Mechanical parts dimension measuring technology based on optical zoom

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Abstract: Since height measured equipment which is applied to traditional Mechanical component have some drawbacks such as low efficiency, high random deviation and small accuracy, the paper puts forward a project which can design a check instrument of high velocity and accuracy. Besides, it takes many details to illustrate the structure of the instrument, design of measuring line road and analysis the system's deviation. In a word, the instrument has characteristics of high efficiency, high accuracy and low random deviation.

Key words: Fast, High-precision, Thickness, Tester

1 INTRODUCTION

With the emergence of the world advanced CNC machine tools, grinders, milling machines, the machine is also toward specialization, specific direction of development. in order to reduce the cost of machining, increase the economic efficiency of enterprises and the machining mechanical parts tend to specific production. The requirements of the mechanical parts interchangeability have become more sophisticated, so the test is an important task of the machined parts. Especially parts high level of detection, the result of detection is a measure of one of the important criterion for eligibility of certain parts. Currently, domestic enterprises for the height of the detection of large quantities of parts often are used sample survey methods, and are mostly manual inspection. The disadvantage as follow: on the one hand ，parts of detection is slow, low efficiency. On the other hand, the use of sampling to detect can not guarantee that every products are qualified, and the extracted local detection products can not accurately represent all products. The existing inspection gages are difficult to achieve high precision detection parts height. Mechanical parts of fast, high-precision detection instruments are quite expensive price. For the above-mentioned drawbacks, there is necessary to design a fast, precision height detector. In the case of the instrument of lower cost, it can achieve fast, high-precision detection of the height when the mechanical parts are large quantities. It improved work efficiency， and ensure that the output of each products are qualified products. What is more， it Weeds out unqualified products, and generates greater economic benefits.

1.1 The height detection principle parts and overall program

1.1.1Detection of the basic principles

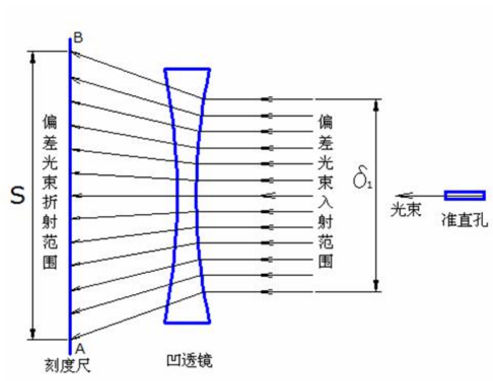


Fig. 1 Refraction of light path

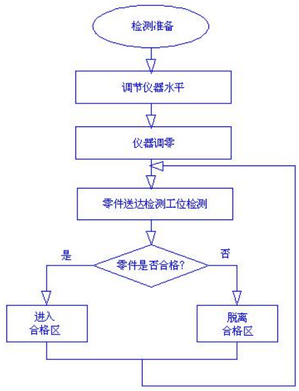


Fig. 2 The flow chart of the detection scheme

As Figure 1， the colored light through the collimator hole (behind equipment introduced)，and a so fine beam irradiation out， and it thorough the concave lens refraction. After it arrives on the scale, and forms a bright spot. Bright spots that in the scale of the position react each beam of lights with respect to the relative distance of the concave lens centerline. When the height of the detected object and a reference height are deviation, the reference hole with respect to the vertical position of the centerline of concave lens will have a deviation. Due to refraction action of the concave lens, the light and the horizontal direction can be biased to a certain angle. When the light incident on the scale, Bright spots offset distance is n times than actual height deviation of the detection object, and therefore it can be seen that there is a significant deviation. As figure 1, if the qualified object that to be measured height tolerance range is δ_1 .When the object is detected, the centerline of the hole collimator and the concave lens centerline are coincident. According to the principle of a concave lens refraction, the corresponding range of the bright spots on the scale is S. Therefore, when the product is testing. The bright spots within range S is qualified products. Otherwise, the bright spot outside the range S is non-qualified products.

1.2 Design of the overall programme of work

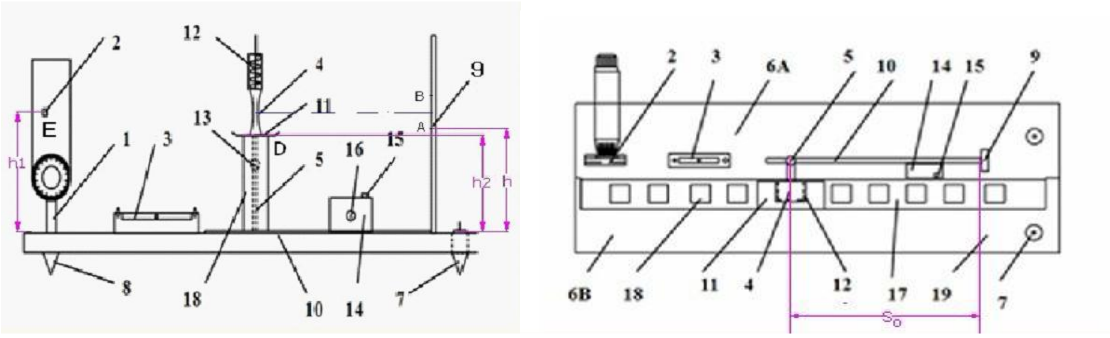
According to the principle of optical zoom, the height detection equipment is designed .The detection scheme is shown in Figure 2.First, adjust the instrument level, and ensure the correctness of the detection. Then, the instrument is zero, so it returns the original state. Next, the mechanical parts are sent to the detected position and detect mechanical parts. Finally, we distinguish whether the mechanical parts are qualified and the unqualified parts are separated.

2 THE STRUCTURAL DESIGN OF THE HEIGHT OF THE HEIGHT OF THE DETECTOR

Detector structure based on the design principles of the optical amplification is shown in Figure 3

2.1Functional analysis of the various components

The base of the instrument includes a the instrument region 6A and the analyte pipeline sports area 6B, while the bottom of the base of the instrument has a symmetrically distributed in the four corners of the pyramidal probe，in order to fix the entire device. In a period of two active probes can freely adjust the height of the entire detector.



1.Precision Micro rotating rod; 2. Collimator hole; 3 the blisters level meter; 4. Concave lens; 5. Support bar; 6A. The instrument District; 6B. The analyte lines motor area; 7. Activities probe; 8.The fixed probe; 9. Scale; 10. Rails; 11. Detection into place board; 12. Return spring; 13. Knob; 14. Unloading device; 15. Remote parts; 16. Springs; 17. Conveyor belt; 18.Analyte; 19. Unloading area

Fig. 3 a schematic diagram of the overall structural design of the height detector

Correction device is equipped with a high degree of precision micro rotating rod adjustable, and the rotating rod is equipped with a collimator holed 2.Collimator hole and the distance of the base is adjustable. The collimator holes can monochromatic injection according to the straight-line trajectory. The detection apparatus consists of the rail 10, the support rods 5, the detection plate 11 into position, a concave lens 4 and the return spring 12, etc. The Support rod 5 can move back and forth along the rails, in order to adjusting the distance between the concave lens 4 and the scale 9.The return spring 12 ensures that make concave lens reset before an object is detected, in order to detect the next object.

Blister Level 3 is mounted in the base of the instrument of the detector zone, adjust the activity probe 7 slowly. If the observation blisters locate in the middle position, otherwise, it should continue to adjust until the entire device is horizontal. Detection device and scale also has remote control parts 15 and 16 spring, it formed the unloading device 14.And through remote control parts 15 and 16 control springs to render unqualified object detection after the pop-up to the unloading area 19.

Scale 9-after resolved beam refraction location fell on the scale. Two eligible product dimensions at the detection limit position, the bright spot on the scale of the two extreme positions is to detect boundary points. Test dimensions based on the bright spot position and location to determine whether parts of the two boundary points qualify.

2.2 detection part of the actual work process

Detection of the object's height process, the detection device is calibrated, and the base is a base point. First, adjust the knob on the detection device 13, make a qualified object place the detection into bits board 11 below, and adjust the precision micro screw 1 so that the collimator hole up to the appropriate height position. Then, the concave lens center and the collimated holes "+" are in a straight line. Record the "+" and the scale coincides position, and fix precision jog auger. Remove under the detect place board11 of qualified items. Then, detecting means is fixed to a certain position on the rail 10.For example， 17mm is the exact height of the object, but also it is permissible error range. After adjustment by the above steps, then the deviation limit 16.95mm and 17.05mm of objects were placed under detection into bits plate 11.When the concave lens is moved up and down, resulting in the light is refracted of striking the concave lens. Because the light shines on the scale, and because the object is error .Extreme deviation position in the scale is on the vertical position②③.②③Range is the object of qualified area. You can use a pen to mark the limit position in order to distinguish. The detection of the preparatory work is completed.

The measured object 18 is placed on conveyor 17 regional. When measured object on a conveyor belt is moving to detection into place board under plate 11， Due to the error of the object, it will affect the test into the tablet under the tiny mobile. Thus, it is caused by the micro concave lens up and down. Let the light refraction to scale on 9 ， and observation whether the light is in the region of the vertical scale. If the light is in the region ②③ to that meet the requirements, not in the unqualified. Immediately, pressing the remote control unit to start the unloading device. Meanwhile, the spring 16 of the unloading device14 is working， the unqualified object is catapulted into the unloading area 19.To detect quickly the defective object. According to the height of the need to adjust itself up and down object limit deviations so determine the appropriate area, to achieve the required accuracy.

3 RESULTS AND DISCUSSION

3.1 Experimental study

After the instrument leveling and instrument zeroing，thus, start the height of parts detection experiments. Assuming that the parts of the basic size is D， upper deviation is es and lower deviation is ei. Accordingly, the height of parts is tolerance for T.

$$T=es-ei$$

The upper and lower deviation is not the same as parts assembly requirements， and it can be assumed that the upper and lower deviation values are equal to simplify the analysis of the optical path. Not only does eliminate the tedious process of transformation, but also it are convenient for the analysis and calculation of the optical system. The results of the analysis does not affect the reliability of the sleeve means. Experiment unified assumption is ei=-es.

Part of the basic tolerances band shown in Figure 7:

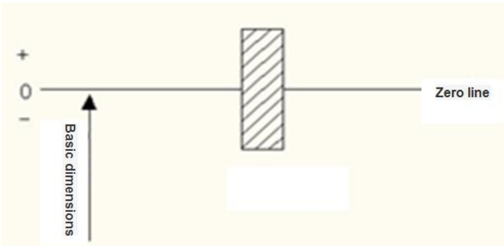


Fig. 4 basic tolerance zone

As figure 4， adjust precision Micro rotating rod 1.The collimator hole center E and the surface of the horizontal base of the vertical distance is h_1 .At the same time， Adjust the knob 13 of the support bar 5 .As shown in Figure 5, end of the detection into place board 11 into position D and the vertical distance of the horizontal base surface is h_2 .As figure 6, adjust the support rods 5 and the rail 10 at the junction C, and it is away from the scale 9 that is S_0 .The range of the scale 9 on the deviation of the beam refraction lowest point is A, and the highest point is B. The distance between the highest point and the lowest point is S. The vertical distance of the lowest point A and the horizontal is h. Precision Micro rotating rod1 and the distance of the scale 9 is a constant k.

By the principle of detecting know that it is $h_1 = D$ .The distance of the concave lens and the center of detection into position plate 11 is constant a. $h_2 = D - a - ei$ .At the same time f is the focal length of the concave lens. Table 1 shows the detection requested data. Table 2 is the detection of the test result data of the instrument.

Table 1 Detected data Table 2 Experimental results data

CESHI	F /mm	Theoretical Deviation es=ei/mm	h_1 /mm	h_2 /mm	S_0 /mm	h/mm	s/mm
1		3	30	17	150	23.571	12.857
					250	19.286	21.428
2	70	5	80	65	250	62.143	35.714
					400	51.429	57.142
3		6	100	84	400	65.714	68.571
					500	52.143	85.714
4		5	80	65	250	71.071	17.857
					400	65.714	28.571
5	140	6	100	84	400	82.257	32.286
					500	78.571	42.857
6		8	120	102	500	91.429	57.142
					600	85.714	68.572

Detecting the number of groups	Detecting a range of values/mm	Detecting the number / N	Qualified occurrences/n	Relatively qualified occurrences w=n/N
1	23.571--36.428	10	9	0.9
	19.286--40.714	10	9	0.9
2	62.143--97.857	10	10	1
	51.429--108.571	10	10	1
3	65.714--134.286	10	9	0.9
	52.143--142.857	10	10	1
4	71.071--88.929	10	8	0.8
	65.714--94.286	10	9	0.9

By the formula, $\overline{W}=\frac{\sum_{i=0}^{n} w_i}{N}$. The average pass rate

$$\overline{W}=\frac{W_1+W_2+W_3+W_4+W_5+W_6+W_7+W_8+W_9+W_{10}+W_{11}+W_{12}}{12}=95\%.$$

Therefore, the detection efficiency of the detector is at about 95%.

3.2Traditional testing instruments

If the traditional micrometer detects parts pass rate. In order to meet the scientific nature of the experiment, So the same number of parts is tested. Each group of 10 parts was measured, and the measurement results shows in Table 3:

Table 3：Conventional micrometer detected data

Detection number of groups	No.	Theory es = ei	D/mm	l_i/mm	Measurement bias	Pass rate
1	1	3	30	32.975	-2.975	0.9
	2		30	31.083	-1.083	
	3		30	31.224	-1.224	
	4		30	29.382	0.618	
	5		30	28.529	1.471	
	6		30	34.156	-4.156	
	7		30	27.016	2.984	
	8		30	28.163	1.837	
	9		30	27.359	2.641	
	10		30	27.085	2.915	
2	1	5	80	83.201	-3.201	0.9
	2		80	81.132	-1.132	
	3		80	85.307	-5.307	
	4		80	80.339	-0.339	
	5		80	78.535	1.465	
	6		80	79.306	0.694	
	7		80	81.005	-1.005	
	8		80	74.345	5.655	
	9		80	80.696	-0.696	
	10		80	77.485	2.515	

Detection number of groups	No.	Theory es = ei	D/mm	l_i/mm	Measurement bias	Pass rate
3	1	6	100	99.305	0.695	0.8
	2		100	104.328	-4.328	
	3		100	94.058	5.942	
	4		100	93.272	6.728	
	5		100	105.449	-5.449	
	6		100	101.107	-1.107	
	7		100	106.363	-6.363	
	8		100	95.158	4.842	
	9		100	97.325	2.675	
	10		100	94.329	5.671	

4	1	5	80	83.201	-3.201	0.9
	2		80	82.147	-2.147	
	3		80	80.128	-0.128	
	4		80	77.328	2.672	
	5		80	82.113	-2.113	
	6		80	79.305	0.695	
	7		80	75.104	4.896	
	8		80	73.085	6.915	
	9		80	84.305	-4.305	
	10		80	83.442	-3.442	

Detection number of groups	No.	Theory es = ei	D/mm	l_i/mm	Measurement bias	Pass rate
5	1	6	100	103.112	-3.112	0.9
	2		100	100.458	-0.458	
	3		100	98.358	1.642	
	4		100	102.362	-2.362	
	5		100	108.553	-8.553	
	6		100	97.325	2.675	
	7		100	95.284	4.716	
	8		100	105.648	-5.648	
	9		100	101.747	-1.747	
	10		100	99.21	0.79	
6	1	8	120	125.234	-5.234	1
	2		120	122.547	-2.547	
	3		120	118.285	1.715	
	4		120	127.352	-7.352	
	5		120	115.204	4.796	
	6		120	123.019	-3.019	
	7		120	120.335	-0.335	
	8		120	125.771	-5.771	
	9		120	121.357	-1.357	
	10		120	118.055	1.945	

The standard deviation can be calculated from the residual error that to draw the traditional more accurate measurement results; $\delta_i = l_i - \mathrm{D}$

When the right end of the equality plus a $\overline{W}$ and subtracting a $\overline{W}$;

$\delta_i = (l_i - \overline{W}) + (\overline{W} - D) = v_i + \Delta D$

Among $\overline{W}$——arithmetic mean

l_i——i th measured value

v_i——residual error

ΔD——The arithmetic mean value minus the true value

$\Delta D = \frac{1}{n}\sum_{i=1}^{n}\delta_i$ （because of $\sum_{i=1}^{n}\delta_i = 0$）

On system values squared obtained: $\sum_{i=1}^{n}\delta_i^2 = \sum_{i=1}^{n}v_i^2 + n\Delta D^2$ （because of $2\Delta D \times \sum_{i=1}^{n}v_i = 0$）

Final finishing drawn: $\sigma = \sqrt{\frac{1}{(n-1)}\sum_{i=1}^{n}v_i^2}$

In practice, the measured values can not be an infinite number. Therefore, In the actual production of the experimental standard deviation s is represented, such as：

$s = \sqrt{\frac{\sum_{i=1}^{n}(l_i - \overline{W})^2}{n-1}}$ Or $s = \sqrt{\frac{\sum_{i=1}^{n}v_i^2}{n-1}}$

Take the measuring data into the formula:

$\overline{D_1} = \frac{l_1 + l_2 + l_3 + l_4 + l_5 + l_6 + l_7 + l_8 + l_9 + l_{10}}{10} = 29.687\ mm$

At the same time， $\delta_i = l_i - D$

$s = \sqrt{\frac{\sum v_i^2}{n-1}} = \sqrt{\frac{(-2.975)^2 + (-1.083)^2 + \bullet\bullet\bullet + (2{,}915)^2}{9}} = 2.562\ mm$.

And $s_{\overline{D}} = \frac{S}{\sqrt{n}} = \frac{2.562}{\sqrt{10}} = 0.810\ \mathrm{mm}$.

The final results： $l_1' = \overline{D_1} \pm 3s_{\overline{D}} = 29.687 \pm 3 \times 0.810 = 29.687 \pm 2.43\ \mathrm{mm}$.

So， qualified products is 9， $\overline{W_1'} = 90\%$.

Similarly，analysis drawn： $\overline{W_2'}$ 、 $\overline{W_3'}$ 、 $\overline{W_4'}$ $\bullet\bullet\bullet\bullet$ $\overline{W_{10}'}$. $\overline{W'} = \frac{\overline{W_1'} + \overline{W_2'} + \overline{W_3'} + \bullet\bullet\bullet + \overline{W_{10}'}}{10} = 90.012\%$.

By the above draw $\overline{W'} < \overline{w}$ ： Spiral micrometer that detect parts of the passing rate is lower than the detection accuracy of the detector design. And the work efficiency of the detector is significantly better than the spiral micrometer; this reflects the principle of optical amplification detection technology superiority.

4 CONCLUSIONS

First, use the physical principle of optical refraction, tiny tolerance through the light will be zoomed. Control the qualified products in a range; it is easier to find substandard products. The advantage of this is ： rapid discovery of substandard products and screening. Since the optical signal is amplified, and the accuracy is easily controlled so the detected error is greatly reduced. This achieves a fast high precision.

The new detection technology is extensive, good economic practicality. As long as the parts to be detected does not interfere with the normal working of the device performance of the work piece that can be applied. Automated detection of small objects can achieve pipeline， and Large objects can manually control. This method is simple, convenient, high detection accuracy, high efficiency that can be used for a variety of production workshop or processing lines to reduce the amount of labor, increase productivity, reduce production costs. The optical amplification principle method detects part size that it has a role in promoting for a small processing plant that detects the height of the parts.

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