DIFFERENT PLUG GAUGES USED FOR INSPECTION OF DIAMETER OF A HOLE: A REVIEW

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Abstract

Gauges are widely used in manufacturing industries for the inspection of dimensions during the mass production. It saves a lot of time for the verification of products for its validity under the given dimensional tolerance. The gauges are used to replace the frequent use of high-cost measurement tools. The Plug gauge which is also called as GO and NO-GO gauge is used to verify the internal diameter of hole manufactured under given tolerance. Some other gauges are also came into existence which are highlighted in review.

1. Introduction

In mechanical industries many times the object is manufactured in huge quantity or ass production. The products are manufactured with same specification and same dimensional tolerances to maintain the standards and for better application of products. These products can be hollow shafts, internal combustion engine cylinder or holes etc. Before the application of these products, it is necessary to inspect the diameter of hole to maintain the required quality level of product with reference to its basic diameter. This dimension is inspected by vernier caliper or by using some gauge for quick result. Because during the mass production it is not possible to use the vernier caliper, so a plug gauge is referred to get the quick result. During the manufacturing of object, it becomes very difficult to obtain the accurate dimensions or basic size of object. It happens due to human error, error in machine or tool wear etc. To encounter this problem, In this context a tolerance is referred along with basic size. For example if a "hole" is to be manufactured with a specific diameter it becomes difficult to produce the same internal diameter of hole for each product in mass production. So, these holes are manufactured with a given tolerance with reference to its given diameter.

1.1 Tolerance

Tolerance is difference between two allowable dimensions of same hole under required functioning of object. By the use of this tolerance the working of the product is not affected. For example if a hole is to be manufactured with the basic size of 20 mm with the tolerance of ±0.05 as shown in figure1, reveals that the maximum and minimum size of the hole is 20.05 and 19.95 respectively. The size obtained between this limit

will be accepted for its application and the size beyond this limit will be rejected. The rejected holes or products can be over sized or under sized. The difference or variation from the basic size of the hole is recognized as a tolerance. The tolerance is of two types:-
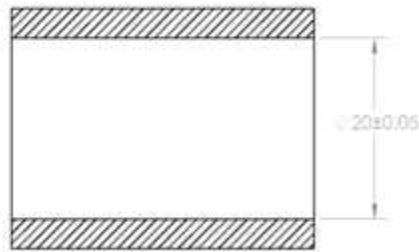

Fig. 1 Circular hole

1.1.1 Unilateral tolerance:- In this case the tolerance is provided for either positive size or negative size. For example, if the diameter of hole is manufactured with either +0.05 or -0.05 with reference to basic size is called is unilateral tolerance.

1.1.2 Bilateral tolerance:- In this case the tolerance is provided in positive as well as in negative direction. For example, if the diameter of hole is manufactured with ±0.05, which is for positive as well as for negative variation is called as a bilateral tolerance. To measure the diameter of these holes different instruments are used depending on the requirement. Generally a plug gauge is considered for the quick results instead of using vernier caliper or other instruments.

2. Literature Review

Now days, lot of measuring gauges are available and widely used in industries due to its ability to give the quick response. These are invented by many researchers with their useful efforts. Few of them are highlighted in this review.

Luo et. al. [1] The invention relates to the inspection of pipe or verification of thickness of the pipe during mass production. This is also called as line pipe plug gauge. As shown in figure 2, It consists of two parts with outer diameter plug gauge and wall thickness plug gauge and both are connected to each other. The wall thickness plug gauge side is comprises of cylinder with successively increasing diameter and on the other hand the outer diameter plug gauge is manufactured with a groove which detects the outer diameter of and hence the thickness of the pipe is observed. The gauge is designed to verify the diameter and thickness simultaneously with some scientific adjustments. It is very useful and efficient in mass production. *Volker et.al* [2] The gauge is prepared with four guides channels which is placed transversely on the cross section about the axis of plug gauge. Also spherical elements are connected to guide with spring wire so that they can move. During the inspection, the gauge is inserted into hole to make the contact between sphere and internal surface of hole. It results in the movement of vertical component and measurement inserts on the probes gives the diameter of hole. *Guo e. al.* [3] The model is applicable to measuring tool and categorized as a screw plug gauge. The screw gauge is consists

of a shank which is connected to two ends as shown in figure 3. These two ends are the called as go end and no-go end. For the measurement of depth of thread of hole, a scale is also provided on the shaft with a journal. As shown in figure 3, it is arranged inner face of go side of the gauge along the axis. The diameter of shaft journal which contains the scale is less than
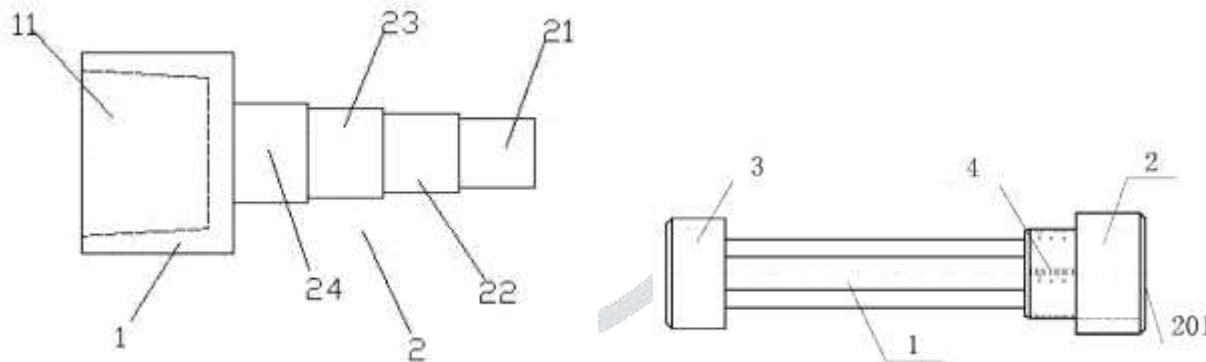

Fig. 2 & 3 Various Plug gauges

the base diameter of go side. Also the length of go side is less as compare to the minimum standard of depth of thread. The utility model can achieve the precision as well as accuracy of the thread for its application under different speeds. This type of plug gauge having less cost, simple in structure and can be used in mass production. *Dia et. al.* [4] The plug gauge is applicable in the verification of internal diameter of bearing. As shown in figure 4, the gauge consists of two major ends having different diameter according to the required tolerance. These two ends are prepared as a go end and no-go end which assists the lower limit of diameter of hole and upper limit of diameter of hole respectively. These two ends are further connected by an intermediate element which is in the form of frustum of cone. During the inspection the gauge is inserted into the hole from go side. Its minimum and maximum diameter joins the go and no-go end of the gauge respectively. It is obvious that the diameter of intermediate part varies from go side diameter to no-go side diameter which lies in between the tolerance. During the inspection, the gauge is inserted into the hole from go side and the contact between gauge and edge of hole is observed. If the contact between the both is observed at intermediate part indicates that diameter of has qualified the tolerance zone. The restriction of the hole for the entrance of go side of the gauge indicates the diameter as undersize. On the other end, the advancement of no-go side in the hole indicates the diameter as oversize. *Xia et.al.* [5] The utility model is prepared
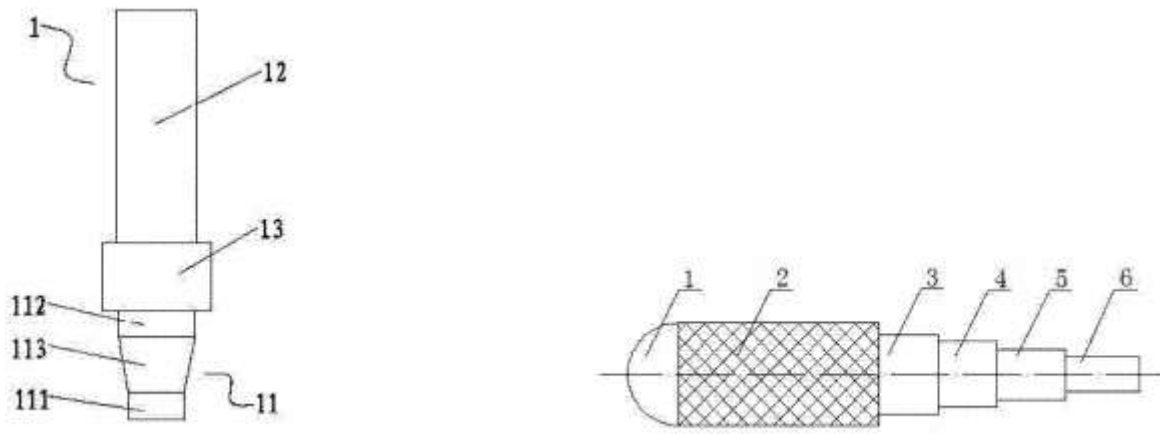
Fig. 4 & 5 Various Plug gauges

with the ability to verify the diameter of hole of vehicle frame. As shown figure 5, it is very simple in construction, which comprises of a knurled handle and cylinders of different diameter in the form of steps. In the said model, these cylinders with different diameter are known as go gauges and minimum two go gauges are required in the construction. These all the step has different external diameter and co-axial in construction. Its handle is provided with knurled surface to increase the friction for better handling. The holes are inspected by inserting the go gauges into the hole and a comparison is made between both the surfaces. The gauge shown in figure 5, can measure the diameter of 10.5 mm, 12.5 mm, 14.5 mm, 16.5 mm. The use of this gauge is very comfortable and efficient during the mass production. *Shen et. al.* [6] The plug gauge consists of a cylindrical handle which is connected axially to the plug head. As shown in figure 6, a transition member is also provided at the side surface and front surface of plug head. In this construction the side wall surface of plug head is adopted as a work surface and its diameter is gradually increasing. The utility model has of advantages, simple in construction, low cost and convenient to use. Luo et. al. [7] The utility model comprising of plug gauge support
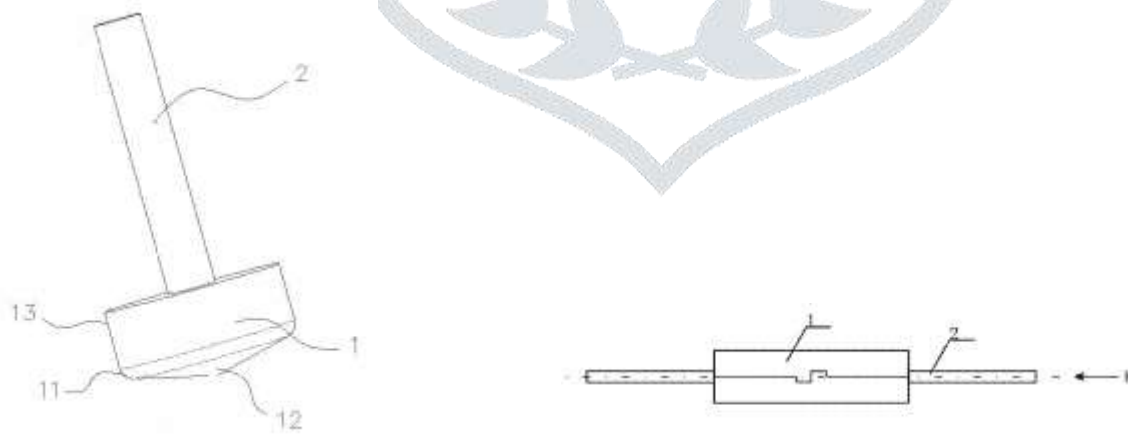

Fig. 6 & 7 Various Plug gauges

and plug gauge body. The operation pillar of plug gauge is mounted around the middle part. It is a round tube of diameter 2.5 mm. The diameter of plug gauge body head is 0.88 mm and 0.92 mm. The gauge is applicable under

the deficiency of vernier caliper, when the diameter of the hole is very less. It shows the good results in the measurement of minor holes with required accuracy. *Hou et. al.* [8] The utility model is prepared to measure the diameter of annular groove
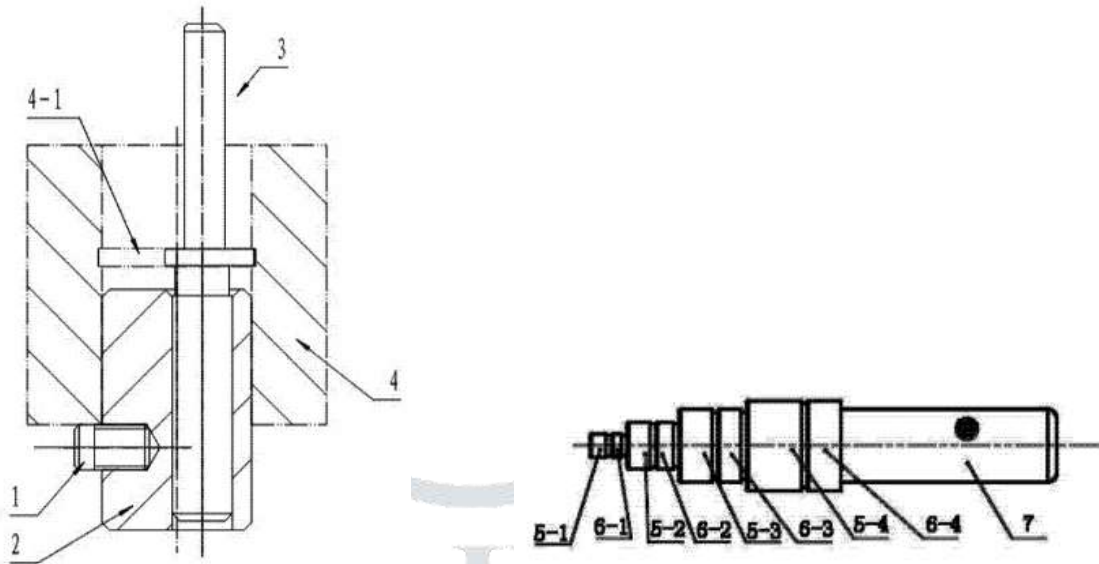

Fig. 8 & 9 Various plug gauge

of a hole as shown in figure 8. It aims to enhance the quality and accuracy during the measurement and to approach the simplified process of measurement. The plug gauge contains a guide post which is equipped with eccentric hole. The external diameter of guide post is same as the internal diameter of groove. The plug gauge consists of go and no-go gauge, lower positioning pin, a measuring body at middle and a handle. The one side of cylinder of plug gauge is truncated into axial plane and eccentric location hole is matched with positioning pin. *Liang et. al. [9]* The utility model is recognized as a plug gauge which is applicable in the measurement of through hole. As show in figure 9 its construction is prepared by the steps of different external diameters in the form of steps. The steps are made to overcome the existing dumbbell shape gauge which can detect only one through hole. It is observed that the utility model comprises of more than one go and no-go gauges adjacent to each other. The go and no-go diameters are prepared with reference to tolerance given to the hole, whose diameter has to be measure. The stepped plug gauge is capable to detect the accuracy of through holes of different diameters efficiently. *Liu et. al.* [10] The utility model is known as a plug gauge which play a vital role for
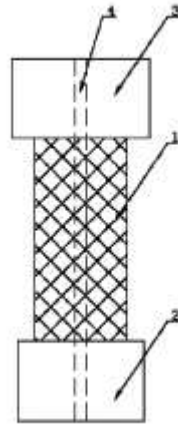
Fig. 10 Plug gauge

the inspection of diameter of hole during the mass production. As shown in figure 10, the gauge consists of two cylindrical shapes connected at the ends of a rod or handle. The two cylindrical shapes are considered as go and no-go gauges. The diameter of go gauge and no-go gauge is prepared as a lower and upper allowable limit of diameter of hole respectively. The acceptance of manufactured hole is verified at two stages with go side and no-go side. The restriction of hole for go side and entrance of no-go side into hole is considered as failure due to under size and oversize respectively. The acceptance of the hole under the given tolerance is considered with two operations which is advancement of go side into hole and restriction of hole to no-go side. The highlighted model is widely used into mechanical industries for the inspection of diameter of hole in mass production. The quick response, simplified in construction and easy to use makes it more efficient and useful.

This research can pave away to design a plug gauge with certain specification. This research can highlight various technical aspects like tolerance, fits associated while designing a plug gauge. The gauge can find a vital application in field of inspection in case of various automobile and mechanical industries. However the actual size of the hole cannot be determined using a specific series of plug gauge.

3. *Future Scope*

In the history of plug gauges, the researchers had developed existing plug gauges with some modifications or by changing the design. These gauges can be replaced by digital plug gauges to improve its performance and to get the better results. The results from these gauges are only in the form of acceptance or rejection of hole under the given tolerance. The detection of the actual size of hole during inspection is one of the major aspects in both acceptance of hole as well as rejection of hole. The determination of actual size of the hole can be utilized for the following:-

1. Selective assembly

2. Statistical Quality Control (SQC)

3. Machine tool control

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[3] https://patents.google.com/patent/CN204043544U/en?oq=CN204043544U (Patent publication No.CN204043544U:- Depth measuring type screw plug gauge)

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