MechNEWS

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Welcome

Welcome to the May/June issue of Mech*NEWS*™, a service provided by MechSigma Consulting, Inc. In this issue, we show how to make a paper gage to verify conformance to a positional tolerance for a four-hole pattern.

We hope you enjoy this issue of Mech*NEWS*™ and continue to tell your colleagues about it.

Paper Gaging[1]

As you know, positional tolerances for round features (holes, pins, etc.) typically prescribe round tolerance zones. Most dimensional inspection techniques, however, measure parts in relation to a square, Cartesian (X-Y) coordinate system. Paper gaging provides a convenient and accurate method that marries the round tolerance zone with the square coordinate system. Often referred to as *graphical inspection analysis*, paper gaging is a graphical method of verifying conformance to position tolerances. It is often used where it is cost-prohibitive to build hard gages.

Simply stated, paper gages graphically represent the measured locations of features on a Cartesian coordinate grid. By overlaying acceptable tolerance zones on this grid, we can verify whether or not the parts pass the positional tolerances (including those modified to MMC).

Figure 1 shows a four-hole pattern located with a positional feature control frame, | ⌖ | Ø.010Ⓜ | A | B | C |. As you know, this control allows the axis of each hole to be within a Ø.010 if the hole is produced at its MMC size limit of Ø.309. As each manufactured hole departs from its MMC size, the allowable tolerance zone increases. (See July/August 2004 issue of Mech*NEWS*™.)

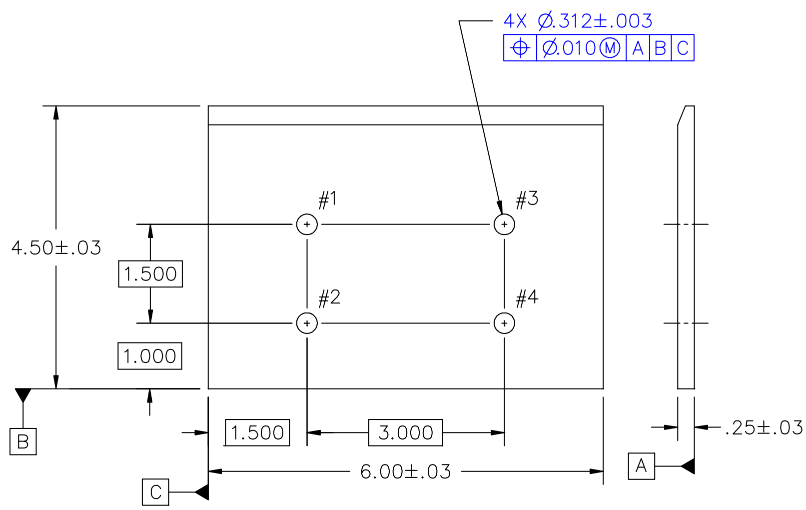

Figure 1

To verify the positional requirements for the holes, the inspector must know the produced size of each hole to calculate the amount of positional tolerance allowed for each hole. The difference between the measured size and the specified MMC size, Ø.309, is the allowed "bonus" tolerance. This bonus tolerance is then added to the tolerance value in the feature control frame, Ø.010, to calculate the allowable tolerance zone for each hole.

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1. *Much of this article is taken from Marty Wright's Paper Gage Techniques chapter in Dimensioning and Tolerancing Handbook (ISBN 0-07-018131-4).*

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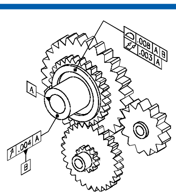

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The inspector typically takes location measurements using a CMM or a surface table and angle plate setup (such as with a height gage). This data is typically collected in the form of "X" and "Y" values for the location of features in relation to the measurement origin. Table 1 illustrates a sample inspection report that provides the data for paper gage evaluation of the hole pattern.

LAYOUT INSPECTION REPORT													
NO.	FEATURE	FEATURE SIZE			ALLOW TOL.	X LOCATION			Y LOCATION			ACCEPT	REJECT
		MMC	ACTUAL	BONUS		BASIC	ACTUAL	DEV	BASIC	ACTUAL	DEV		
1	*.312±.003*	*.309*	*.311*	*.002*	*Ø.012*	*1.500*	*1.503*	*+.003*	*2.500*	*2.501*	*+.001*	*X*	
2	*.312±.003*	*.309*	*.313*	*.004*	*Ø.014*	*1.500*	*1.505*	*+.005*	*1.000*	*.998*	*-.002*	*X*	
3	*.312±.003*	*.309*	*.312*	*.003*	*Ø.013*	*4.500*	*4.496*	*-.004*	*2.500*	*2.497*	*-.003*	*X*	
4	*.312±.003*	*.309*	*.310*	*.001*	*Ø.011*	*4.500*	*4.494*	*-.006*	*1.000*	*1.002*	*+.002*		*X*

Table 1

The data from the inspection report is then transferred to the paper gage by plotting each of the holes on a coordinate grid as shown in Fig. 2. The *center* of the grid represents the *basic* or *true position* for each of the holes.

Each basic dimension is subtracted from the hole's *actual* value to calculate a hole *deviation*. For example, the X location basic dimension for hole #1 is 1.500. The inspection report shows an actual X location of 1.503, so the deviation (from basic) is .003 (1.503-1.500).

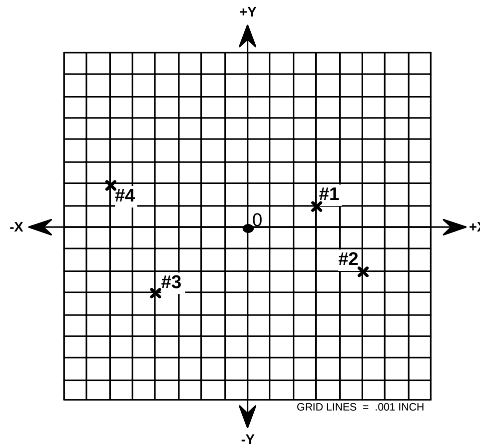

Figure 2

After the X and Y deviations for the four holes are calculated, the holes' locations in relation to their true positions are plotted on the grid. Then a polar coordinate system (representing the round positional tolerance zones) is laid over the coordinate grid. See Fig. 3. The rings of the polar coordinate system represent the range of positional tolerance zones shown in the inspection report. With the center of the polar coordinate system aligned with the center of the coordinate grid, the inspector then visually verifies that each plotted hole falls inside its allowable position tolerance. If all the holes fall inside their zones, the part is good and the inspector is done.

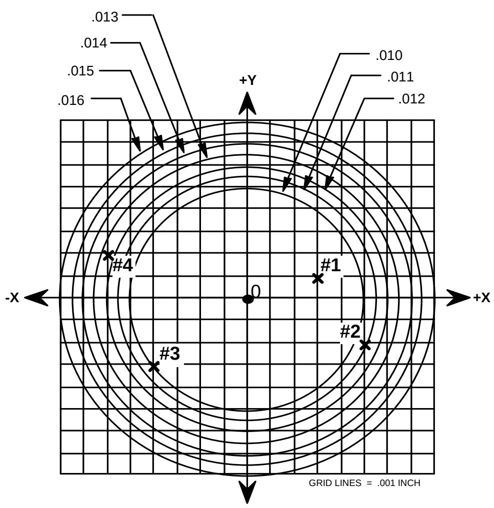

Figure 3

For this example, holes #1, #2, and #3 fall inside their respective tolerance zones. Hole #4, which is required to be inside a Ø.011 tolerance zone, does not. However, the paper gage shows that the hole *does* fall inside a Ø.013 ring. With the MMC concept, the hole may be enlarged by Ø.002 to a size of Ø.312, which in turn increases the allowable positional tolerance to Ø.013. This brings the hole into compliance with the drawing specification.

Three-Dimensional Hole Pattern Verification

In our example, the holes were verified using a two-dimensional (2-D) analysis of the hole pattern using only measurements taken along the X and Y axes. This is a common practice used to reduce inspection time. By using only a 2-D analysis of the hole pattern, the inspector assumes that the holes are relatively perpendicular based on known capabilities of the processes. If the inspector does not want to take this risk, he/she should take measurements at the top of the hole and at the bottom of the hole. Instead of plotting a point as we did in our example, the inspector plots two points for each hole and draws a line between them, representing the axis of the hole. Each axis must fall within its respective allowable tolerance zone to verify conformance.

(Continued)

Events:

The next meeting of the Y14 Committee is tentatively scheduled for the week of October 2, 2006, at the Red Lion Hanalei Hotel in San Diego, California. These meetings are open to the public.

For more information: http://cstools.asme.org/csconnect/CommitteePages.cfm?Committee=C64041000&Action=5151

Advantages and Disadvantages to Paper Gaging

Paper gaging techniques graphically represent the functional acceptance boundaries for part features, without the high costs of design, manufacture, maintenance, and storage required for a fixed-limit gage. Additionally, paper gaging does not require that any portion of the product tolerance be sacrificed for gage tolerance or wear allowance.

Since it provides a visual record of the actual produced features, paper gaging can be an extremely effective tool for evaluating process trends and identifying problems. Unlike a hard gage, which verifies GO/NO-GO attributes of the part, the paper gage provides the operator with a better illustration of production problems and the precise adjustment necessary to bring the process back into control. Factors such as tooling wear and misalignment can readily be detected during production through periodic paper gaging of verified parts.

In a future article, we will show how paper gaging can capture dynamic tolerances found in datum features subject to size variation or feature-to-feature relationships within a pattern of holes. Neither of these can be effectively captured in a typical layout inspection.

The primary drawback to paper gage method of verification is that it is much more labor-intensive than use of a fixed-limit gage. Paper gaging requires a skilled inspector to extract actual measurements from the part and then translate this data to the paper gage. For this reason, paper gaging is typically used when the quantity of parts to be verified is small, or when parts are to be verified only as a random sampling.

Note that although we call this "paper gaging" it can be done very easily and more accurately using a computer to draw gage.

Joke of the Bi-Month

SIXTEEN THINGS THAT TOOK ME OVER 50 YEARS TO LEARN:

by Dave Barry, Nationally Syndicated Columnist

1. Never, under any circumstances, take a sleeping pill and a laxative on the same night.

2. If you had to identify, in one word, the reason why the human race has not achieved, and never will achieve, its full potential, that word would be "meetings."

3. There is a very fine line between "hobby" and "mental illness."

4. People who want to share their religious views with you almost never want you to share yours with them.

5. You should not confuse your career with your life.

6. Nobody cares if you can't dance well. Just get up and dance.

7. Never lick a steak knife.

8. The most destructive force in the universe is gossip.

9. You will never find anybody who can give you a clear and compelling reason why we observe daylight savings time.

10. You should never say anything to a woman that even remotely suggests that you think she's pregnant unless you can see an actual baby emerging from her at that moment.

11. There comes a time when you should stop expecting other people to make a big deal about your birthday. That time is age eleven.

12. The one thing that unites all human beings, regardless of age, gender, religion, economic status or ethnic background, is that, deep down inside, we ALL believe that we are above average drivers.

13. A person who is nice to you but rude to a waiter is *not* a nice person. (This is very important. Pay attention. It never fails.)

14. Your friends love you anyway.

15. Never be afraid to try something new. Remember that a lone amateur built the Ark. A large group of professionals built the Titanic.

16. Men are like fine wine. They start out as grapes, and it's up to the women to stomp the crap out of them until they turn into something acceptable to have dinner with.