ISO/TR 10064-1:2017-07 (E)

Code of inspection practice - Part 1: Measurement of cylindrical gear tooth flanks

Contents

Page

Foreword vi

1 Scope 1

2 Normative references 1

3 Terms, definitions, symbols and abbreviated terms 1

4 General considerations 5
4.1 Background 5
4.2 Required inspection information 5
4.3 Measurement selection 5
4.3.1 Substitution of measurement methods 5
4.3.2 First piece inspection 5
4.3.3 Sampling and statistical process control 5

5 Conventions and measurement positions 6
5.1 General 6
5.2 Datum axis 6
5.3 Left or right flank 6
5.4 Left hand or right hand helical gears 7
5.5 Numbering of teeth and flanks 7
5.6 Numbering of pitches 8
5.7 Number of pitches "k" in a deviation symbol subscript 8

6 Types of measuring equipment and principle 8
6.1 General 8
6.2 Measurement methods 14
6.2.1 Generative measurement methods 14
6.2.2 Non-generative measurement methods 16
6.2.3 Pitch measurement methods 17
6.2.4 Hand-held pitch measuring devices 18
6.2.5 Radial runout measurement 20
6.2.6 Computer tomography methods for small gears 21
6.2.7 Optical devices for small spur gears 21
6.3 Calibration of equipment 22
6.4 Tooth thickness, differences between CNC/CMM and manual measurement 22
6.5 "In-process" gear measurement on manufacturing machines 23
6.6 Gear mounting 23
6.7 Example output format from a CNC GMM 24
6.7.1 General 24
6.7.2 Example evaluations of modified helices and profiles 27

7 Recommended measurement procedure and good measurement practice 28
7.1 Measurement procedure 28
7.2 Probe problems when measuring aluminium parts 30
7.3 Suitable artefacts for calibration of measuring machines 30

8 Inspection procedures for gears that are too large for gear inspection machines 31
8.1 General 31
8.2 Profile inspection using portable device 31
8.2.1 Disassembly of segments 31

8.2.2 Measurement by portable gear inspection device using coordinates 31
8.2.3 Profile inspection by gear tooth caliper 32
8.3 Inspection of helix form deviation 36
8.3.1 Inspection of helix form deviation on the gear cutting machine 36
8.3.2 Straightness inspection using a cylinder 37
8.3.3 Inspection of the tooth contact pattern 37
8.4 Inspection of the pitch 38
8.4.1 Calculation of pitch 38
8.4.2 Inspection using an automatic device on the cutting machine: inspection of the single circular pitch and the cumulative pitch deviation 38
8.4.3 Manual inspection: inspection of base pitch, pb, and base pitch deviations, fpb 39
8.5 Measuring tooth thickness 39
8.6 Measuring gear radial runout and axial runout of reference surfaces 39

9 Measurement analysis -- Profile, helix, pitch and radial runout 39
9.1 Profile 39
9.1.1 Profile deviation 39
9.1.2 Profile deviation diagram 40
9.1.3 Evaluation of profile diagrams 41
9.1.4 Algebraic signs of fH, fb and f 42
9.1.5 Mean profile slope deviation, fHm 42
9.2 Helix 43
9.2.1 General 43
9.2.2 Helix deviation diagram 44
9.2.3 Evaluation of helix diagrams 45
9.2.4 Algebraic signs of fH and f 46
9.2.5 Machine corrections based on mean helix slope deviation, fHm 47
9.3 Pitch 48
9.3.1 Pitch deviation 48
9.3.2 Pitch deviation measurement 48
9.3.3 Relationships of pitch parameters and measuring methods 48
9.3.4 Calculation of cumulative pitch (index), Fp 49
9.3.5 Calculation of single pitch, fpi 50
9.3.6 Calculation of total cumulative pitch deviation, Fp 50
9.3.7 Calculation of sector pitch deviation, Fpk 50
9.3.8 Segment gear measurement 50
9.4 Radial runout, determining eccentricity 51
9.4.1 Measuring principle 51
9.4.2 Evaluation of measurement 51

10 Interpretation of profile, helix, pitch and radial runout results 52
10.1 Interpreting measurement results 52
10.2 Procedure for interpreting measurement results 52
10.3 Recognition of common manufacturing errors 53
10.3.1 General 53
10.3.2 Example of a profile with pressure angle deviation 53
10.3.3 Example of profile deviations with varying pressure angle deviation 53
10.3.4 Hob runout or shaping cutter deflection 54
10.3.5 Consistent mean helix slope deviation 55
10.3.6 Helix slope variation 55
10.3.7 Profile control diameter not achieved 56
10.3.8 Variation in profile non-clean up and profile control diameter not achieved 56
10.3.9 Pitch results with radial runout of the gear blank 58
10.3.10 Pitch with indexing deviations 58
10.3.11 Pitch with repeating deviation patterns that may cause noise 61

11 Single flank composite testing 61
11.1 Single flank composite testing principle 61
11.2 Single flank composite test 62
11.2.1 Single flank test setup 62
11.2.2 Single flank composite deviations 64

11.3 Single flank measurement with master gear 65
11.3.1 Master gear requirements 65
11.3.2 Influence of profile deviations 65
11.3.3 Influence of pitch deviations 66
11.3.4 Influence of helix deviations 66
11.4 Single flank measurement of product gear pair 69
11.4.1 Differences between tests with a master gear and between two product gears 69
11.4.2 Identification and location of defects 69
11.4.3 Selective meshing of gears 69
11.5 Data analysis by the Fourier transform method 70

12 Additional measurements 71
12.1 Flank measurements 71
12.1.1 General 71
12.1.2 Twist measurement 71
12.1.3 Topographical measurement 72
12.1.4 Undulations 73
12.2 Surface roughness measurement 74
12.3 Tooth root fillet radius measurement 74

13 Filters and data density 75
13.1 General 75
13.2 Examples of filtered results 75
13.3 Working principle of the Gauss 50 % filter 75
13.4 Filter limitations 81

14 Additional calculations 81
14.1 Calculation of single pitch deviation, fpt, from normal base pitch measurements 81
14.2 Additional calculations for normal base pitch measurements 82
14.2.1 Included parameters 82
14.2.2 Calculation of normal base pitch deviation, fpbn 82
14.2.3 Calculation of mean normal base pitch deviation, fpbnm 82
14.3 Additional calculations for profile measurements 82
14.3.1 Included parameters 82
14.3.2 Mean base diameter deviation and mean pressure angle deviation 83
14.3.3 Calculation of effective base diameter, db eff 84
14.3.4 Calculation of effective transverse pressure angle, t eff 84
14.3.5 Calculation of effective normal pressure angle, n eff 84
14.3.6 Calculation of mean transverse pressure angle deviation, fmt 85
14.3.7 Calculation of mean normal pressure angle deviation, fmn 85
14.4 Additional calculations for helix measurements 85
14.4.1 Included parameters 85
14.4.2 Required preliminary data 86
14.4.3 Calculation of effective helix angle at the measurement diameter, M eff 86
14.4.4 Calculation of effective lead, pz eff 86
14.4.5 Calculation of effective helix angle at the standard pitch diameter, eff 87
14.4.6 Calculation of mean lead deviation, fpzm 87
14.4.7 Calculation of mean helix angle deviation, fm 87

Bibliography 89