2003年暑期学术沙龙活动总结

青年学术沙龙 力学与工程科学系

2003 年 9 月 7 日

Youth Academic Salon

Department of Mechanics & Engineering Science

活 动 总 结

03年暑期学术沙龙在诸多研究生同学和少数本科同学的支持和关心下，我们共进行了10次综述性的报告，内容涉及固体、一般力学、流体力学、生物力学以及计算机科学等较多的方面。每次报告平均都有十余位研究生和本科同学参加，并且都有相应的讨论。这些都表明，学术沙龙已经越来越为研究生同学所接受。学术沙龙让我们能够学习和了解其它方向研究的思想和方法，籍此在提高自己认识水平的同时也能提供其他方向同学有价值的信息。现代科学技术需要各方面的经常性的、广泛并且深入的交流，我们的学术沙龙为我提供了这样的机会，由此也越来越多地得到支持和响应。

从报告的内容来看，基本上都为报告同学最新的科研成果，并且可以达到公开发表的水平；这一点明显反映在各位所提供的报告内容详细摘以及由报告人所撰写（或参与）的相关论文上。在叙述上，大家都精心准备*ppt*，准备演讲的条理，使得我们的表达能力都得到了锻炼和提高。在学术交流过程中，我们不仅对科学研究产生了更为浓厚的兴趣；而且这种兴趣又增进的我们的友谊。我们期待能经常聚在一起，自己作报告或聆听其他同学的报告，享受学术交流的乐趣。正因为这种冲动和向往，研究生团学联准备在中秋时节以学术交流为主题而开展迎新活动。这一活动将由新学期第一次学术沙龙拉开帷幕。

这次暑期学术沙龙有了第一次纯粹关于计算软件方面的报告；报告我们日常科研中所需软件的使用技巧。这对于学习者而言会起到事半功倍的效果，所以对科研而言是非常有价值的。新学期的第一次报告也是同类型的关于目前流行的CFD商业软件的使用技巧。这些报告也拓宽了我们交流的范畴。

我们应该感谢报告同学无私地表述他们经过摸索而获得的经验和感悟；我们也为拥有这种真诚的交流氛围而感到欣喜。

在此，我们也要感谢系里对学术沙龙的支持。对此次活动，我们获得了800元的经费。经BBS上意见的征求，我们基本上以400元作为活动用的经费，主要在炎炎夏日为所有参与沙龙的同学提供些冷饮；另外400元则资助报告同学的购书或文具用品。

系青年学术沙龙

2003年9月7日

目录

1 03-07-04报告：颅内动脉瘤的血液动力学模型研究与数值模拟及浅谈LaTeX

报告人：戴建华（硕士研究生，导师：丁光宏教授）

报告题目:（I）颅内动脉瘤的血液动力学模型研究与数值模拟*（II）浅谈LaTeX

摘要及介绍†

血液动力学在颅内动脉瘤的形成，生长和破裂过程中起着非常重要的作用，动力学参数如血液流速、压力、壁面切应力等都是颅内动脉瘤破裂的重要风险因子。但是，上述参数在活体内很难进行测量，本文采用CFD（计算流体力学）软件结合医学影像对动脉瘤内的流动进行数值模拟，希望为颅内动脉瘤破裂机理和风险因子的评估提供一种方法。

血液动力学在颅内动脉瘤的形成、生长、破裂、以及治疗中是重要的因素，众多的动力学参量如壁面切应力、压力、冲击力、血液流速和（血液在瘤内的）驻留时间，已经被研究认为与瘤的生长和破裂有着重要的联系。由于在活体内测量上述的参量比较困难，所以有必要采取可行同时可靠的方法计算出这些动力学参量。

到今天为止，对颅内动脉瘤的研究绝大多数都是在活体外进行的，采用的是在数学上理想化了的规则模型。这样的研究使我们了解了颅内动脉瘤的血液动力学的某些规律，但是对于某个特定的病例，某个特定的瘤来说，却无法提供足够的信息，无法给出评估颅内动脉瘤破裂的风险因子的很好方法，因而不能在临床实践中应用。所以，需要一种适用于特定的病例，特定的动脉瘤形态并能在临床广泛使用的方法来评估其风险因子。

现在的医学影像技术已经能够提供高分辨率，二/三维的瘤的图像，通过处理后就可以得到瘤的外形轮廓，结合CFD有限元软件就能够在体外对颅内动脉瘤内的血液流动进行数值模拟，进而可以得出相应的血液动力学参量以便进行风险因子的评估。现在越来越多的研究精力被投入到这种针对特定病例（不仅仅是颅内动脉瘤）的研究工作中去，甚至开发出了一些可以应用于临床的软件系统。

ABSTRACT

BACKGROUND AND PURPOSE: Haemodynamics is believed to play an important role in the formation, growth and rupture of intracranial aneurysms,and haemodynamic parameters such as blood velocity, pressure, and wall shear stress are key risk factors of the rupture of

*本报告提供论文《颅内动脉瘤的血液动力学数值模拟》，戴建华、丁光宏、龚剑秋等，2003。

†本部分内容及以下英文摘要均摘自《颅内动脉瘤的血液动力学数值模拟》，戴建华、丁光宏、龚剑秋等，2003

intracranial aneurysms. However, these parameters are difficult to be measured *in vivo*; this study demonstrates that CFD(computational fluid dynamics) combined with medical images can simulate the flow in aneurysms, and this may be a prospective way to evaluate the rupture mechanism and the risky factors.

METHODS: An DSA image of an intracranial aneurysm provided by Huashan Hospital, is handled by some image processing software and the lumen geometry are extracted. The profile meshed by some CFD software, together with boundary conditions, is used to simulate the flow.

RESULTS: CFD analysis reveals that for steady condition, the two sides of the aneurysm neck endure comparatively high pressures and wall shear stresses, and strong vortex exists aross the inlet, while velocities are low inside the aneurysm although weak vortex still exists. It is also demonstrated that for unsteady(pulsatile) conditon, velocities inside the aneurysm are very low and nearly stagnant, while vortex ebbs and flows in the inlet area, and the pressures acted on the two side of the aneurysm neck oscillate within a wide range, and wall shear stresses there oscillate within a small range.

CONCLUSIONS: The pressure and wall shear stress obtained by the numerical simulation are important haemodymic factors and key risk factors. CFD simulation can provide key haemodynamic information for clinic diagnosis and treatment of intracranial aneurysms.

Keywords: intracranial aneurysm; CFD; numerical simulation; medical image

2 03-07-09报告：有限长轴承油膜力计算及其运用

报告人：沈光琰（硕士研究生，导师：郑铁生教授）

报告题目：有限长轴承油膜力计算及其运用*

摘要及介绍†

本文基于变本法提出了一个求解雷诺边界条件下有限长轴承油膜力的快速算法，并且用此算法对一个三油叶不平衡轴承－转子系统的非线性动力学行为进行了一系列的分析。数值模拟的结果显示了转子由稳定的同步涡动分岔为半频油膜涡动继而变为油膜振荡的失稳过程，本文还分析了荷载与质量偏心对转子运动的影响。结果表明，转子的失稳转速随着荷载的增大而减小，增大荷载不利于转子的运行。中小质量偏心下，转子达到失稳转速后会出现半频涡动以及更为复杂的油膜振荡现象，而大质量偏心情况下，转子始终是同步涡动。文中还计算了同样参数条件下的椭圆轴承－转子系统的失稳转速，结果表明三油叶轴承系统的失稳转速高于同类条件的椭圆轴承系统，所以使用三油叶轴承有利于提高转子系统的稳定性。

传统的轴承转子系统的动力学分析都是借助于线性化的描述，基于小扰动的假设，将非线性系统简化为一个用八个刚度阻尼系数表征的线性模型。然而在很多情况下转子不再仅仅局限在平衡位置的附近做小扰动，此时的轴承转子系统的动力学行为会表现出很强的非线性。线性分析已经失效，只有借助于分析原始的非线性动力方程才能更彻底更清晰的了解系统的运动特性。对转子动力学行为进行非线性分析的一个主要障碍就是如何快速而准确的计算瞬态油膜力。最精确但同时也是最耗时的方法是以有限元法和有限差分法为代表的数值方法。这些方法虽然能够比较准确的求出油膜力，但其计算量十分巨大。而非线性分析中常常要进行数值积分瞬时模拟需要进行上十万次的油膜力计算，有限元法和有限差分法已经难以实际运用于非线性分析。因此在进行非线性分析时，人们计算油膜力的雷诺方程中的某些项，从而可以简化雷诺方程求出油膜力的解析解。根据文献，只有当轴承的长径比小于0.2时才能采用短轴承假设当长径比大于2.5时才能用长轴承假设。

在实际情况下滑动轴承一般由几块轴瓦油叶构成，并不满足这些假设。此时如果还是运用短轴承或长轴承理论下的油膜力就会给系统的分析带来很大误差甚至导致定量分析失效。根据精确和快速的原则，本文基于变分法提出了一个雷诺边界条件下油叶轴承油膜力的快速算法并用这个算法对一个三油叶轴承转子系统的非线性动力学行为进行了一系列分析。用轴心轨迹图*Poincare*截面图以及分岔图等现代非线性分析手段作为工具展示了不平衡转子系统的失稳过

*本报告提供论文《油叶型轴承不平衡转子系统的非线性动力学分析》，沈光琰提供

†本部分内容摘自《油叶型轴承不平衡转子系统的非线性动力学分析》

程以及不平衡转子的质量偏心和其它参数对转子稳定性的影响。分析结果表明，转子的质量偏心较小时转子的同步涡动更容易失稳分岔，且失稳后的运动情况复杂；而质量偏心增大时转子的失稳转速提高；当转子质量或轴承的间隙增大时会降低失稳转速使分岔提前，不利于转子的稳定运行。通过转子分别支承在椭圆轴承和三油叶轴承上的计算结果对比，得出了三油叶轴承的稳定性要优于同样参数条件下的椭圆轴承的结论。

3 03-07-15报告：*A Brief Introduction To VOF Method*

报告人：胡越（硕士研究生，导师：张慧生教授）

报告题目：*A Brief Introduction To VOF Method*

摘要及介绍*

这一次呢，我将讲一下VOF，内容主要包括VOF的思想，发展过程，和其可以改进的地方。也将包括3种界面重构的方法：比较原始的$HIRT$的方法，（因其在VOF发展过程中的开创性地位，我想还是应该为大家介绍一下），$FLAIR$方法（我认为最精细，但推广到轴对称情形有相当困难，所以我们并未采用），和$YOUNGS$的方法，（比较精细，操作起来相对简单，容易推广到轴对称）。这次的报告非常欢迎本科生参加。我认为VOF方法本身在数学要求上不是很多，基本意义上的掌握也不会很困难。但其思想我觉得是值得大家借鉴的。本科生完全可以听的懂并掌握之。另外这个方法的应用前景和应用范围都相当广阔，且具有相当的发展空间。透露一个小秘密，这种方法在使用中还很少有人考虑相变的问题黄军涛博士正在摸索之中，有兴趣的本科生（主要是00和01级的$DDMM$）如果现时加入，应该是很有希望突破的，这可是原创性的工作。呵呵，跑题了。

还有一次，我将介绍一点现在比较流行的高精度高分辨的格式，主要是以前介绍过一点的TVD，和尚未介绍过的ENO和$WENO$格式。后两种格式在现在的航空领域得到了广泛的应用，而本质上无振荡的这种性质给我们的工作带来了相当的好处。且其可以没有困难的推广到任意阶精度。另外还将简要介绍一点其他的自由面的处理方法，和我对这些方法的评价。这次报告呢，可能在数学上的要求比较高一点，说实话，很多地方我自己也未必搞的懂。只好讲一点我懂的了，呵呵。

总之，非常希望我们的工作能够为其他组的工作带来一点帮助，也希望有更多的本科生能够加入到我们组的工作中来。

*本部分内容摘自胡越发表在BBS上的文章：日月光华(2003年06月25日08:13:28 星期三)

4 03-07-24报告：流体实验室最近的一些工作

报告人：郭明旻（博士研究生，导师：徐有恒教授）

报告题目：流体实验室最近的一些工作

摘要及介绍*

流体力学实验和理论分析、数值计算一样，是流体力学研究的一种有力手段。本报告将结合我们实验室的现状，介绍流体力学实验的一些基本方法。同时，还将报告我们这一两年来所做的主要工作，包括建筑物风洞实验、室内环境研究、流动诱发的圆柱振动、桥梁横断面的气动力分析等，以及我们在工作中碰到各种问题。欢迎大家集思广益的积极参与讨论，讨论的内容除了我们工作碰到的问题，还包括如何将理论和计算更好的与我们的实验联系起来。

*本部分内容由郭明旻提供

5 03-07-31报告：$Fortran$和$Matlab$混合编程简介

报告人：陆华剑（硕士研究生，导师：张慧生教授）

报告题目：$Fortran$和$Matlab$混合编程简介

摘要及介绍*

呵呵，跟上次的报告很不一样，这次的报告一个公式都没有:) 而且把复杂的部分都去掉了，挑的都是最简单的例子，只要学过编程的同学应该就可以听得懂。

内容主要包括两部分，一部分是$Fortran$通过$MatlabEngine$和$Matlab$应用程序之间进行数据传递，另一个是用$matlab$的mex命令将$*.for$文件编译成$*.dll$（这一部分简单介绍一下）,和PPT一起上传的还有两个程序，$main$是第一种方式，$timestwo.for$是第二种方式另外还有一些$Fortran$和$matlab$的比较（纯属个人体会，仅供参考），

不过这个方面的东西我也不是很熟，只是因为我算的东西用$matlab$算速度太慢，用$Fortran$觉得调试不方便，就想把它们放在一起用，所以就去找了一些资料，其实我只是略知一点皮毛而已//$blush$

不过我想这些内容做数值计算得同学可能会碰到，所以就和大家一起讨论一下，就算是一次读书报告吧:)

*本部分内容摘自陆华剑发表在BBS上的文章：日月光华(2003年07月29日16:03:34 星期二)

6 03-07-31报告：非粘性阻尼的等价粘性阻尼方程

报告人：高淑华（硕士研究生，导师：唐国安教授）

报告题目：非粘性阻尼的等价粘性阻尼方程

摘要及介绍*

1.粘弹性阻尼的应用背景及研究进展粘弹性阻尼的应用背景及研究进展

1) 粘弹性阻尼材料简介

粘性阻尼与非粘性阻尼的区别

只要是能量耗散函数$D(t) = \frac{1}{2}\dot{u}(t)^T \int_{-\infty}^{t} g(t-\tau)\dot{u}(\tau)d\tau$ 非负的模型都可能是某种阻尼模型。粘性阻尼假定瞬时$generalized$速度是决定阻尼的唯一相关状态变量。非粘性阻尼模型，阻尼由除了瞬时速度外的任何状态变量决定的阻尼模型。其中，通过对松弛函数的卷积积分，阻尼依靠运动的历史的阻尼模型是非粘性阻尼的一种。松弛函数G也可以叫做延迟函数，继承函数等，它有许多形式，指数函数只是其中一种。粘弹性材料的特征粘弹性材料集合了纯弹性材料和粘性材料的特点。纯弹性材料能量在载荷移去时完全存储起来，应力与应变曲线是同相的，适用$Hooke$定理,应力与应变成比例，系数是应力与应变的比值。粘性材料当载荷移去时所有的能量都作为纯阻尼而丧失，应力与应变曲线是不同相的，它们的比值是粘性系数μ，粘性材料没有刚度，只有阻尼。粘弹性材料届于纯弹性和粘性之间，部分能量被储存起来，其它部分作为阻尼耗散。（粘性材料的阻尼包括上文说的粘性阻尼和非粘性阻尼。）粘弹性材料的应用粘弹性材料可以有效抑制结构的高频振动，作为结构中的隔振器、衬垫可以改善结构整体的动力学特性，被广泛应用于航空、航天、建筑等结构的振动控制。

2) 等价粘性阻尼的作用

粘性阻尼的研究

粘性阻尼就是经典意义下的$K-C-M$系统的动力学问题已被深入研究，固有振动特性分析、时域和频率响应计算等技术日趋成熟，而且也是主流商用FEM程序的基本功能。如果导出另一种形式、且系数矩阵具有对称性$K-C-M$的等价方程，就可以方便的利用商用FEM程序来计算非粘性阻尼的问题。

3) 现在非粘性阻尼计算的研究进展

*本部分内容由高淑华提供

状态空间法

a. $N.Wagner$ and $S.Adhikari$ b. 李军强局限性：1.非对称矩阵；2.非经典$K-C-M$形式；若矩阵非满秩情况，svd分解

2.VE材料的本构关系介绍

非粘性阻尼的松弛函数的选择(指数型松弛函数的选择)

3.等价粘性阻尼的运动方程的推导

对于虽然推导的过程必须要求K_{11}、K_{12}(也就是C)是非奇异矩阵。但是可以直接验证，即使C是奇异的，两个方程仍然是等价的，者可以把两式都进行$Laplace$ 变换，他们的变换后形式是一样的，由$Laplace$变换的唯一性，可知两式是等价的。

4.算例

结论

7 03-08-15报告：*Coherent Structures & Navier – Stokes System*

报告人：谢锡麟（博士研究生，导师：徐有恒教授、周慧良副教授）

报告题目：*Coherent Structures & Navier – Stokes System*

摘要及介绍*

无论在*Laminar Flow*向*Turbulence*转捩过程中还是充分发展的湍流场中都会拟周期性地出现某种大尺度的旋涡结构。对于我们目前所注目的自由剪切流系统（包括平面剪切层、射流和尾迹），这种周期性既是时间上也是空间上的；并且它们集中了流动的主要的能量。有许多实验和CFD（大都为DNS）研究这些结构，所以第一部分为着重介绍已有的一些研究结果，也包含我们实验室对轴对称自由剪切流的一些研究。

第二部分，想结合$Navier-Stokes$方程陈述一些感受。这里说感受似乎都没有资格。数学上对$Navier-Stokes$方程的研究至今仍是个*Big Open Problem*，或者说没有什么实质性的结果，至上世纪30年代*Leray*的一些研究工作以来。实际上目前有个问题：一方面，实验结果出来不久，DNS就有结果了而且往往在大的方面会符合得很好，这说明NS方程对这些流体系统的描述是适合的。另一方面，数学上的研究（指偏微分方程方面）所给的结果往往难以描述主要的实验现象，这样数学上的研究框架是否需要有某些调整以对准主要的矛盾。

实际也是我们实验室现在着力研究的方面，即寻求实验上揭示NS方程的动力学行为（包括奇异性*Singularity*，分叉$Bifurcation$等）的思想和方法。目前我们仅获得些非常基本的尝试性的结果。

ABSTRACT†

It is well known that Navier-Stokes equation(NS equation) is the governing equation of fluid mechanics; its convective term due purely to kinetics is the unique nonlinear mechanism in this equation, but it brings the tremendous difficulties in the mechanical and mathematical study. Problems of existence and uniqueness and so on of solutions in some normed spaces play an essential role in mathematical study, however does the norm of velocity or vorticity happen to blow-up in finite time, i.e. Leray assumption, or does the global attractor exist are the big open problems until now. In the study of the generation mechanism of turbulence, such as the work leaded by Williamson in nineties last century on the dynamical behaviors of the wake of circular

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cylinder in the range of Reynolds number from 100 to 300, the ideas and methods of dynamical systems theory are more and more introduced into the experimental and analytical studies in order to interpret the status of attractors, bifurcations and routes of transition discovered in experiments. As supported by the consistences between DNS and experiments, NS equation can be considered as suitable at least in the study of the generation mechanism of turbulence. The study based on experiments and combined with the theory of partial differential equations as we thought on the ideas and techniques that can be used to reveal the dynamical behaviors of NS equation is an approach worthy of trying.

The ideas and techniques of polyspectral analysis is extended in this paper combined with the argument of spatial mode of hydrodynamical stability theory and based on our study on axisymmetric free shear flows.The detailed contents include the following aspects.

A technique that can be used to determined the phase number and phase speed based on spatial cross-correlation is put forward. The so called phase speed matching condition that is the phase speed of the fundamental frequency is equal to that of the subharmonic for pairing and merging of axisymmetric structures is confirmed by our experiments. In addition, it was discovered that the characteristic frequencies of helical structures are also meet the phase speed matching condition. We think based on our experiments that dynamically closed behaviors of physically open flow systems can in fact correspond to the validity of spatial mode that is the validity of linear mechanism.

General polyspectral analysis is based on the fundamental relation:

$$Y_m = L_m X_m + Q_{ij}^m X_i X_j \quad f_i \pm f_j = f_m \tag{1}$$

where L_m and Q_{ij}^m represent linear and quadratic nonlinear transfer functions (determined by experiments) respectively, and it was just used in local position mean. We extent this relation in this paper to finite separated positions. Its validity (1) is confirmed by the energy relation:

$$\langle |Y_m|^2 \rangle = |L_m|^2 \langle |X_m|^2 \rangle + 2Re[L_m Q_{ij}^{m*} \langle X_i^* X_j^* \rangle] + Q_{ij}^m Q_{kl}^{m*} \langle X_i X_j X_k^* X_l^* \rangle, \tag{2}$$

in particular dominant frequencies are quite well agree with energy relation. The validity of energy relation also implies the 'global' correlation (or dynamically closed) characteristic of flow fields. This characteristic should be reflected by NS equation in some cases such as there exist forceful vortical structures in flow fields, but we can not provide the rigorous mathematical support to the validity of (1) in global mean until now. The general auto-power spectrum

based on the relation (1) can be separated into three parts: linear, quadratic nonlinear and linear-nonlinear mechanisms.

It is discovered in experiments that energy is transferred from the fundamental to its subharmonic through linear-nonlinear mechanism in pairing process of axisymmetric structures, then energy is controlled step by step by nonlinear mechanism in aft-phase of merging process, finally nonlinear mechanism keeps dominant fully after merging and makes contributions to broadband frequencies. We think, therefor, that nonlinear mechanism (corresponding to convective term of NS equation) plays key important role in turbulence generation. As soon as helical structures are concerned, linear mechanism, however, keeps dominant in the whole spatial evolution and energy transfer does not be detected. In this case, the dominance of linear mechanism is consistent to the high level of spatial coherency. Three mechanisms as mentioned above can be further separated into different frequency pairs (corresponding to the form of NS equation through Fourier transfer). These are studied in detail in this paper and we discovery that only some discrete frequency pairs makes dominant contributions, furthermore an approach through that the infinite dynamical system can be deduced to a finite one is provided. It is worthy of further study.

The spatial evolutionary equation of energy is deduced based on the assumption that Fourier analysis can be applied to velocity fluctuation.

$$\frac{1}{Re}\frac{d|Y_m|^2}{dx} = U\cdot|Y_m|^2 + \mathrm{i}\omega_{\underline{m}}\int_{x_0}^{x} Y_{\underline{m}}(x)Y_m^*(\xi)d\xi + \frac{1}{2}\cdot\sum_{\omega_k+\omega_l=\omega_m} Y_mY_k^*Y_l^* + Y_m\cdot\mathcal{F}^*(x_0),$$

It is evident that $Y_mY_k^*Y_l^*$ (corresponding to $self-bispectrum$) represents the contribution of convective term to energy spatial growth. The spatial evolution of $self-bispectrum$ is studied in detailed in this paper and indicates that the majority effect of convective term is represented by some discrete frequency pairs in the evolutionary process of vortical structures and convective term makes fundamental contributions to the stimulation of small broadband structures that is the process of turbulence generation.

In this paper, the dynamical behaviors of Navier-Stokes equation has been studied to a certain extend and put emphasis on spatial coherency and convective term. Certainly, the contents reported here is quite naive so that we are longing for this opportunity to discuss some problems as listed below.

- How does spatial coherency in real flow fields relate to global behaviors of NS equation?

Does it relate to some interior and global estimates in the theory of partial differential equations, relate to L^p theory or *Schauder* theory?

- What kinds of normed spaces are suitable to velocity and vorticity fields of real flow fields, $W^{m,p}(\mathbb{R}^n)$, $C^{m,\alpha}(\mathbb{R}^n)$ or others?

- The solution to NS equation regularized by mollifiers has been proved to exist in global time with the high regularity. Does this kind of regularized NS equation correspond to large scale structures(coherent structure)?

Key Words: Navier-Stokes equation; axisymmetric free shear flow; spatial coherency; polyspectral analysis; experimental study

8 03-08-21报告：$Trefftz$法解压电材料平面问题

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ABSTRACT & INTRODUCTION*

For decades, piezoelectric ceramics have been used widely in the fabrication of electromechanical devices, because piezoelectric materials possess many desirable properties. Their main disadvantage, however, is their brittleness: piezoelectric ceramics have a tendency to develop critical crack growth due to the stress concentrations induced by both mechanical and electrical loads. Also, other defects such as voids, inclusions and delaminations may contribute to failure of structure components as well. Because of the material anisotropy and electromechanical coupling, a numerical treatment would be necessary for solving the problems of piezoelectric media in most cases.

Sosa employed the method of stress function to solve the two-dimensional inclusion or crack problems of infinite transversely isotropic piezoelectric media with the generator of the elliptical cavity or the crack front perpendicular to the poling direction and obtained the closed form solutions. Liu et al. studied the electro-elastic Green's function for a piezoelectric half-space and their application. Lee and Jiang developed the BEM formulation for piezoelectric solids and also obtained the fundamental solutions for plane piezoelectricity by using the double Fourier transform technology. Ding et al. derived the fundamental solutions in terms of harmonic functions and developed the BEM with several test cases for 2-D and 3-D problems.

Trefftz method as a boundary solution technique has long been available and applicable to a wild variety of engineering problems. The generation of data input is easier and the cost of computer time is less than the domain-type solution procedures such as the finite element and the finite difference methods. Because Trefftz method employs the complete solutions of differential equation, the formulations are regular and thus, avoid the construction of the singular fundamental solutions, which used by the ordinary boundary element method. Trefftz methods can be classified into Trefftz indirect method (TIM) and Trefftz direct method (TDM). In this paper, we use Trefftz Galerkin method (TGM), which belongs to TIM, to solve plane problems of piezoelectric media. In the TGM, the solutions of the problems to be solved are approximated by

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the superposition of the complete solutions and then, the unknown parameters are determined by Galerkin method so that the approximate solutions satisfy the boundary conditions. This article is organized as follows. In section 2, the governing equations of piezoelectric media are listed. In section 3, general solutions with constant coefficients are introduced. Then, in section 4, the Trefftz boundary integral equation is derived and TGM are explained in detail. In section 5, TGM is applied to some numerical examples including finite piezoelectric plane and infinite piezoelectric plane with a circular hole. Finally, in section 6, the conclusions are drawn, briefly.

9 03-08-27报告：血管中的切应力和张应力

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报告题目：血管中的切应力和张应力*

ABSTRACT & INTRODUCTION†

The report intends to introduce some recent work of Biomechanics Laboratory in developing useful models to obtain the shear stress and circumstance stress in arteries and veins, which are important factors in vessel remodeling.

Part 1: Velocity And Shear Stress of Periodic Oscillatory Blood Flow in Vessel with Stenosis

A mathematical model of periodic oscillatory blood flow in arteries in the presence of local stenosis was developed, and the analytic expressions of axial velocity, radial velocity and shear stress of periodic oscillatory blood flow were obtained with reference to the pressure gradient, and the variation of pressure gradient along the axis in arteries was discussed. As an example, assuming the geometry of the stenosis as a cosine form, a detailed discussion is performed through numerical calculation, which helps estimating how the steady pressure gradient and different harmonic components of pressure gradient at the upstream uniform segment influence the velocity and shear stress in the constricted region. Numerical results indicate that not only the pulsatile amplitude of wall shear stress will increase apparently but also the wall shear stress gradient will increase significantly in the constricted region.

Part 2: Influence of Arterial Pressure on Distribution of Circumferential Stresses in Vein Wall

Autologous vein is often used as the substitute of disabled artery segment. The change of stress in the wall of grafted vein ,which is resulted from the rapid increase of pressure in the lumen ,is one of the important factors that influence the vein graft. In order to compare the distribution of circumferential stresses before graft (under the vein pressure) and immediately after graft (under the arterial pressure), in this paper , the P(pressure)-V(volume) data of vein at certain axial extension ratio is measured and fitted using the 3-parameter strain energy density function , then , the residual stress and the circumferential stress in the vein wall can be obtained .The analysis on canine femoral and jugular veins shows that when those vessels are placed under arterial pressure , the circumferential stresses in their wall will increase rapidly . For example,

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under the arterial pressure, in the wall of jugular vein , the circumferential stress will increase nearly 2 order comparing with its counterpart under the vein pressure . Furthermore , results indicate that , like the residual stress in the artery wall , the residual stress in the vein wall can greatly weaken the circumferential stress concentration at the inner wall and result in an obviously smaller circumferential stress gradient along the radial direction, although the value of the residual stress in vein wall is much smaller than that in artery wall.

10 03-09-04报告：整星隔振技术

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摘要及介绍*

对于卫星结构设计来说，运载火箭的动力学环境是一个主要的设计依据。火箭在主动飞行过程中给卫星带来的动力学环境,如火箭发动机点火、关机、阵风、纵向耦合振动等工况，是卫星承力结构的重要设计依据；采用整星隔振技术改善运载火箭的动力学环境，能够提高卫星的可靠性。本文主要对一种带有粘弹性材料的隔振器作仿真。根据实际情况，对隔振器建立了比较适合仿真计算的模型，并建立了一套能够运用现有FEM软件的对带有粘弹性材料的复合结构的仿真计算方法。

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