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Variable Plain Plug Gauge

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Abstract: *The purpose of this project is to offer an improved option over the fixed size plug gauges with a 'cost effective' measuring solution that addresses the measurers intended dimensions, while still offering accuracy in all diameters. The final prototype allows for an easy vertically adjusting meld component system to replace the cam. This will vertically raise the followers to accommodate the change in measuring range. The project was made by a distribrute of mild steel components common in fabrications, makes it available and affordable for smaller industries and schools. The paper focuses on the mechanical design, working principle, materials, and manufacturing processes of the final version. This research has occupations value in providing a usable gauge head for a calibration tool used in construction and industry for quality control and inspection. In addition, it has been a useful training mechanism for considering future designs, even showing its potential uses as a research gauge. This innovation contributes to the better use of dimensional inspection.*

Keywords: Variable gauge

I. INTRODUCTION

Importance of Gauges in Manufacturing:

In industrial manufacturing, particularly in mass production, consistency and accuracy in dimensional inspection are vital to ensure that parts meet design specifications. Among the various measuring tools, gauges play a crucial role in fast, reliable, and repeatable inspection of components without the need for continuous numerical readings. Gauges are especially valuable in quality control processes where thousands of parts must be inspected efficiently.

Why Gauges Are Preferred :

Unlike conventional instruments like calipers or micrometers, gauges are designed to provide a Go/No-Go result, meaning they quickly verify whether a part is within acceptable tolerance limits. This approach significantly reduces inspection time and operator error, making gauges the ideal choice for batch and continuous production environments.

Types of Gauges :

Gauges are classified based on what they measure and how they function. Here are the main types:

A. Plug Gauges

• Used to check the internal diameter of holes.
• Have two ends:
• Go-End: Slightly smaller than the lower tolerance limit should fit.
• No-Go End: Slightly larger than the upper tolerance should not fit.
• Common in mass production for quick checking of hole sizes.

B. Ring Gauges

- Used to check external diameters of cylindrical parts.
- Made from hardened steel rings with a precise internal diameter.
- Go/No-Go versions are also available.

C. Snap Gauges

U-shaped tools for checking external dimensions.

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- Can be fixed or adjustable.
- Common in workshops for checking shafts and rods.

D. Thread Gauges

• Verify thread profile, pitch, and diameter.

Two types:

- Thread Plug Gauges for internal threads (female threads).
- Thread Ring Gauges for external threads (male threads).

E. Feeler Gauges

- Thin Steel Blades – Comes as a set of different thickness blades.
- Used in Assemblies – Common in engines for valve clearance and spark plug gaps.
- Quick Gap Estimation – Inserted between surfaces to determine fit.
- Flexible and Manual – Requires manual skill and feel to use properly.

F. Height and Depth Gauges

- Used to measure vertical distance or depth of slots, holes, or recesses.
- Often combined with digital indicators for high precision.

Limitations of Conventional Plug Gauges :

Despite their simplicity and usefulness, traditional plug gauges come with significant limitations:

- Only suitable for one specific size.
- Requires multiple gauges for different parts, leading to increased costs.
- Storage and maintenance become complex in mass production setups.
- Not adaptable for custom or varied diameters without investing in new gauges.

II. OBJECTIVES

- To design a single adjustable plug gauge that can measure multiple internal diameters, reducing the need for multiple fixed-size gauges.
- To apply a cam and follower mechanism for precise control of the expanding and Contracting motion of the gauge head.
- To minimize inspection time and increase efficiency in industrial environments by using a quick, easy-to-adjust measuring tool.
- To reduce production and maintenance costs by using a single variable gauge instead of many separate gauges.
- To ensure long-term dimensional accuracy by selecting appropriate materials and
- analyzing wear behavior in the cam-follower components.
- To test and validate the gauge design for reliability, repeatability, and ease of use in real workshop conditions.

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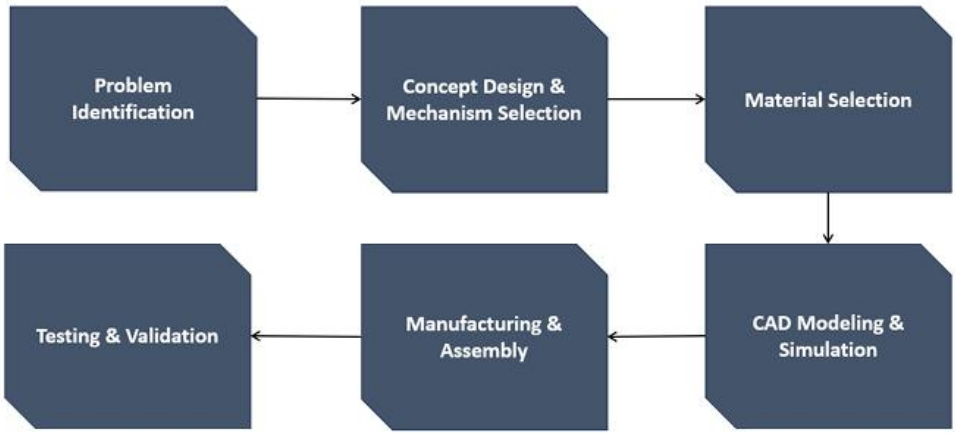
III. METHODOLOGY



The working drawing of the Variable Plain Plug Gauge provides a visual representation of the gauge in its partially expanded state, showing how the internal components are positioned when the tool isset to measure an inner diameter of 120 mm. This drawing serves as a key reference to understandhow the gauge appears during operation, particularly when the cam mechanism is used to adjust themeasuring range.

In this configuration, the cam inside the gauge has been advanced to the second step, which has a height of 20 mm. As a result, the followers resting on this cam step are raised to a moderate height. The upward movement of the followers causes the outer ends of the gauge—responsible for measuring the inner diameter—to expand. This action sets the tool to a measuring diameter of 120 mm, which is reflected in the dimensions shown in the drawing.

Unlike motion diagrams, this working drawing does not include arrows or symbols to indicate part movement. Instead, it presents a fixed position of the gauge after adjustment. The drawing clearly shows the positional arrangement of all internal parts, including:

- The cam, resting on the second step.
- The followers, uniformly lifted to match the cam height.
- The casing, enclosing all components and maintaining alignment.
- The bolt and nuts, which hold the assembly together and guide the cam's path.
- The overall measuring area, which now reflects an inner diameter setting of 120 mm.

This static drawing plays a crucial role in communicating the functionality of the gauge through detailed geometry and part placement. It confirms that the design accommodates intermediate size settings without requiring part replacements or manual recalibration.

By showing the mechanism in a practical state (not fully open or closed), the drawing helps demonstrate that the gauge is adjustable across a range, and not limited to fixed positions. This proves the real-world application of the cam and follower concept in plug gauge design.

In summary, although the drawing does not include directional arrows or motion indicators, it effectively communicates the adjusted state of the gauge at a 120 mm setting, with the cam positioned on the second step. It is an essential part of the documentation that validates both the design concept and operational feasibility of the Variable Plain Plug Gauge.

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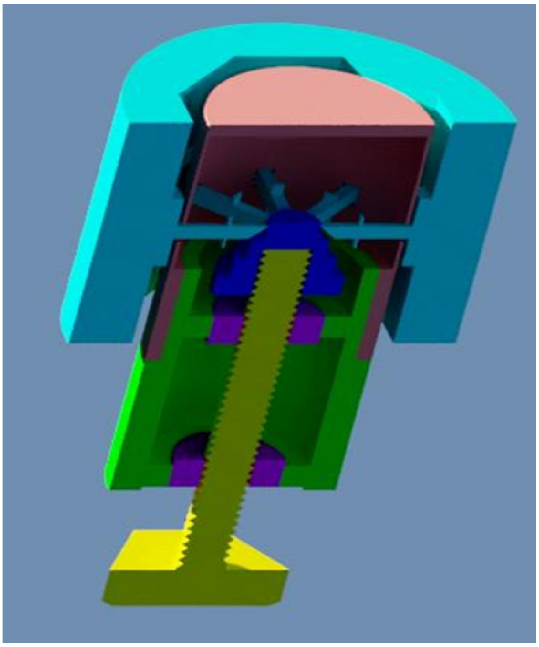
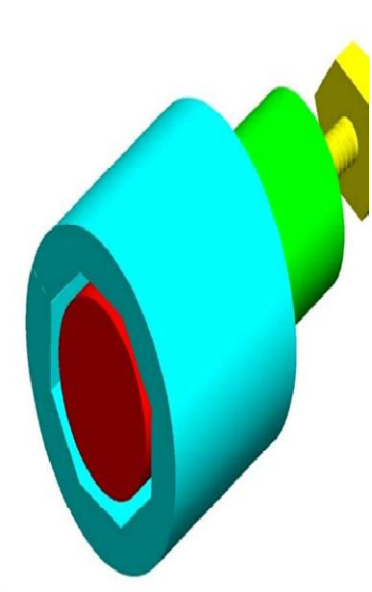


3D Sectional View



B. Isometric View

III. RESULT & DISCUSSION

Results:

Upon completion of the manufacturing and assembly process, the prototype was subjected to a series of functional tests to assess its working mechanism and reliability in real-world conditions. The core function — adjusting the measuring diameter via a stepped cam and follower mechanism — was successfully demonstrated.

The device was manually operated using the bolt connected to the stepped cam. As the bolt was rotated, the cam moved forward, gradually shifting the followers onto a higher cam step.

During testing, the gauge was adjusted to the second step, corresponding to a measuring diameter of approximately 120 mm. The motion was smooth, and all four followers expanded equally, confirming the precision in the alignment of components.

Other results observed include:

• Consistent expansion and contraction across multiple trials, showing mechanical repeatability.

• Stable follower movement without any mechanical jamming or misalignment, proving the mechanical concept's effectiveness.

• The prototype was able to measure different bore sizes without changing the tool, saving time and effort compared to using multiple traditional plug gauges.

• The replaceable cam design (in the final iteration) made it easy to adapt the device for other diameter ranges if needed. Despite being a manually operated prototype, the performance was satisfactory for smallscale industrial use, particularly in quality inspection or workshop settings.

IV. DISCUSSION

The development of this prototype brought forward a range of learning outcomes and insights. One of the most significant achievements was the ability to combine mechanical simplicity with functional versatility. The stepped cam and follower mechanism — a relatively low-cost solution — proved effective in providing multi-range diameter adjustability.

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Design Iterations and Improvements:

The first design helped validate the basic mechanism but had some limitations, such as low casing strength, fewer cam steps, and a non-replaceable cam. These limitations were addressed progressively:

• In the second design, increasing the number of cam steps and centralizing the followers improved accuracy and smoothness.

• In the third and final design, a thicker casing and replaceable cam system were introduced, enhancing durability and modularity.

Manufacturing and Operational Observations:

• The prototype was fabricated using lathe and milling operations, which were sufficient for achieving the required geometry and functionality.

• Some differences existed between the designed and manufactured parts (e.g., cuboid in design replaced by a conical form in manufacturing), which were made to simplify production.

• The absence of fine finishing (such as surface polishing or coating) slightly affected the feel but did not compromise functionality.

V. APPLICATION & FUTURE SCOPE

Applications :

The current version of the Variable Plain Plug Gauge is a versatile measuring tool with a broad scope of applications. Its ability to measure multiple inner diameters with a single instrument reduces the dependency on a large number of traditional plug gauges. This flexibility makes it highly suitable for the following uses:

• Manufacturing Quality Control: In machining industries, the gauge can be used during in-process or final inspection to verify bore diameters of components such as bushings, cylinders, sleeves, and pipes.

• Tool Rooms and Workshops: Small-scale industries and tool rooms where different sizes of bores are frequently inspected can greatly benefit from a single adjustable gauge that reduces space and tool investment.

• Educational and Training Institutes: Engineering colleges and technical institutes can use this tool for demonstration purposes and hands-on training in mechanical design and metrology.

• Maintenance and Repair Departments: For industries where repair and fitting work is common, the gauge can be a handy solution to quickly verify internal dimensions without needing a full set of gauges.

Future Scope :

While the current prototype delivers basic functionality effectively, several enhancements and features can be introduced in future versions to increase precision, durability, and ease of use. These improvements can further expand its usability in more advanced industrial settings.

- Digital Integration: Adding a digital measurement scale or sensor can help in directly displaying the inner diameter on an LCD screen, improving accuracy and user convenience.
- Calibration Scale: A visible scale or engraving on the device can allow users to preset the diameter more accurately instead of relying purely on manual adjustment.
- Automatic Locking Mechanism: Incorporating a locking system would help hold the followers in a fixed position after adjustment, preventing unintentional movement during measurement.
- Use of Lightweight and Strong Materials: Instead of mild steel, future models could explore aluminum alloys or composite materials to reduce weight without compromising strength.
- Commercial Product Development: With further refinement, the gauge can be standardized and launched as a commercial product targeted at SMEs (Small and Medium Enterprises), inspection firms, and tool manufacturers.
- Surface Finishing and Coating: In mass production versions, aesthetic finishes, corrosion resistance coatings, or color coding could improve both appearance and longevity.

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