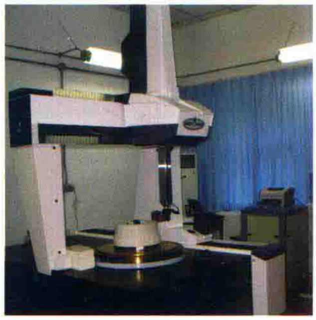
张国雄论文选集

Selected Proceedings of Guoxiong Zhang

张国雄　等著
By Guoxiong Zhang et al



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张国雄论文选集

张国雄　等著

机 械 工 业 出 版 社

张国雄教授1936年生于上海，1959年毕业于原苏联莫斯科机床工具学院，曾任天津大学精密仪器系主任、精密仪器与光电子工程学院院长、校图书馆馆长、全国仪器仪表专业教学指导委员会主任委员；先后获国务院政府特殊津贴、香港栢宁顿教育基金会孺子牛金球奖、全国模范教师、天津大学师德楷模、天津市劳动模范等荣誉；完成科研项目60项。获国家发明奖1项，省市部委科技进步奖5项。此外，在美国国家标准与技术研究院做访问学者期间，他与美国同事一起完成的1个项目获美国1983年最佳100项科研成果奖，部分成果纳入美国和国际相关标准。

为庆贺张老师从教56周年暨八十华诞，我们作为他培育的弟子整理出版这本论文集，希望他的学术思想、毕生的积累得到更好的传播。本书选取了张国雄教授等的31篇已发表的代表性论文，按研究方向分为制造精度基础、坐标测量系统、精密测量、纳米制造等四个专题。本书对从事几何量测量相关工作的科研人员具有很好的参考价值，供学校教学和学术交流用。

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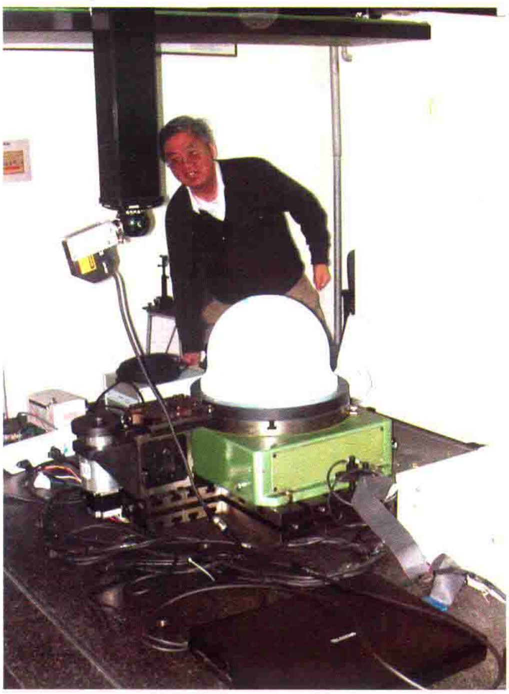
1996 年获莫斯科国家工业大学荣誉博士

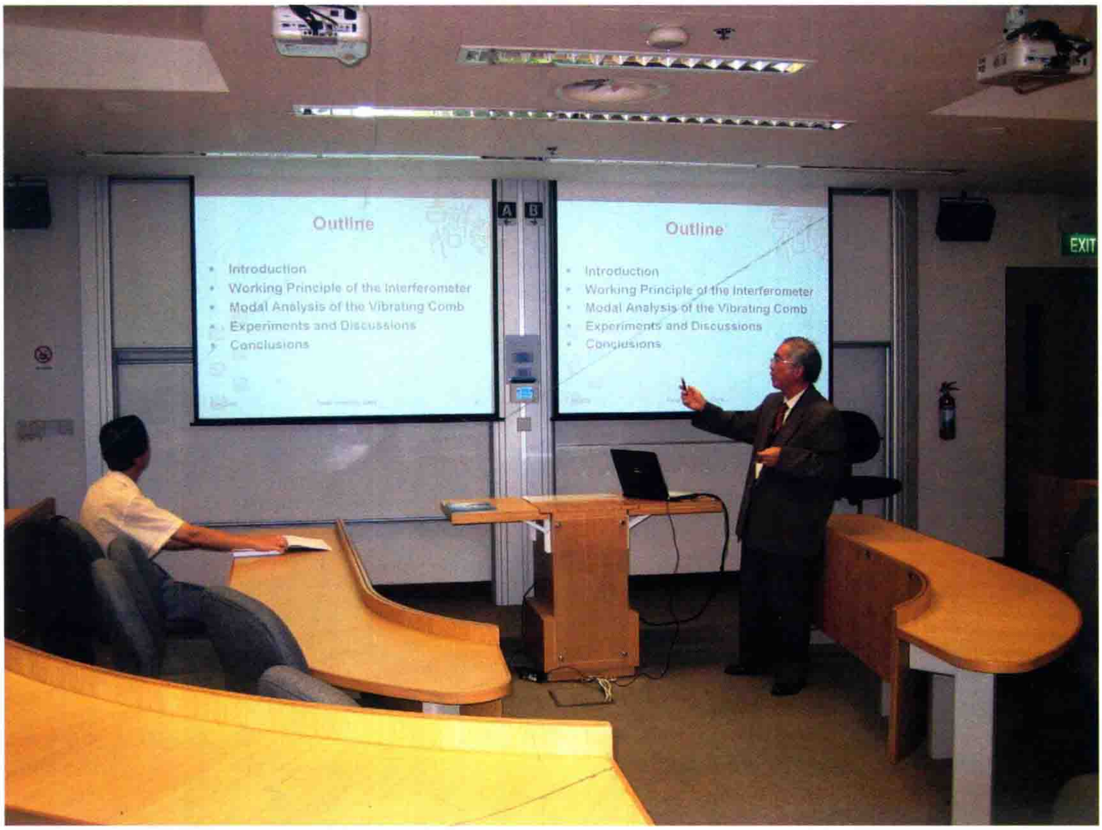


2003 年 在所研制测量机上做实验

2010 年在意大利国际学术会议上做报告

2004 年在 Michigan University 讲学参观

2004 年参加上海中德国际会议



2008 年参加新加坡第一届纳米制造国际会议

2010 年参加精密测试技术及仪器国家重点实验室学术会议

2012 年在国际生产科学院年会上与美国教授交谈

2013 年参加欧美同学会 100 周年大会

序
——学高为师，身正为范

张国雄教授1936年4月生于上海，1959年以全校唯一的全优成绩毕业于原苏联莫斯科机床工具学院，同年开始在天津大学任教，至今已有半个多世纪的光阴。今天，看到他的学生为庆贺恩师从教56周年暨八十华诞，整理出版了这本论文集，我感到十分欣慰，并衷心希望他的学术思想和科研成果能得到更广泛的传播，带给人们更多的启迪，为祖国的建设、人类的进步添砖加瓦。

张国雄教授的教学、科研贡献卓著，是有目共睹的。他从1986到2000年，先后担任天津大学精密仪器系主任、精密仪器与光电子工程学院院长，并曾兼任学校图书馆馆长。1996—2001年任全国仪器仪表专业教学指导委员会主任委员。他还先后获国务院特殊津贴（1992）、香港栢宁顿教育基金会孺子牛金球奖（1995）、全国模范教师(2001)、天津大学师德楷模（2002）、宝钢优秀教师奖（2002）、天津市劳动模范(2003)、天津市2002年度职工职业道德建设先进个人（2003）等荣誉称号。天津市曾授予他“荣誉授衔专家”称号，俄罗斯莫斯科国家工业大学授予他荣誉博士学位，他先后被选为国际生产工程科学院精密工程专业委员会主席、中国机械工程学会常务理事、中国机械工程学会生产工程分会主任委员、中国仪器仪表学会机械量测试仪器学会副主任委员等，并担任国内外多个学术刊物编委会主任或委员。

在漫长的从教生涯中，他桃李芬芳。为数千名大学生、研究生讲授了自动检查尺寸仪器、量仪设计、几何量电测量仪、精密仪器电路、测控电路、机床计量学、三坐标测量机等课程，获得赞誉无数。他指导的博士研究生有54人、硕士研究生有68人、博士后研究人员有11人、进修教师有6人。

在勇攀科技高峰的道路上，他硕果累累。他完成科研项目60项，包括国际合作项目13项、国家科技攻关与“863”项目6项、国家自然科学基金项目8项，其中52项为项目负责人。获国家发明奖1项，省市部委科技进步奖5项。此外，在美国国家标准与技术研究院做访问学者期间，他与美国同事共同完成的1个项目获美国1983年最佳100项科研成果奖，部分成果纳入美国和国际相关标准。国内外对他深厚的学术造诣给予很高的评价。

他的科研著作等身。至今有公开出版著作12部，其中1部在美国出版，多部著作获国家图书或教材奖。据不完全统计，他和学生在国内外科技刊物和各类学术会议上发表教学与科研论文655篇，其中第一作者131篇，国外刊物74篇，国内刊物425篇，国际学术会议106篇，国内学术会议50篇，为SCI收录49篇、EI收录141篇。论文被国际上引用1274次，有2篇论文被引用超过100次。本论文集遴选了其中有代表性的31篇。

熟悉张国雄教授的人，不仅能感受到他丰富的学识和深厚的学术造诣，更能感受到

他严谨治学的态度和一丝不苟的学风。他从不弄虚作假，也绝不允许他的学生在学风上有任何瑕疵。他经常说，美化数据、掩盖问题是害人、害己、害科学，很多发现、创新都是从不掩盖矛盾开始的。他说教书是手段，育人才是目的，只有培养出一大批德才兼备的年轻人，才能为祖国争光、为人类造福。他希望他的学生“青出于蓝而胜于蓝”，将培养更多的卓越人才视为人生最大的成就。他是天津大学“实事求是”校训的模范履行者，他的科学精神、严谨态度和做人准则将指引更多的有志青年克服前进道路上的困难，成为国家和民族的栋梁。

祝愿张国雄教授健康长寿！

天津大学校长 李家俊

2015年9月14日

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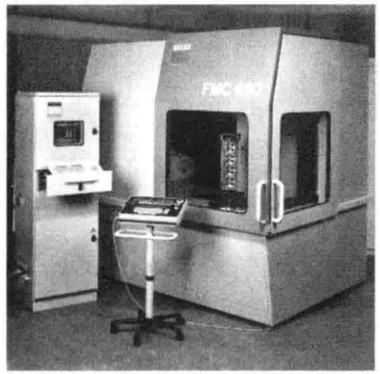

A Study on the Abbe Principle and Abbe Error

G. X. Zhang, Tianjin University/China
Received on January 10, 1989

Abstract

A new definition of Abbe principle "The line connecting the reference point and sensing point should lie in the sensitive direction" is proposed in this paper. This definition is applicable for all cases of dimensional measurements, including 1-D, 2-D and 3-D measurements, straightness and roundness measurements, runout measurements etc. A new formula for calculating the Abbe error in the form of $\delta = \Delta(l\sin\varphi)$, where l is the distance between the reference point and the sensing point, and φ is the Abbe angle, is given in the paper. Different cases are discussed in the paper and the effectiveness of the new definition and the new formula is shown.

Keywords

Abbe principle, Abbe offset, Abbe angle, Abbe error, reference point, sensing point, sensitive direction

INTRODUCTION

The Abbe principle is called the first principle in metrology by some scholars. The great importance of this principle in machine tool and instrument design, in the design of the method of measurement has been proved by the practices in a whole centry since Prof. Abbe first proposed this principle in 1890. However with the development of science and technology the definition of the Abbe principle and the concept of Abbe error are needed to be updated urgently. It is mainly caused by the following facts:

(1) The Abbe principle is mainly aimed at the displacement and length measurements. However, there are a lot other cases, such as straightness and roundness measurements in dimensional metrology and manufacturing engineering.

(2) The Abbe principle is mainly aimed at one dimensional measurements. There are a lot of new problems needed to be solved urgently with the development of 3-D metrology and manufacturing engineering.

(3) A lot of new measures for compensating the Abbe errors were provided by the development of modern electronics, optics and computer science.

THE CLASSICAL DEFINITION OF ABBE PRINCIPLE AND BRYAN'S PROPOSAL

For the better understanding Abbe principle we start from discussion of its classical definition.

Abbe principle says:

(1) In displacement measurement the reference should be in line with the displacement to be measured or on its extension.

(2) In the case when the reference is not in line with the displacement to be measured but parallel to it the distance between these parallel lines is called Abbe offset r.

(3) In the case of complying with the Abbe principle the angular error motion of the measuring device will cause only a second order error in measurements, which is usually negligible small. On the opposite, when it does not comply with the Abbe principle, in which the Abbe offset $r \neq 0$, an first order error $\delta = r\Delta\varphi$ will be caused. This error is called Abbe error.

The chief metrologist of Lawrence Livermore Laboratory of USA Mr. J. B. Bryan has proposed following statements as generized Abbe principle:

(1) The displacement measuring system should be in line with the functional point whose displacement is to be measured. If this is not possible, either the slideways that transfer the displacement must be free of angular motion or angular motion data must be used to calculate the consequences of the offset. The key point of Bryan's this proposal is that the case, when we can compensate the angular motion of the measuring device by certain hardware to make it have no angular motion or to compensate the Abbe error by software, should be treated as complying with the Abbe principle.

(2) The effective point of a straightness measuring system should lie along a line which is perpendicular to the direction of slideway travel and passes the functional point whose straightness is to be measured.

Bryan's proposal has made the Abbe principle applicable for both displacement and straightness measurements. It is his important contribution to the Abbe principle. However, it should be mentioned, there are also many other fields in dimensional metrology, including roundness and runout measurements, 2-D and 3-D measurements. It is needed to set an unified definition for the Abbe principle which will be applicable for all cases of dimensional metrology.

A PROPOSAL FOR THE NEW DEFINITION OF THE ABBE PRINCIPLE

For the purpose of setting a new definition for the Abbe principle the following terms and concepts are introduced.

1. Reference Point and Sensing Point

Any dimensional measurement is a comparison process of the quantity taken as reference with the quantity to be measured. The reference might take the form of a standard part, such as gage block, scale, straightedge or reference ball etc. or a natural reference, such as wave length of an optical beam or a reference motion, such as standard linear motion, rotation, involute motion or helical motion etc. To read out the reference value a reference point is needed. In Figure 1 point A on the cross hair of reference microscope 1 might be taken as the reference point. In Figure 2a the