IJFANS INTERNATIONAL JOURNAL OF FOOD AND NUTRITIONAL SCIENCES

ISSN PRINT 2319 1775 Online 2320 7876

Research paper **Volume 11, Sp.Iss 7 , 2022**

A novel method to improve the tolerance of position in profiles using a tooling hole

B Kiran Kumar[1*], K Venkatesan[2], B Saikrishna Srikar[3]

[1]Associate Professor, Department of Mechanical Engineering, Koneru Lakshmaiah Education Foundation (KLEF), Deemed to be University, Vaddeswaram, Green fields, Guntur, Andhra Pradesh, India -522302

[2] Professor, Department of Automobile Engineering, Bharath Institute of Higher Education and Research, Chennai, Tamil Nadu, India

[3]Tata Consultancy Services, Adibatla, Telangana, India

*Corresponding author: buragaddakirankumar15@gmail.com

DOI : 10.48047/IJFANS/11/S7/017

Abstract: Thedie-making industry does the machining of holes by drilling, reaming, boring, grinding and EDM operations for the fitment of punches, pillars, tool inserts, etc., or assembly purposes like screw relief holes, tapped holes, and riveting holes by using standard fixturing. Normally the hole locations are given in the manufacturing drawing by taking two accurately finished perpendicular datum features. Thesedatum features will be used in machining, inspection,reworks, and they need to be protected from damages. Any inaccuracy in the datum features like flatness, and perpendicularity leads to the wrong measurement or location of the hole, shows an inaccurate assembly. This paper presents the novel method ofusing tooling hole in the manufacturing drawing andillustrate the advantages through experiments. While dimensioning, the concept of tooling hole enhances the tolerance of position in profiles and permits faster machining/inspection activities; thereby increases productivity.

Keywords:Positional accuracy, datum feature, tooling hole, die-making

1. Introduction:

The die-makingindustry makes the parts for sheet metal stamping dies, moulds,jigs,fixtures, and gaugesthat need to be assembled. The manufacturing drawing contains the dimensioning of hole positions and referencepoints for various profiles given from two datum features [1]. Figure 1 shows the sample part drawing of a die plate, and thedatum featuresare indicated by datum references B and C, which needsto be machined accurately either by milling or grinding within the tolerance of the zone of perpendicularity. These plates are often moved from machine to machine either for a series of machining operations or inspection or rework and to locate the existing hole centers from datum features. As there is no specific distance is specified in the drawing, the operator may take any point on thedatum feature to move the coordinates by using the edge finder. Thereby it is difficult to get to the previously located center. There is a chance to get a deviation of 0.001mm to 0.05mmin the hole location.

To eliminate hole positioning inaccuracies, WEDM technology will be used to manufacture the entire round or special holes in the mould plate in one setup [2]. The feature-related position tolerance (also known as FRTZ) is used to manage the relationship between a group of holes. FRTZ is used to ensure that matching pieces are properly assembled. Due to the lack of a datum reference frame whose job is to

ISSN PRINT 2319 1775 Online 2320 7876
Research paper **Volume 11, Sp.Iss 7 , 2022**

impose translational and rotational constraints on the component, assessing feature-related positional inaccuracy is a tough process.A mathematical model for three-dimensional feature-related positional inaccuracy was presented by Jiang, et al. [3]. Assemblability and functional compliance of products are affected by geometric variations. Because small part differences accumulate in large-scale assembly and cause malfunctions [4]. To address form defects, a CAD model with integrated tolerancing was created [5]. Such deviations are not acceptable in the precision machining of tool parts. The addition of material condition like MMC/LMC increases the complexity of the manufacturing process [6]. Finally, it affects the tool assembly, function, life of the tool as well as component accuracy. The danger of wrongly locating the hole center each time to be overcome. Pandya, et al. [7] developed and implemented a computer assistance to help designers in allocating design sizes and tolerances that fulfil functional translation, rotation, and assembly limitations imposed on four common datum systems. In complex assemblies the need of alternative method is anticipated, in order to ensure the assembly of the parts right at first time [8]. Attempts were also done to understand the significance of datum-oriented errors in 2D assemblies [9] and 3D assemblies [10] and non-rigid assemblies [11].

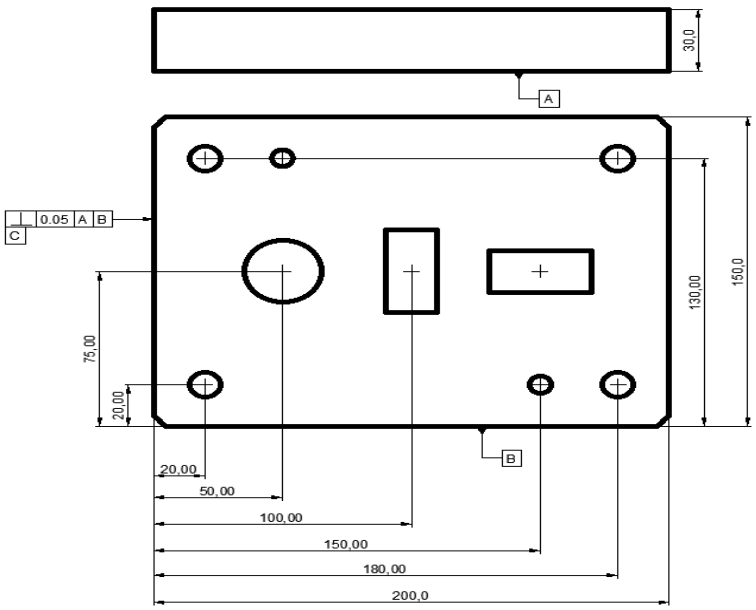

Figure 1: Sample part drawing of adie plate

Section 2 of this article dealswith the methodology of introducing tooling hole in the plates to overcome hole location problems. Case studies on the usage of tooling hole are discussed in Section 3 and it is concluded in Section 4.

2. Improve position tolerance utilizing Tooling Hole – Novel method

A tooling hole (TH) is an additional or existing hole placed in every plate of an assembly, which is accurately machined by reaming, boring, grinding, and WEDM operations by controlling hole cylindricity and perpendicularity. They are placed in the non-functional area of the part thickness. The tooling hole can be 5mm deep from the plate's top surface, with the rest relieved.

If the plate has to be heat treated, the TH should be finished thereafter. The tooling holes can be either one or two numbers depending onthe availability of an

ISSN PRINT 2319 1775 Online 2320 7876
Research paper **Volume 11, Sp.Iss 7 , 2022**

external flat surface for pre-setting using a lever-type dial indicator. If one tooling hole is used, the hole and profile centers are located by dialing accurately machined datum feature (B) and taking the tooling hole (TH) center as the origin. This method doesn't require the machining of the second datum feature. Figure 2 shows the dimensioning of the hole and profile centers from the tooling hole center.

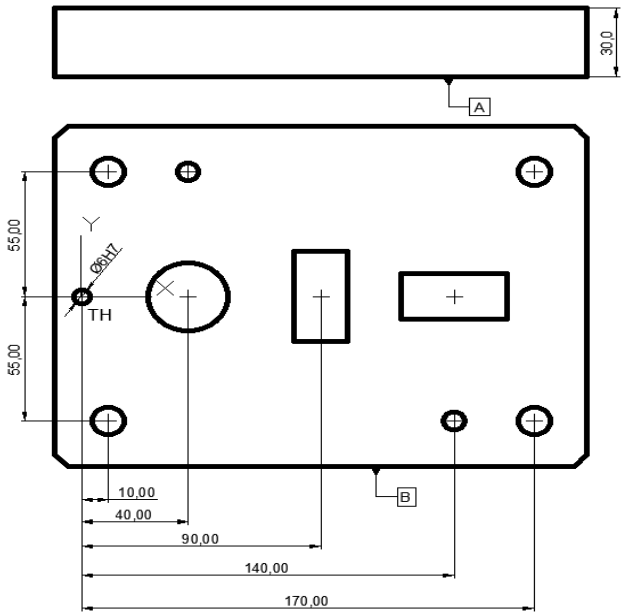

Figure:2 Dimensioning hole or profile centers from tooling hole centre

Two tooling holes are preferred when the plate size is too big to finish the datum features. Figure 3 shows the positioning of tooling holes to set the datum and also it reduces the manufacturing cost of tool parts as the accurate machining of datum feature is eliminated.

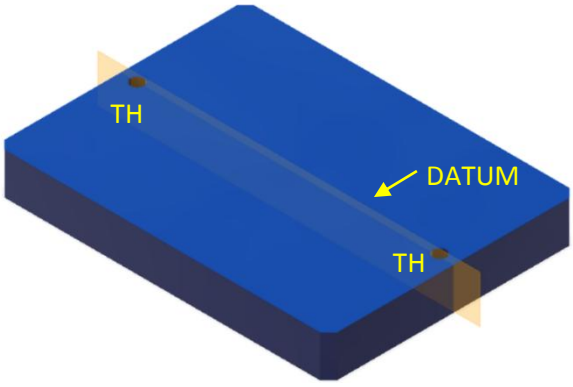

Figure:3 Datum formed by two tooling holes.

3. Case studies on Tooling hole applications

3.1 Part having uneven external profiles

Parts like machine housings, bodies, etc are processed primarily fromcasting.A sample diagram is shown in Figure4,anditis not having any external flat surfaces. If the fixturing is not preferred for machining of flat surfaces due to a smaller number of

ISSN PRINT 2319 1775 Online 2320 7876
Research paper **Volume 11, Sp.Iss 7 , 2022**

samples, the butting surfaces are machined by milling. Identify two holes that are in line as tooling holes (TH) and locate them on a co-ordinate drilling machine to finish to the size. By taking one of the tooling hole center as origin, move the coordinates to drill, ream, and bore the remaining holes to the required size. This tooling hole concept permits to locate hole centers any number of times either duringthe inspection or reworks without any deviation.

Figure: 4 Machine part without external flat surfaces

3.2 Ease of verification of part dimensions that are going to be assembled

Usually, the parts that are going to be assembled will have a common hole center distance for screw holes, dowels, punches, inserts,but with various block sizes. If two datum features are used for dimensioning either by manual or computer-aided drafting, the dimensions need to be verified by suitable addition or subtraction. The process ofdimensions verification is simplified by the tooling hole concept in the drawings. It is depicted in Figure 5 with two die plates having similar dimensions from tooling hole centerfor easy verification.

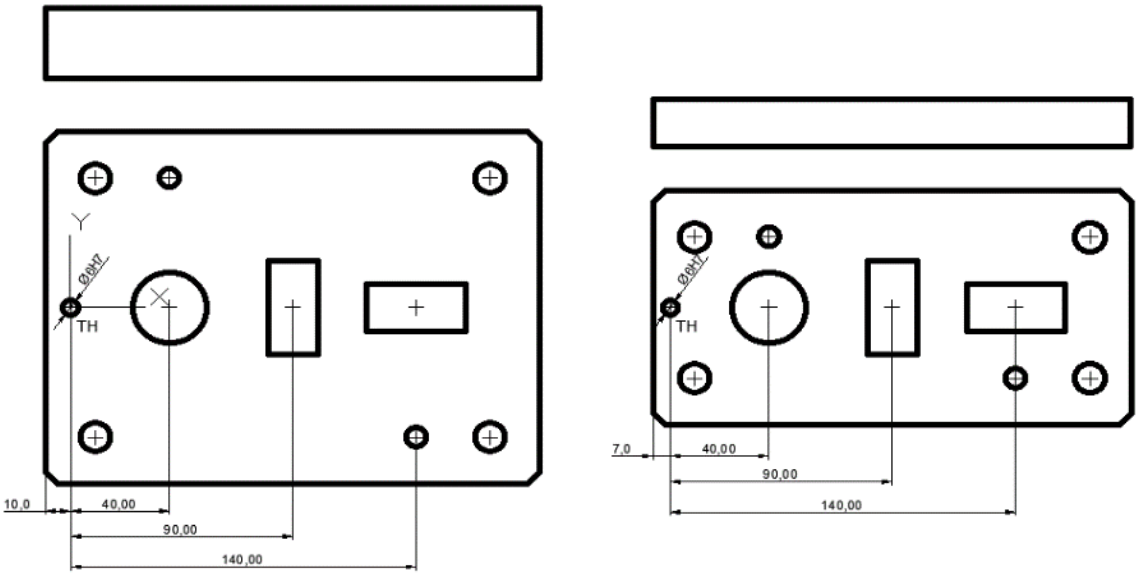

Figure:5 Die plates having similar dimensions for verification

3.3 Rapid location of hole centersutilizing THfor machining or inspection

ISSN PRINT 2319 1775 Online 2320 7876
Research paper **Volume 11, Sp.Iss 7 , 2022**

Parts with one tooling hole will have one reference side machined to be set straight and the tooling hole center to be located by dialingdirectly or with an inserted plug gauge. The tooling hole center is set asthe origin to check the position of other holes or profiles. This practice appliesto all conventional machines like co-ordinate drilling, jig boring, or jig grinding machines. On non-conventional machines like EDM or Wire EDM, it is quickly done by setting the reference side straight followed by tooling hole location with an electrode tool. It is easier to set the datum as shown in Figure 3on co-ordinate measuring machine (CMM) and from one hole center, other hole locations are checked. Figure 6 depicts an example of part drawing with a polar coordinate system, which can be quickly done by the tooling hole concept by taking a Ø.875 hole as a TH.

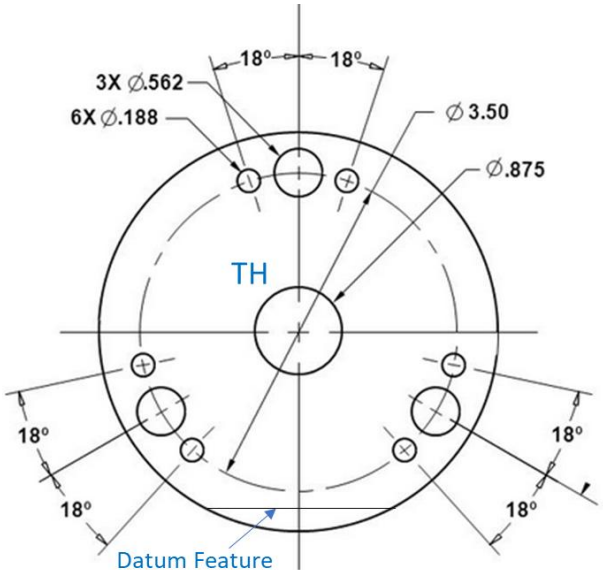

Figure:6 An example of part drawing with a polar coordinate system

3.4 Small capacity machines using TH for operations on lengthier workpieces

Sometimes it is necessary to drill the holes in the workpiece which is more than the travel capacity of the machine. In such cases, it is necessary to make several tooling holes with the known centerdistance, which is less than machine capacity, and in one line. This setup permitsthecompletionof one set of holes by setting the datum straight and moving co-ordinates from the first tooling hole. The left-out holes are machined by resetting the workpiece to move co-ordinates from the second tooling hole. Figure 7 illustrates an example of a die plate with two tooling holes when its length is larger thanthe machine's capacity.

ISSN PRINT 2319 1775 Online 2320 7876
Research paper **Volume 11, Sp.Iss 7 , 2022**

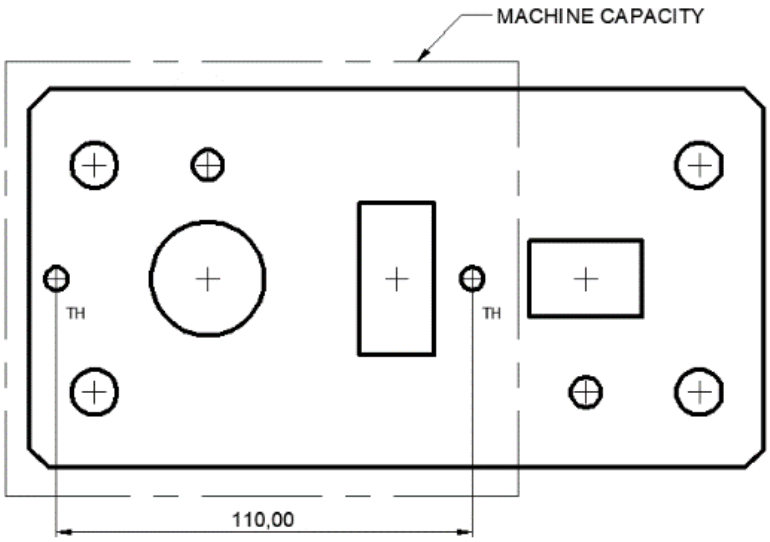

Figure:7 Sample die plate with two TH larger than machine capacity

3.5 Accurate positioning of angular holes using TH

It is the major advantage of tooling hole by accurate positioning for machining of angular holes. It can be either a single or compound angle. This can be done onco-ordinatedrilling machine with a sine table attachment. It does not require any complicated CNC part program.Figure 8(a) depicts a part drawing with angular hole requirement in front and top views. Figure 8(b) shows the part setup (i.e., 30°) on sine table and a calculated distance (i.e., 20.00) to be moved from the tooling hole (TH)centerto drill the hole Ø10.

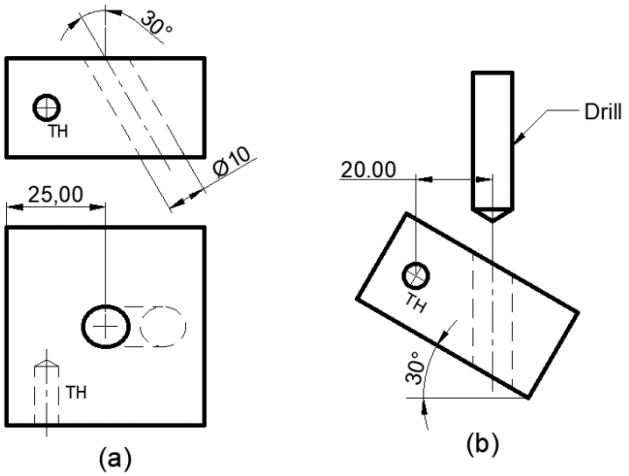

Figure:8 Sample part drawing and its machine setup for angular hole drilling

In this process and an additional hole (i.e., tooling hole) is provided to fit a gauge pin. After tilting the workpiece on the sine table, the calculated movement is given to the workpiece to complete the required hole. In the end, the tooling hole need to be blocked and protected for future reference.

ISSN PRINT 2319 1775 Online 2320 7876
Research paper **Volume 11, Sp.Iss 7 , 2022**

4. Conclusion

The dimensioning of manufacturing part drawing is normally given from two datum features. As the tolerance is given for the machining of two perpendicular datum features, it is difficult to locate the same hole center accurately for repetitive tasks especially in series of machining operations. This is because the machine operator may choose to move *x*and *y* coordinate values from any point on datum features. The task of positioning the hole center is simplified by the addition of a tooling hole (TH) and moving the *x*, and *y* distances from its center. When two tooling holes are used then a datum can be set to machine or inspect the plates. It further improves the readability of the various part drawings of their similar center distance in their assembly. The machine capacity is enhanced by the addition of two or more tooling holes in line with their center distance being less than the machine's table travel distance. This concept will be best suitable for angular holes with either a single or compound angle that can be accurately positioned.

References

[1] "ASME Y14.5-2009 Dimensioning and Tolerancing. American Society of Mechanical Engineers." 2009.

[2] Shi, S., Wang, Z., & Li, X. (2012). An Improved Process for Enhancement of Positional Precision in WEDM. *Energy Procedia*, *17*, 1339–1344. https://doi.org/10.1016/j.egypro.2012.02.249

[3] Jiang, G., & Cheraghi, S. H. (2001). Evaluation of 3-D feature relating positional error. *Precision Engineering*, *25*(4), 284–292. https://doi.org/10.1016/S0141-6359(01)00080-0

[4] Movahedi, M. M., M. Khounsiavash, M. Otadi, and M. Mosleh (2017). "A New Statistical Method for Design and Analyses of Component Tolerance." Journal of Industrial Engineering International 13 (1): 59–66. doi:10.1007/s40092-016-0167-5.

[5] Jbira, I., Tlija, M., Louhichi, B., & Tahan, A. (2017). CAD/Tolerancing integration: Mechanical assembly with form defects. Advances in Engineering Software, 114, 312–324. https://doi.org/10.1016/j.advengsoft.2017.07.010

[6] Wu, Yuguang. 2018. "The Correlational Design Method of the Dimension Tolerance and Geometric Tolerance for Applying Material Conditions." The International Journal of Advanced Manufacturing Technology 97: 1697–1710. doi:10.1007/s00170-018-2052-4.

[7] Pandya, G., Lehtihet, E. A., & Cavalier, T. M. (2002). Tolerance design of datum systems. *International Journal of Production Research*, *40*(4), 783–807. https://doi.org/10.1080/00207540110021019O1

[8] Jietong, L., & Thimm, G. (2004). Constraint Generation for Alternative Dimensional specifications. *Computer-Aided Design and Applications*, *1*(1–4), 675–681. https://doi.org/10.1080/16864360.2004.10738313

[9] Meifa, H., and Z. Yanru. 2007. "Optimized Sequential Design of Two-dimensional Tolerances." The International Journal of Advanced Manufacturing Technology 33 (5–6): 579–593. doi:10.1007/s00170-006-0475-9.

ISSN PRINT 2319 1775 Online 2320 7876
Research paper **Volume 11, Sp.Iss 7 , 2022**

[10] Pierre, L., D. Teissandier, and J. P. Nadeau. 2009. "Integration of Thermomechanical Strains into Tolerancing Analysis." International Journal on Interactive Design and Manufacturing 3 (4): 247–263. doi:10.1007/s12008-009-0058-8.

[11] Korbi, A., M. Tlija, B. Louhichi, and A. BenAmara. 2018. "CAD/tolerancing Integration: A New Approach for Tolerance Analysis of Non-rigid Parts Assemblies." The International Journal of Advanced Manufacturing Technology 98 (5–8): 2003–2013. doi:10.1007/s00170-018-2347-5.