International Journal of Engineering and Technical Research (IJETR)
ISSN: 2321-0869 (O) 2454-4698 (P), Volume-3, Issue-10, October 2015

Quality Assurance of Screw Thread through ANOVA Analysis

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Abstract— **In this paper, special purpose thread is used for analysing i.e. socket screw thread which is used in mainly for assembly purpose. A screw thread which is made of hot rolled alloy steel material is used for study. In this, screw threads one parameter is considered i.e. diameter. The size of screw thread is M8X1.25g. Variations in the screw thread diameter is analysed by ANOVA methodology. It is one of the statistical procedure proceedings, the most powerful procedure for the observation data. ANOVA allows us to test whether the differences among more than two sample means are significant or not. There are two equipment used i.e. Profile Projector and matrix screw thread diameter measuring machine (Floating Carriage) in which ANOVA method is applied. By using ANOVA method which equipment gives less variations in diameter is also tested.**

Index Terms— **major diameter, ANOVA, profile projector, Floating carriage**

I. INTRODUCTION

Of the various screw thread forms which have been developed, the most used are those having symmetrical sides inclined at equal angles with a vertical center line through the thread apex. Present-day examples of such threads would include the Unified, the Whitworth metric and the Acme forms. Symmetrical threads are relatively easy to manufacture and inspect and hence are widely used on mass-produced general-purpose threaded fasteners of all types. In addition to general-purpose fastener applications, certain threads are used to repeatedly move or translate machine parts against heavy loads.

Screw: Threaded fastener with the thread running up to the head of the fastener; has no plain shank.

Screw Thread: A ridge of constant section which is manufactured so that a helix is developed on the internal or external surface of a cylinder.

Socket Screws: While many hex cap screws may be found in vehicles, socket head screws are becoming more popular and have some space saving advantages over hex cap screws. Socket heads take up less space themselves and don't require side room for wrenches. They also are usually made from stronger alloy steel vs. hex cap screws, but this depends on the grade and manufacturer.

Set Screws: These are threaded along their entire length and are typically used to secure a shaft from rotating. They're used in pulleys, sprockets, collars and knobs among other things.

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II. THREAD TERMINOLOGY

Major Diameter: On a straight thread the major diameter is that of the major cylinder. On a taper thread the major diameter at a given position on the thread axis is that of the major cone at that position

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Minor Diameter: On a straight thread the minor diameter is that of the minor cylinder. On a taper thread the minor diameter at a given position on the thread axis is that of the minor cone at that position.

Pitch: The pitch of a thread having uniform spacing is the distance measured parallel with its axis between corresponding points on adjacent thread forms in the same axial plane and on the same side of the axis. Pitch is equal to the lead divided by the number of thread starts.

Pitch diameter : The diameter of an imaginary cylinder having a surface of which cuts the thread forms where the width of the thread and groove are equal.

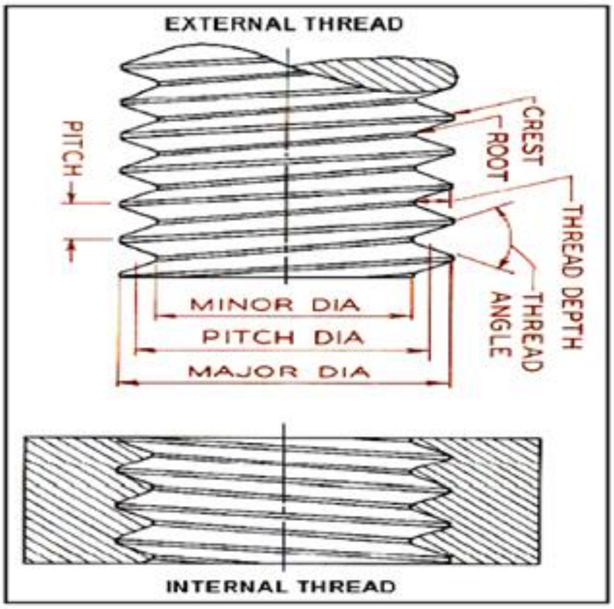


Fig.1-screw threads geometry

Thread Quality Necessity

Threaded parts have commonly been used for critical safety-related purposes, so the control and quality of threading operations is particularly important. Critical thread dimensions must also meet specific tolerances.

The dimensions of threads can be inspected with different levels of verification. If a threaded fastener is only required to assemble other parts together without specific load-carrying requirements, a basic "go/no-go" gage may be adequate for checking its threads. However, these gages only check whether the threads exceed their maximum allowable dimensions; they cannot clearly verify whether thread dimensions meet their minimum size tolerance, or whether the thread pitch diameter and thread shape are correct.

For threaded parts having specific strength requirements in service, a more complete inspection of critical thread dimensions is required. All maximum and minimum diameters and thread angles are checked and charted. This makes process variations due to tool wear visible over time. At the highest level of inspection, characteristics such as roundness and taper are monitored, requiring even more sophisticated thread inspection gages.

III. DATA COLLECTION

For collecting data two methods are used which is

1. Profile projector

An optical comparator (often called just a comparator in context) is a device that applies the principles of optics to the inspection of manufactured parts. In a comparator, the magnified silhouette of a part is projected upon the screen, and the dimensions and geometry of the part are measured against prescribed limits. The measuring happens in any of several ways.

Fig.2- Profile Projector Machine

2. Two wire method on floating carriage

It consists of three main units. A base casting carries a pair of centres, on which the threaded work-piece is mounted. Another carriage is mounted on it and is exactly at 90° to it. On this is provided another carriage capable of moving towards the centres. On this carriage one head having a large thimble enabling reading upto 0.002 mm is provided. Just opposite to it is a fixed anvil which is spring loaded and its zero position is indicated by a fiducial indicator. Thus the micrometer elements are exactly perpendicular to the axis of the centres as the two carriages are located perpendicular to each other. On the fixed carriage the centres are supported in two brackets fitted on either end. The distance between the two centres can be adjusted depending upon the length of tie threaded job. After job is fitted between the centres the second carriage is adjusted in correct position to take measurements and is located in position, The third carriage is then moved till the fiducial indicator is against the set point.

The readings are noted from the thimble head. It is now obvious that the axis of the indicator and micrometer head spindle is same and is perpendicular to the line of two centres. The indicator is specially designed for this class of work and has only one index line, against which the pointer is always to be set. This ensures constant measuring pressure for all readings. Sufficient friction is provided by the conical pegs to restrain the movement of carriage along the line of centres. The upper carriage is free to float on balls and enables micrometer readings to be taken on a diameter without restraint. Squareness of the micrometer to the line of centre can be adjusted by rotating the pegs in the first carriage which is made eccentric in its mounting. Above the micrometer carriage, two supports are provided for supporting the wires and Vee pieces for measurement of effective diameter etc.

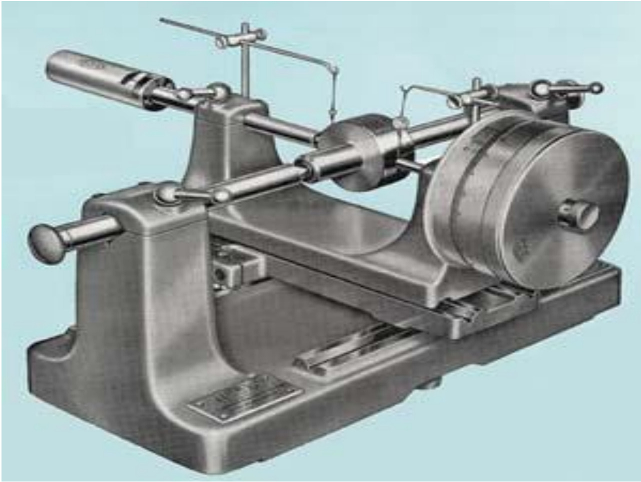


Fig.3- Matrix Floating Carriage Diameter Measuring Equipment

IV. DATA COLLECTED

sr.no.	profile projector	floating carriage
1	7.819	7.863586
2	7.817	7.86511
3	7.816	7.865872
4	7.812	7.864856
5	7.81	7.864348
6	7.866	7.831074
7	7.854	7.844536
8	7.855	7.86003
9	7.86	7.880604
10	7.867	7.88162
11	7.802	7.87146
12	7.804	7.87146
13	7.8	7.866126
14	7.801	7.865872
15	7.798	7.86511
16	7.762	7.862316
17	7.759	7.8613
18	7.762	7.844536
19	7.761	7.86384

20	7.756	7.832344
21	7.83	7.85749
22	7.821	7.85368
23	7.816	7.85114
24	7.82	7.869428
25	7.823	7.882128
26	7.772	7.856728
27	7.79	7.85495
28	7.797	7.85622
29	7.773	7.85749
30	7.77	7.865872
31	7.851	7.88289
32	7.849	7.88924
33	7.847	7.883144
34	7.847	7.880096
35	7.849	7.882128
36	7.782	7.852918
37	7.783	7.834884
38	7.785	7.83082
39	7.783	7.82574
40	7.784	7.851648
41	7.829	7.895336
42	7.829	7.89559
43	7.825	7.86892
44	7.823	7.87908
45	7.828	7.89076
46	7.777	7.887462
47	7.782	7.8867
48	7.782	7.8486
49	7.772	7.874
50	7.775	7.88289

TABLE NO.1 Reading taken on floating carriage

V. METHODOLOGY

Analysis Of Variance, ANOVA, represents one of the statistical procedure proceedings, the most powerful procedure for the observation dates. ANOVA allows us to test whether the differences among more than two sample means are significant or not. This technique overcomes the drawback of the method used in statistical inferences, which allows us to test the significance among the mean drawn from two populations only. This technique plays an important role in day to day decision making. Minitab version17 is used for calculation.

One-way ANOVA: profile projector, floating carriage

Method
Null hypothesis All means are equal
Alternative hypothesis At least one mean is different
Significance level $\alpha = 0.05$
Equal variances were assumed for the analysis.
Factor Information

Factor Levels Values
Factor 2 profile projector, floating carrriage

Analysis of Variance

Source DF Seq SS Contribution Adj SS Adj MS F-Value P-Value
Factor 1 0.08289 56.42% 0.08289 0.082885 126.89 0.000
Error 98 0.06401 43.58% 0.06401 0.000653
Total 99 0.14690 100.00%

Model Summary
S R-sq R-sq(adj) PRESS R-sq(pred)
0.0255578 56.42% 55.98% 0.0666530 54.63%

Means
Factor N Mean StDev 95% CI
profile projector 50 7.80750 0.03170 (7.80033, 7.81467)
floating carrriage 50 7.86508 0.01737 (7.85791, 7.87225)

Pooled StDev = 0.0255578

Tukey Pairwise Comparisons

Grouping Information Using the Tukey Method and 95% Confidence
Factor N Mean Grouping
floating carrriage 50 7.86508 A
profile projector 50 7.80750 B

Means that do not share a letter are significantly different.

Tukey Simultaneous Tests for Differences of Means
Difference SE of Adjusted
Difference of Levels of Means Difference 95% CI T-Value P-Value
floating car - profile proj 0.05758 0.00511 (0.04744, 0.06772) 11.26 0.000

Individual confidence level = 95.00%

Tukey Simultaneous 95% CIs

Fisher Pairwise Comparisons

Grouping Information Using the Fisher LSD Method and 95% Confidence

Factor N Mean Grouping
floating carrriage 50 7.86508 A
profile projector 50 7.80750 B

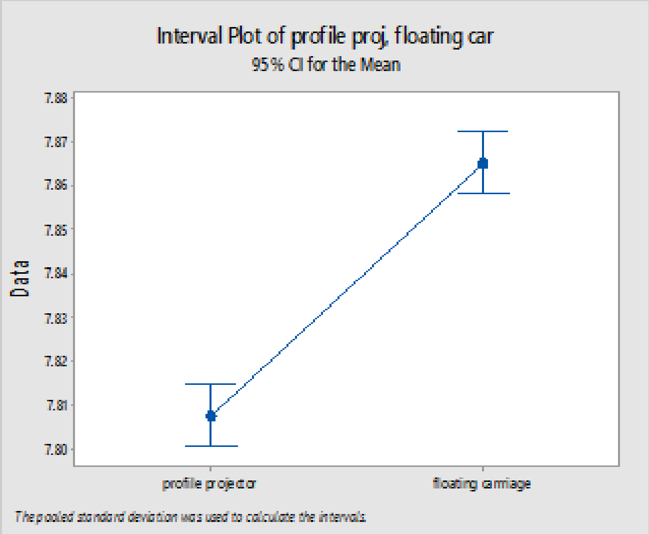
Means that do not share a letter are significantly different.

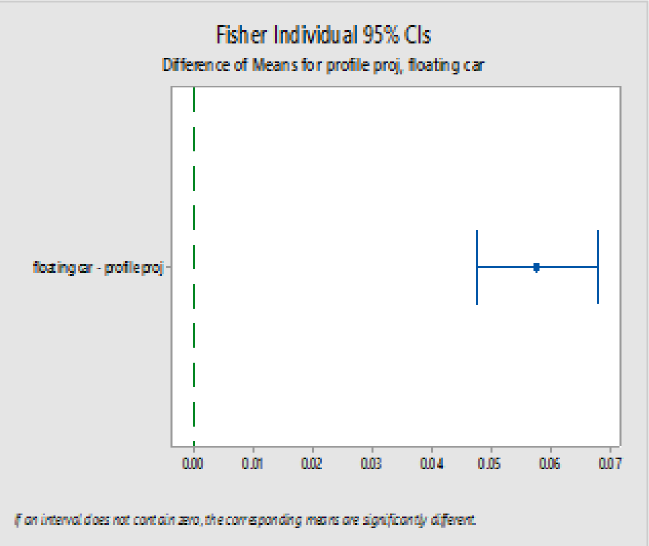
Fisher Individual Tests for Differences of Means

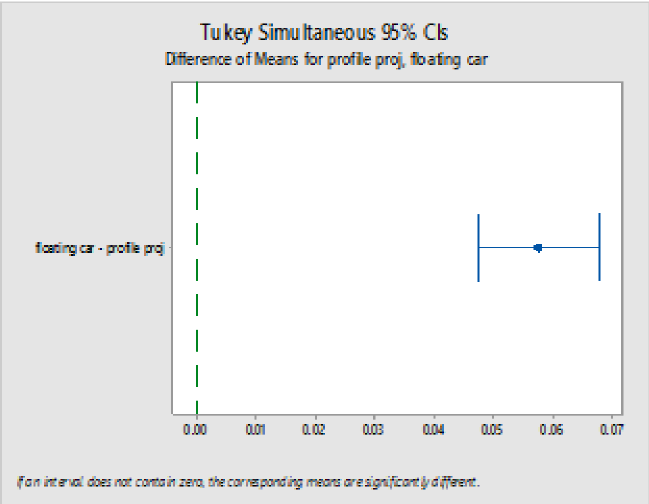
Difference SE of Adjusted
Difference of Levels of Means Difference 95% CI T-Value P-Value
floating car - profile proj 0.05758 0.00511 (0.04744, 0.06772) 11.26 0.000

Simultaneous confidence level = 95.00%

Fisher Individual 95% CIs







VI. CONCLUSION

The ANOVA table shows the squares sum which is split in four components (or five components). For each component, the table shows: sum of squares, degree freedom, mean square and ratio F. Each ratio is the ratio of the value of the mean square for that source of variation of the residual mean square. First Normality test is done to test the significance level i.e. p<0.005. The collected data is passes the normality test. After that ANOVA test is applied to check the variation in major diameter of screw threads whose readings is taken by two different equipment which is profile projector and floating carriage. The calculation shows that the reading taken on profile projector has more variation on compare to floating carriage which results that floating carriage gives less variation values.

	Means	Tolerance limits
Means of profile projector	7.80750	(7.80033, 7.81467)
floating carrriage	7.86508	(7.85791, 7.87225)

The means differences between equipment is 0.0511 and standard error of means is 0.0578. At confidence level of 95%.

Tolerance limit for M8size screw thread major diameter according to their class 6g is

Standard tolerance limit (7.760, 7.972)

Observed tolerance limit is (7.80033, 7.81467) and (7.85791, 7.87225)

On that result, this conclude that quality of screw threads major diameter can be improved by matrix Floating Carriage Diameter Measuring Equipment as compare to profile projector.

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