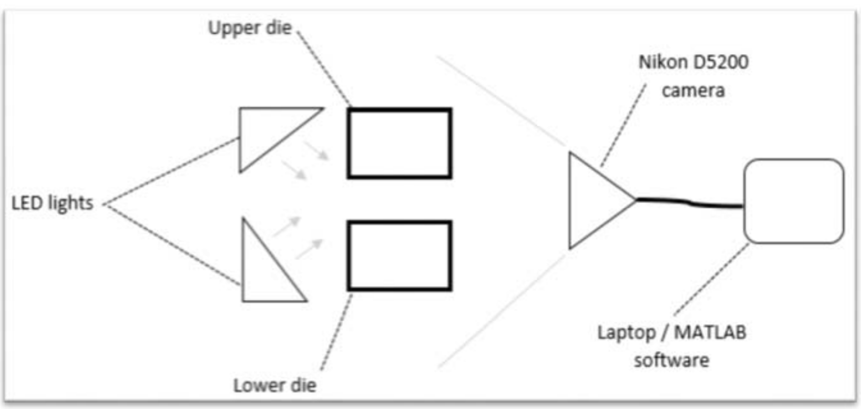

Figure 1(b) Front view image camera set up

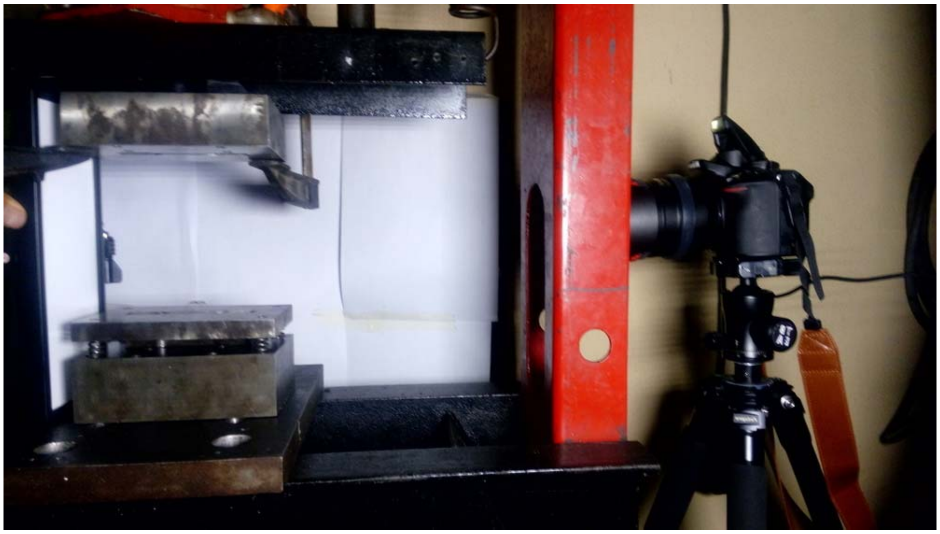

Figure 2(a) Side view image camera set up

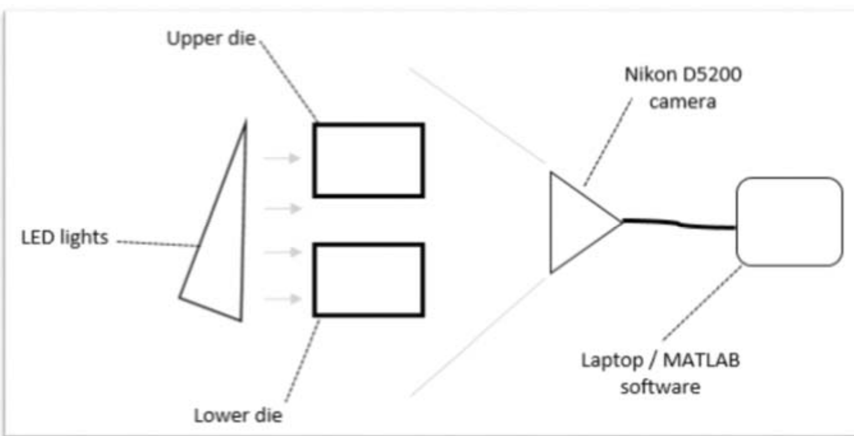

Figure 2(b) Side view image camera set up

2.2 Image capturing

The image of punch-die was captured using the Canon D5200 high definition single lens reflex, HD-SLR camera. The camera has 24.1 Megapixel DX-format CMOS image sensor for exceptional image quality, 3.0-inch 921,000-dot Vari-angle LCD display that swivels to nearly any position, built-in HDR (high dynamic range) and pro-quality special effects and filters, serious video capabilities: Full HD (1080p) recording at 30p, 25p, 24p and 60i, plus an ultra-high quality built-in stereo microphone, and Wi-Fi photo sharing and camera control with the optional WU-1a Wireless Adapter. The image was captured using various resolution, focal length, and controlled lighting condition to investigate the effect on image captured.

The camera was set up as shown in Figure 1(a), Figure 1(b), Figure 2(a), and Figure 2(b). The image was captured at two different views to observe the alignment of punch-die. This was done to ensure that the alignment is align within x-axis and z-axis of the puncher-die set. The image was captured in controlled lighting condition which there is no other light source used unless the LED light as per shown in set up in other words, dark surrounding. Figure 3 shows the front and side view image of the die.

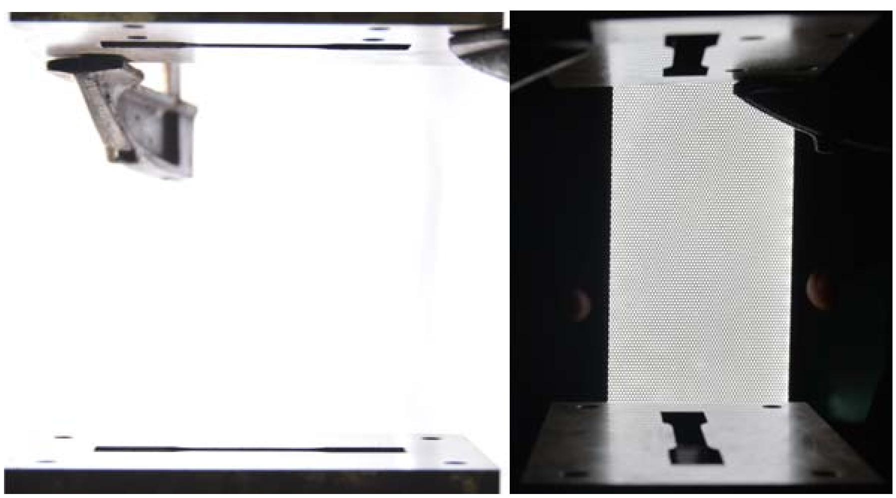

Figure 3 Front and side view image

2.3 Image processing

To analyze a particular region-of-interest centroid the image was converted into grayscale, inverted the black and white color in grayscale image and was cropped into selected region-of-interest. The grayscale was applied to improvise the contrast of the image. The edge of punch-die can be seen clearly after converting to grayscale. The image then was processed into black-and-white ratio balance. The black-and-wh3ite image will enhance the different between bit 1 and 0. The program in MATLAB also defined the centroid point region-of-interest. The centroid point can be seen and compared within this steps (Figure 4). The algorithm used to processing the image is shown in Figure 5. The algorithm was coded in MATLAB (Release: R2013b, The MathWork Inc., USA). Image was analyzed to extract the centroid point to be compared in order to check the alignment of the die.

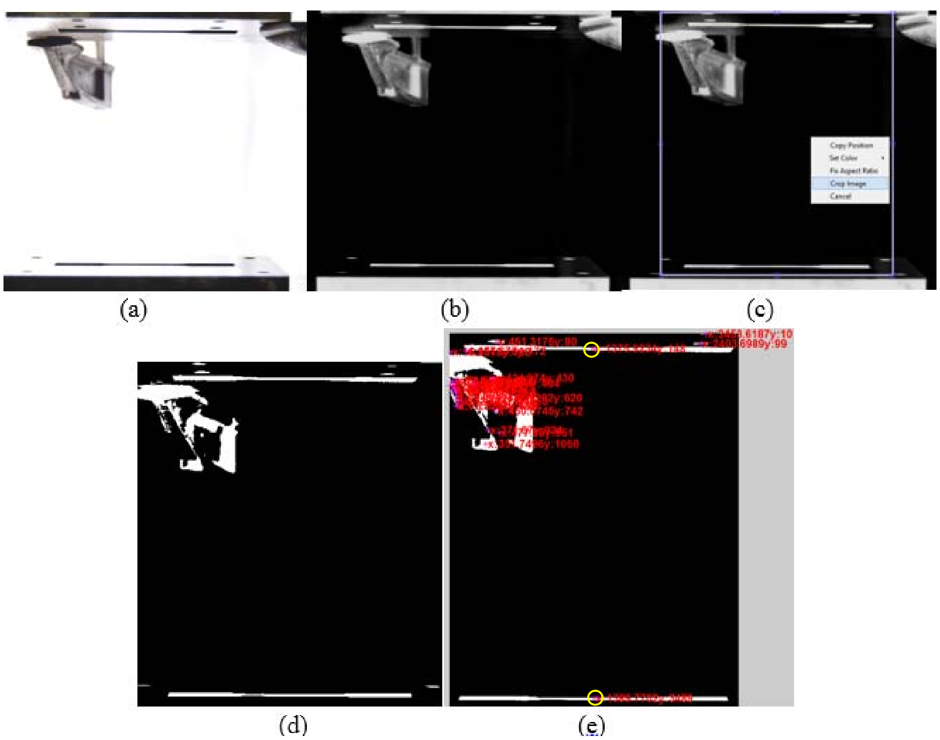

Figure 4 (a) original image, (b) grayscale image, (c) cropping the image, (d) cropped image, (e) superimpose image with centroid point

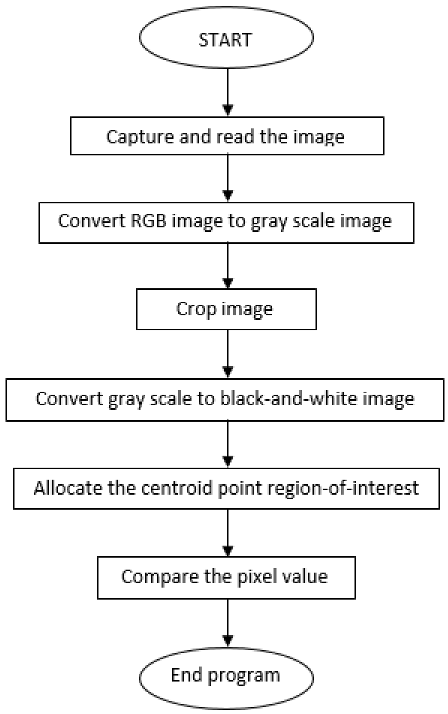

Figure 5 Image processing algorithm flowchart

2.4 Determination of punch-die misalignment

The centroid value were obtained using the MATLAB (Release: R2013b, The MathWork Inc., USA) centroid function program. The value acquired at the centroid of region-of-interest to be analyzed. The comparison is shown in Figure 3. The horizontal value in the centroid was used to detect the misalignment of the punch-die. The die was said to be misalign if there were slight different in horizontal pixel value between the upper die and lower die.

3.0 RESULT AND DISCUSSION

The algorithm to propose a simple solution for the assessment of the alignment parameters in pixel on punch-die by development of image processing system to capture image and develop machine vision system to automatically inspect the misalignment of the punch-die alignment was tested. The relationships between the image capture and alignment measured using MATLAB are presented in yellow circle as point-of-interest as shown in Figure 6, Figure 7, Figure 8, Figure 9, Figure 10, and Figure 11.

Commented [u1]: What is the alignment parameter?

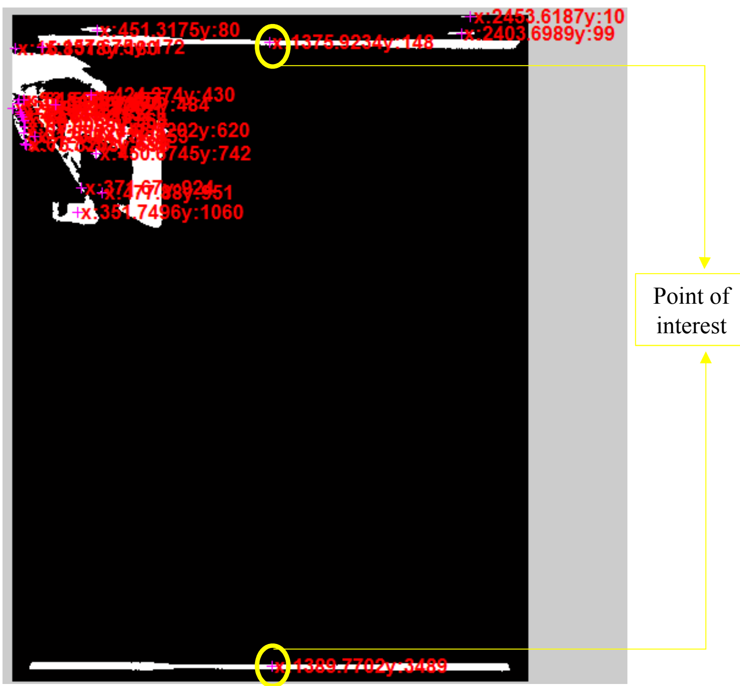

Figure 6 Region-of-interest front view centroid value

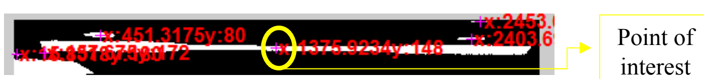

Figure 7 Front view upper die centroid value

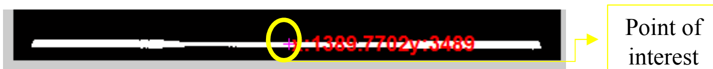

Figure 8 Front view lower die centroid value

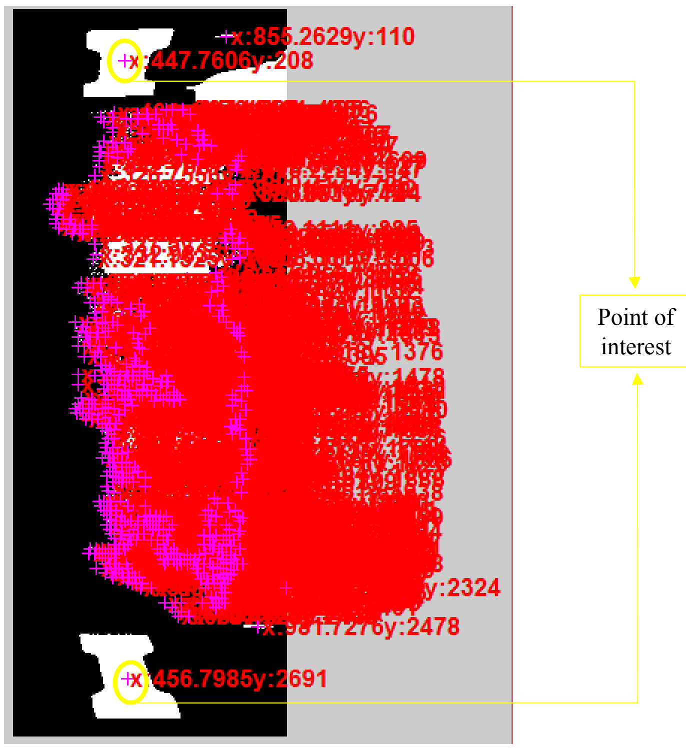

Figure 9 Region-of-interest side view centroid value

Figure 10 Side view upper die centroid value

Figure 11 Side view lower die centroid value

The centroid value is represented super-imposed within black-and-white image. The pixel value of both front and side view were represented in Table 1.

Table 1 Centroid value comparison

	Front view (x-axis, y-axis)	Side view (x-axis, y-axis)
Upper die	1375.9230 , 148	447.7606 , 208
Lower die	1389.7702, 3489	456.7985 , 2691

Table in Figure 10 shown that there are slight different pixel value in x-axis for the front view which is 13.8472 and for side view is 9.0379 unit in pixel value. The lower die x-axis unit is bigger than upper die for both front and side view of the image. The datum point for the crop image is at the top-left-side of the image, thus means for front view image, the lower die is about 13.8472 pixel to the right of the upper die. While for side view image, the lower die is about 9.0379 pixel to the right of the upper die. To eliminate the misalignment for both upper and lower die, some calibration is needed. There are some step needed to convert pixel unit to millimeter (mm) unit. A scale is needed inside the image while capturing the image. Based on the image obtained, measure the scale using 'measure in distance' in pixel unit on 'imtool' command MATLAB. Compare the pixel and scale unit using simple equation to get the exact scale of the image.

4.0 CONCLUSION

A new technique of detecting the misalignment of simple punch-die set from an image is proposed with the use of change the image from red-green-blue (RGB) format to grayscale format, black-and-white ratio, inversing the black-and-white ratio, and located the centroid point within the region-of-interest. The image centroid point within the region-of-interest between the upper and lower die define the die-alignment. The correlation of centroid values is the key to this study. The study of punch-die misalignment using machine vision system provide less cost of manual experimenting the die to determine whether it is align properly or vice versa. In this investigation, this fact was proved when there were only two images needed to detect the misalignment while the common ways of detecting the die alignment was with testing with the real specimen.

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