Ensuring accuracy in measurement – An analysis of differential screw micrometer mechanism design and fabrication

Pratik Shriprakash Kole

Mechanical Engineer, PVPIT Sangli , WCE Sangli Shivaji University, Kolhapur

Abstract - The differential screw is the mechanism that is used for making small, precise adjustments to the spacing between two objects. The accuracy of the measurement depends on the least count of the instrument. For instance, the micrometer adjuster uses a nut sleeve that has varying pitches on the inner and outer thread so as to connect the screw which is on the adjusting rod end with the threads that are inside the main barrel. At the instance when the nut sleeve is rotated by the thimble, the barrel rod and barrel move about each other based on the differential between the threads. The main goal of the paper is to ensure the accuracy needs of any measurement are met. The aim of the project is to achieve the accuracy of the measurement. To achieve the aim, we applied the principle of differential screw. By using this principle, we made screw of mild steel having two different diameters 15mm & 12mm and two different pitches 1.27mm & 0.98mm on one shaft and because of different diameters and pitches; the screw is named as the differential screw. Both the threads are the right hand threads. The movable anvil of the micrometer head get linear differential movement from the differential screw and moves 0.29 mm axially for one complete rotation of the thimble, which is connected to the differential screw.

Keywords— differential screw, mechanical engineering, mechanism, technical modeling

I. INTRODUCTION

A differential screw is a mechanism that provides very fine motions of machine parts. There are several forms of its configuration [1]. It is a mechanism used for making small, precise adjustments to the spacing between two objects. A differential screw uses a spindle with two screw threads of differing leads and possibly opposite handedness, on which two nuts move. As the spindle rotates, the space between the nuts changes based on the difference between the threads. [2]

A. Background

A large number of tools currently have the ability to take very small measurements from many fields of measurement including tasks regardless of the many challenges that are encountered; such tools include the micrometer screw gauge, Vernier calipers and so on. The micrometer screw is a tool that is used to measure very small dimensions of varying objects in terms of their diameter, height, length and width. For it to read these small dimensions, it works on a principle of converting shorter lengths into longer ones so that they can be magnified and therefore make it readable to the human eye on the scale. Its reading is read from a main scale and a thimble scale that has a circular shape.

B. Research Aims and Objectives

In order to achieve aim, the following objectives shall be accomplished:

- To derive the level of growth of mechanical engineering, particularly Differential Screw Micrometer Mechanism.
- To understand and substantially analyze the current concerns that prevent organizations from trusting and adopting such mechanisms within India
- To ascertain the efficiency of such a mechanism in helping organizations in the development and progress of their systems within India.

II. LITERATURE REVIEW AND EMPIRICAL EVIDENCE

A. Introduction

This research paper firstly observes the previous investigations and later makes a comparison between these findings and the empirical data that will be collected through the literature review.

B. Differential Screw Micrometer Mechanism

Accuracy in measurement is a very important thing to put into consideration. Therefore, this research is intended at creating and devising a differential micrometer screw that will be able to record very small least count with high degrees of accuracy. The device takes measurement in term of converting axial motion into linear reading during the process of obtaining a measurement. This axial motion is the rotation that occurs and is then called a pitch. When the pitch is of constant known thread, the axial motion is in return obtained very easily.

This micrometer screw will be made from a mild still that has two varying radii of dimension seven and a half and six millimeter and two varying pitches of dimension

one point two seven millimeter and zero point nine eight millimeter on one shaft. The screw is called differential screw. The differential screw is going to have the following parts; frame, anvil, spindle, sleeve, thimble, ratchet, screw and the lock. The instrument contains two scales namely main scale and the thimble scale.

III. METHODOLOGY

A. Research Purpose

The purpose of this study is to provide a descriptive investigation of various elements of the conditions or phenomena associated with circumstances, situations, or events happening or existing in the knowledge space. Generally, a descriptive research design is adopted when the objective of the research is to establish an empirical ground for generalization of the occurrence or existence of a given set of situations, conditions or phenomena. Descriptive research describes the phenomenon under study in order to have a generalization of the outcome from which theories can be developed. Explanatory research can be used to develop a concrete theory in order to explain the empirical generalizations.

B. Study Design

This study is based on a mixture of the empirical and theoretical study designs. A major focus has been grounded on the empirical design. Empirical evidence was heavily relied upon for the validation and substantiation of the findings, results and claims insinuated by this study. Furthermore, the method is useful in terms of effectiveness in generating theoretically feasible and practically reliable as well as valid results and findings. The study involved resourceful comparison as well as listing of various tools, technical setups and the design and fabrication.

C. Methods of Data Collection

This Qualitative and quantitative data was collected to be used in this study. The quantitative data was collected by past papers, databases and datasets as well as representative information while secondary data as well as interviewing was used in the collection of the qualitative data. Ethical Considerations

Like most empirical and theoretically based studies, this research was performed by observing and adhering to the basic ethical preconditions of empirical studies. The works used in order to realize the goals of this study have been accredited in the most appropriate manner, and the required attributions accorded to the respective authors of the articles using applicable referencing and documentation styles, both in text and on the reference pages, so as to ensure conformance with academic policies prohibiting any form of plagiarism.

IV. TECHNICAL DETAILS

It consist the differential screw which has different diameters as well as pitches.

Pitch - Pitch of the screw threads is defined as the axial distance measured between the two corresponding points on adjacent thread forms in the same axial plane.

Lead - It is the axial distance advanced by the thread in one revolution of the screw.

Least Count - Least count of any instrument is the smallest possible measurement taken by that instrument.

Least count of Micrometer -

Least count of micrometer is given by,

$$L.C. = \frac{\text{Lead of the screw}}{\text{No. of divisions on circular scale}}$$

Parts used -

Serial No.	Name of Part	Quantity	Material
1	Differential Screw	1	M. S.
2	Barrel	1	M. S.
3	Fixed Member	1	M. S.
4	Movable Member	1	M. S.
5	Bush	1	M. S.
6	Collar	1	M. S.
7	Plunger	1	M. S.
8	Thimble	1	M. S.
9	Spring	1	M. S.
10	Screws	7	M. S.

Table A. Parts used in differential micrometer screw

Detailed descriptions -

Differential Screw- While designing the differential screw we considered the gear ratios available on the lathe machine for threads and diameters.

Threads per inch	Stud	Screw
20	32	80
26	16	52

Table B. Defines dimensions of threads, stud and screw

By considering above data and other consideration, we assume the length and the diameters.

Larger diameter = 15 mm; Smaller diameter = 12 mm.

Larger pitch = 1.27 mm; Smaller pitch = 0.98 mm. Both the threads are right hand threads

The detailed drawing is shown below:-

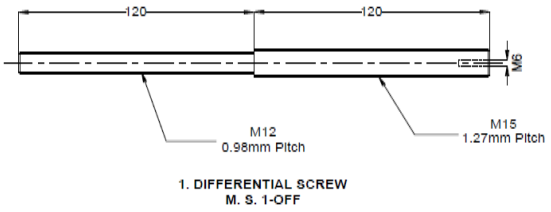


Figure 1. Differential screw (M.S. 1 Off)

Thimble –Thimble is member by which we rotate the differential screw. It is connected to the differential

screw with the help of 4 mm screw at the larger diameter side.

External diameter of thimble = 64 mm.

Internal diameter of the thimble = 56 mm.

Total length of the thimble = 100 mm.

Drawing of thimble is shown below:-

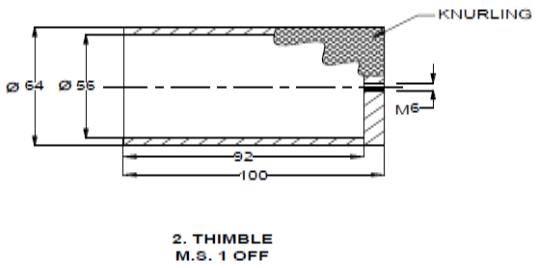


Figure 2. Thimble (M.S. 1 Off)

Barrel- Barrel is part in which all the other parts are fitted. The fixed member is fitted from the right side, while plunger with movable member, bush and collar from the other side.

Total length of the barrel = 240 mm.

Larger diameter of the barrel = 54 mm.

Drawing of barrel is shown below:-

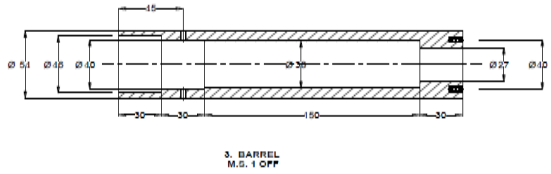


Figure 3. Barrel (M.S. 1 Off)

Plunger –

Plunger is part in which the movable member is fitted from the right side. One end of plunger forms a measuring anvil.

Slot is provided on the plunger over the length of 105 mm to stop the rotary motion of the plunger while reciprocating inside the barrel.

Total length of plunger = 140 mm.

Drawing of the plunger is shown below:-

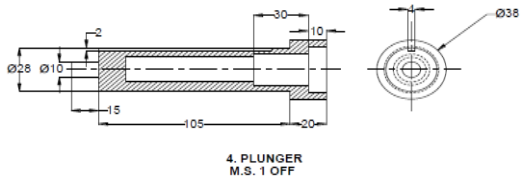


Figure 4. plunger (M.S. 1 Off)

Fixed Member – Fixed member is fitted in the barrel from one side. The larger screw is engaged by the fixed member.

Total length of fixed member = 40 mm.

Larger diameter of fixed member = 54 mm.

Constructional details of the fixed member are given below:-

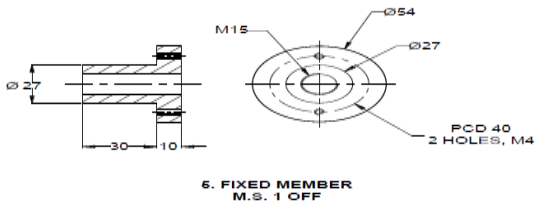


Figure 5. Fixed Member (M.S. 1 Off)

Movable Member – It is fitted in the plunger and smaller screw is engaged by this member.

Larger diameter of movable member = 30 mm. Total length of movable member = 40mm.

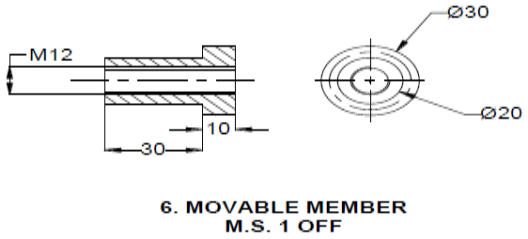


Figure 6. Movable Member (M.S. 1 Off)

Bush – Bush is provided to support the plunger and spring.

Total length of bush = 50 mm.

Larger diameter of bush = 46 mm.

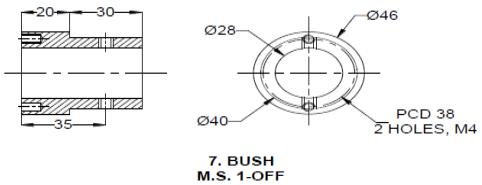


Figure 7. Bush (M.S. 1 Off)

Collar – Collar is used to fix the bush.

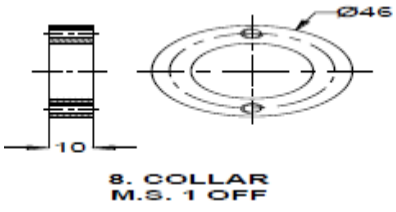


Figure 8. Collar(M.S. 1 Off)

Spring-

Spring maintains contact between the micrometer screw and the two internal threads.

Nominal coil diameter of spring = 19 mm.

Wire diameter of spring = 2 mm.

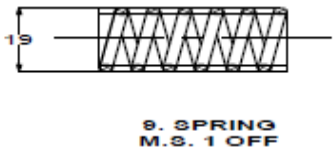


Figure 9. Spring (M.S. 1 Off)

Screws- Screws are used to connect the various parts

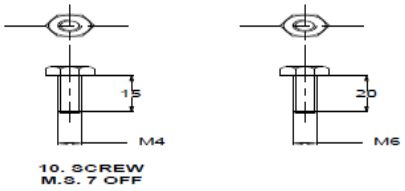


Figure 10. Screw (M.S. 7 Off)

V. EXPERIMENTAL SETUP

Design and Construction --

Circular Scale – The circular scale is attached to thimble. We made 100 equal divisions on the circular scale means one rotation of the thimble is divided into 100 equal parts.

Procedure for making a scale is as follows-

i. Thimble has an outer diameter of 64 mm, hence circumference of the thimble

$= \pi \times 64 = 201.06$ mm.

ii. Draw a line of 201.06 mm on the paper.

iii. Draw another line making an angle of 45° to the horizontal line from one end. Mark 100 equally-spaced markings on inclined line.

iv. Draw the line attaching the last marking to the other end of horizontal line.

v. Draw the lines parallel to this line from each marking on inclined line up to horizontal line.

vi. Attach this scale to the thimble.

Components which are determined in details are assembled in following ways for making the Differential Screw Micrometer Mechanism –

i. Insert the fixed member in the right hand side of the barrel and fix it with the help of the screws.

ii. Insert the spring over the plunger.

iii. Insert both the spring and plunger in the barrel from the left hand side.

iv. Then insert the bush and collar from same side and fix it to the barrel with screws.

v. Connect the differential screw to the thimble and insert it from the right hand side into the barrel and rotate.

Details of Mechanism –

In this mechanism, the differential screw has two diameters on single shaft, one of 15 mm and the other is of 12 mm. The larger diameter has pitch of 1.27 mm (20 threads per inch) and the smaller diameter has the pitch of 0.98 mm (26 threads per inch). Both the threads are right handed. The larger screw is engaged by the fixed member at end, while the smaller screw passes through a movable member. The movable member is fitted in the sliding plunger whose other ends forms one of the measuring anvil. A spring over the plunger maintains contact between the micrometer screw and the two internal threads. The micrometer screw is attached to thimble.

The net movement of the plunger is 1.27 - 0.98 = 0.29 mm for one complete rotation of the screw. The edge the thimble is graduated in 100 divisions.

Then, least count of the micrometer is given by,

$$L.C. = \frac{\text{Lead of the screw}}{\text{No. of divisions on circular scale}} = \frac{0.29}{100} = 0.0029m$$

Hence, least count of the micrometer is 0.0029 mm.

Table C. Part details and cost

SR. NO.	NAME OF PART	QTY.	COST IN Rs.
1	Differential Screw	1	300
2	Barrel	1	1250
3	Fixed Member	1	500
4	Movable Member	1	400
5	Bush	1	500
6	Collar	1	100
7	Plunger	1	850
8	Thimble	1	500
9	Spring	1	50
10	Screws	6	50
Total Cost=4500Rs.			

Advantages –

i. Accuracy is increased than ordinary micrometer.

ii. This mechanism is simple in construction.

iii. It is rugged in construction.

iv. It is portable.

VI. DISCUSSION

Differential screw micrometer mechanism is one of the most significant recognitions to have occurred, and the researcher has taken efforts to carry on academic benefits in the field. In addition, the researcher identified the challenges that may be encountered in ensuring the validity and liability of the research that would be used in the enhancement system in the domains that it operates in.

The below diagrams are real-life validations of the research at hand, conducted in a secure experimental

setup. The pictures are benchmarks for the research at hand, and therefore valuable pieces of data.

Figure 11. A

Figure 11. B

Figure 11. A and B. Differential screw micrometer Assembly

VII. CONCLUSION AND RECOMMENDATIONS

The paper entails adequate information and knowledge in the mannerism that it can be have benefit to initiate further research objectives. As there is sparse information on the topic, a proper set of literature will allow upgrading similar tactics, therefore increasing the accuracy of measurement and reducing the scope for error.

We should also consider:

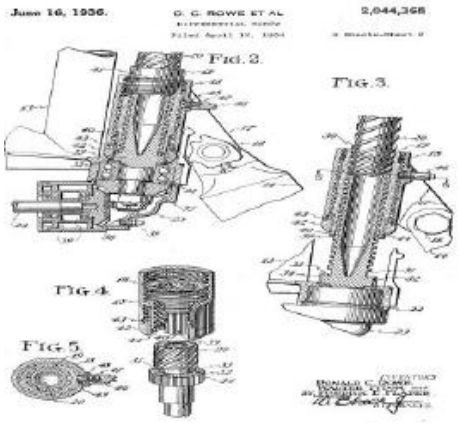
- Publications of comparable results
- Take a broad view of the data on the basis of relative literature
- Publications on less important performance parameters is also significant

VIII. FUTURE WORK AND IMPLICATIONS

The research has significantly underscored relevant past research due to the mere lack of information. This is accomplished by means of a very high pitched lead screw, wherein the advance of the lead screw pitch is on the order' of more than one screw diameter for one turn of the screw. Such a high pitch screw mechanism, as is well known, has the property of being reversible, that is, if a substantial translational force is exerted on the nut, the nut will be caused to translate along and rotate the lead screw. In the past, locking bolts have been provided to prevent reverse rotation of the lead screw or to prevent reverse translation of the nut, but these locking mechanisms have had no part in the retracting mechanism per se, and usually have been operated by a. separate control mechanism.

This invention provides a differential screw arrangement whereby the `major portion of the retracting and' extending movement of the landing gear is accomplished by a high pitch lead screw, but the extending motion is accomplished by a low pitch screw arrangement which is irreversible and self-locking.

In future, as a means of enhancing the adoption of the differential screw micrometer mechanism, it would be significant to have systems that should be operational and responsive in the context of organizations. Implementation will time based on the complexity of future work, however this domain includes a great deal of scope in its inherent characteristics. More importantly, timely data and records should be made available on the promptness of the research to further put its effectiveness to use.



REFERENCES

[1] Ezymechanic, (2015) “Differential screw for fine adjustments of precision equipment” on Ezymechanic.com. Retrieved 4 August 2016, from http://www.ezymechanic.com/2015/07/differential-screw-for-fine-adjustments.html

[2] Bhavikatti, S. (2000). Mechanics of Solids. Daryaganj: New Age International.

[3] Gwyther, J., Brown, W., & Williams, G. O. 1 mechanical engineering science in SI units.

[4] Khalil, W. & Dombre, E. (2002). Modeling identification & control of robots. New York, NY: Taylor & Francis

[5] Rajput, R.K, "Strength of Materials" Revised Edition, S. Chand and Company Limited., 2010 , pp.1448 , ISBN 81-219-2594-0.

[6] Shariff, Abdulla, "Hand Book of properties of Engineering Materials and Design Data For Machine Elements", Dhanpat Rai & Co.(P) LTD, 2010

[7] Revolvy, L. (2016). "Differential screw" on Revolvy.com. Revolvy.com. Retrieved 4 August 2016, from http://www.revolvy.com/main/index.php?s=Differential%20screw

[8] Metrology & Quality Control by R. K. Jain

[9] http://ijseas.com/volume1/v1i3/ijseas20150343.pdf

[10] Machine Design by R. S. Khurmi

[11] Ahmad, A. (1999). adjustment mechanisms (1st ed.).

[12] Bozdana, A. ME 472 – Engineering Metrology and Quality Control (1st edition)

[13] https://www.google.com/patents/US2044368