同行专家业内评价意见书编号: 20240855056

附件1

浙江工程师学院（浙江大学工程师学院）
同行专家业内评价意见书

姓名： 袁毓珺

学号： 22160052

申报工程师职称专业类别（领域）： 机械

浙江工程师学院（浙江大学工程师学院）制

2024年03月26日

一、个人申报

（一）基本情况【围绕《浙江工程师学院（浙江大学工程师学院）工程类专业学位研究生工程师职称评审参考指标》，结合该专业类别(领域)工程师职称评审相关标准，举例说明】

1. 对本专业基础理论知识和专业技术知识掌握情况

本人具有良好的品德修养，具有精益求精、追求卓越的工匠精神，具有求真务实、持之以恒的学习态度，对职业抱有积极态度，熟悉行业技术需求和专业理论知识，掌握基本的专业技术知识和行业知识，具有参与工程建设所需的基本技能，能综合运用先进仪器设备、专业软件、现场数据采集与算法分析等工具开展工程建设和项目研究工作，具有技术创新与实践能力，具备团队合作能力以及跨文化交流能力。目前已取得论文发表、装备创新实例等代表作。

2. 工程实践的经历

本人在浙江金马逊机械有限公司实习，项目为航空航天关键部件制造用高性能加工装备，来源于浙江省重点研发计划项目，主要针对金属导管弯曲成形技术进行研究，研究复杂金属管件成形缺陷控制理论和方法，研究弯管装备及模具对对薄壁管成形质量的影响，并研究不同工艺参数条件下对薄壁管弯曲缺陷的影响与抑制作用，搭建金属管件弯曲成形实验平台，配合应变片等传感器实现对管件起皱缺陷的实时监测，进而构建金属薄壁管件弯曲成形的数字孪生模型。提出金属管件弯曲成形装备创新性设计，对现有装备进行了结构优化。

3. 在实际工作中综合运用所学知识解决复杂工程问题的案例

在实际工作中，运用所学知识，用以解决金属导管弯曲成形技术，研究复杂金属管件成形缺陷控制理论和方法，研究弯管装备及模具对对薄壁管成形质量的影响，并研究不同工艺参数条件下对薄壁管弯曲缺陷的影响与抑制作用。针对航空航天关键部件制造用高性能加工装备，特别是金属导管弯曲设备，研究复杂金属导管弯曲装备设计与工艺优化技术以及复杂金属导管关键成形缺陷模型构建技术，针对现有管件弯曲成形装备及模具存在的弯制成形成本高、效率低、精度有待提高等问题，进行其相关模具的创新性研发及装备参数优化等工作，具体研究装备工艺参数设计对薄壁管成形质量的影响，并且针对圆截面金属管件起皱、截面畸变、回弹和壁厚减薄等关键成形缺陷进行了研究，利用有限元数值模拟和实验，研究工艺参数等对成形缺陷的影响，并根据相关塑形成形理论，能量法等研究了成形缺陷的形成机理，通过智能算法研究成形缺陷预测模型以及管件缺陷实时监测模型的构建。研究不同管径不同弯制要求在不同工艺参数条件下影响管件弯曲起皱缺陷产生的因素，并通过能量法，智能算法等构建管件起皱缺陷预测模型，并实现在弯曲过程中起皱缺陷的时序预测，同时搭建金属管件弯曲成形实验平台，配合应变片等传感器实现对管件起皱缺陷的实时监测，进而构建金属薄壁管件弯曲成形的数字孪生模型。同时，本人主要负责管件弯曲设备的创新性结构设计研发以及现有装备及工艺的参数优化工作。在薄壁管材在弯管机上弯曲成形之前夹紧过程中，由于薄壁管的管壁很薄，刚度较差，在直管段进行夹持时容易由于夹持力度较大造成夹紧段截面变形，影响薄壁管件的弯曲性能和成形质量。而目前在工业生产中用到的薄壁管件直管段夹持机构夹持装置大多数只考虑管壁外侧的变形，而很难在夹紧管件的同时实现对管壁内侧的保形，满足对薄壁管件夹紧过程中对截面变形控制的需求，为此，本人利用所学知识创新性的提出了实现管件内撑外夹式助推装置，通过控制夹紧滑块和内胀支撑滑块的同步运动，使内胀支撑件在管壁内侧向外撑开，同时使夹紧块在管外侧向内夹紧，同步实现薄壁管内外侧同时夹紧，和内胀保形装置在管件内部提供支撑实现薄壁管直管段的保形功能，防止夹紧装置夹紧力过大使截面发生变形。同时，通过管内外两侧分别施加的夹紧力和内胀力增大对管内外两侧的压力，进而增大管助推时所获得的摩擦力，实现助推功能提供更大的助推

力。根据加工生产要求，通过更换与夹紧块通过螺栓相连的外圆弧板和与内胀支撑件相连的内圆弧板实现不同直径、不同壁厚管材直管段的夹紧保形功能。

（二）取得的业绩（代表作）【限填3项，须提交证明原件（包括发表的论文、出版的著作、专利证书、获奖证书、科技项目立项文件或合同、企业证明等）供核实，并提供复印件一份】					
1. 公开成果代表作【论文发表、专利成果、软件著作权、标准规范与行业工法制定、著作编写、科技成果获奖、学位论文等】					
成果名称	成果类别 [含论文、授权专利（含发明专利申请）、软件著作权、标准、工法、著作、获奖、学位论文等]	发表时间/授权或申请时间等	刊物名称/专利授权或申请号等	本人排名/总人数	备注
A multi-state fusion informer integrating transfer learning for metal tube bending early wrinkling prediction	TOP期刊	2023年10月27日	Applied Soft Computing https://www.sciencedirect.com/science/article/pii/S1568494623010098	2/5	
A hierarchical prediction method based on hybrid-kernel GWO-SVM for metal tube bending wrinkling detection	核心期刊	2022年07月15日	The International Journal of Advanced Manufacturing Technology https://link.springer.com/article/10.1007/s00170-022-09691-2?utm_source=xmol&utm_content=meta	2/6	
一种用于薄壁管弯曲成形的直管段内撑外夹式夹持助推装置	发明专利申请	2023年05月26日	申请号：ZL 2022 1 0403885.4	2/5	

2. 其他代表作【主持或参与的课题研究项目、科技成果应用转化推广、企业技术难题解决方案、自主研发设计的产品或样机、技术报告、设计图纸、软课题研究报告、可行性研究报告、规划设计方案、施工或调试报告、工程实验、技术培训教材、推动行业发展中发挥的作用及取得的经济社会效益等】

<table>
<tr><td colspan="2">（三）在校期间课程、专业实践训练及学位论文相关情况</td></tr>
<tr><td>课程成绩情况</td><td>按课程学分核算的平均成绩： 83 分</td></tr>
<tr><td>专业实践训练时间及考核情况(具有三年及以上工作经历的不作要求)</td><td>累计时间： 1 年（要求1年及以上）
考核成绩： 88 分（要求80分及以上）</td></tr>
<tr><td colspan="2">本人承诺</td></tr>
<tr><td colspan="2">个人声明：本人上述所填资料均为真实有效，如有虚假，愿承担一切责任，特此声明！

申报人签名：</td></tr>
</table>

浙 江 大 学 研 究 生 院

攻读硕士学位研究生成绩表

学号：22160052	姓名：袁毓珺	性别：女	学院：工程师学院	专业：机械	学制：2.5年
毕业时最低应获：24.0学分		已获得：28.0学分		入学年月：2021-09	毕业年月：2024-03
学位证书号：1033532024602142			毕业证书号：103351202402600368		授予学位：机械硕士

学习时间	课程名称	备注	学分	成绩	课程性质	学习时间	课程名称	备注	学分	成绩	课程性质
2021-2022学年秋季学期	工程计算机图形学		2.0	84	跨专业课	2021-2022学年春季学期	研究生英语		2.0	免修	公共学位课
2021-2022学年秋冬季学期	中国特色社会主义理论与实践研究		2.0	84	公共学位课	2021-2022学年春季学期	研究生英语基础技能		1.0	免修	公共学位课
2021-2022学年冬季学期	工程伦理		2.0	81	公共学位课	2021-2022学年夏季学期	机器人智能控制		3.0	70	专业学位课
2021-2022学年冬季学期	智能工业机器人		2.0	88	专业学位课	2021-2022学年夏季学期	自然辩证法概论		1.0	79	公共学位课
2021-2022学年秋冬季学期	研究生论文写作指导		1.0	93	专业学位课	2021-2022学年春夏季学期	优化算法		3.0	96	专业选修课
2021-2022学年春季学期	人工智能制造技术		2.0	93	专业学位课	2021-2022学年春夏季学期	工程技术发展前沿		2.0	95	专业学位课
2021-2022学年春季学期	科技创新案例探讨与实战		2.0	85	专业选修课	2023-2024学年秋季学期	网球		1.0	优	公共素质课
2021-2022学年春季学期	数学建模		2.0	73	专业选修课						

说明：1.研究生课程按三种方法计分：百分制，两级制（通过、不通过），五级制（优、良、中、及格、不及格）。

2.备注中“*”表示重修课程。

学院成绩校核章：

成绩校核人：张梦依

打印日期：2024-04-02

浙江大学研究生院 (60) 成绩校核章

22160052

二、日常表现考核评价及申报材料审核公示结果

日常表现 考核评价	非定向生由德育导师考核评价、定向生由所在工作单位考核评价： ☑优秀　□良好　□合格　□不合格 德育导师/定向生所在工作单位分管领导签字（公章）：陈芯岩　年　月　日
申报材料 审核公示	根据评审条件，工程师学院已对申报人员进行材料审核（学位课程成绩、专业实践训练时间及考核、学位论文、代表作等情况），并将符合要求的申报材料在学院网站公示不少于5个工作日，具体公示结果如下： □通过　□不通过（具体原因：　　） 工程师学院教学管理办公室审核签字（公章）：　年　月　日

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A multi-state fusion informer integrating transfer learning for metal tube bending early wrinkling prediction

Zili Wang [a,b], Yujun Yuan [a], Shuyou Zhang [a,b,*], Yaochen Lin [a,b], Jianrong Tan [a]

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HIGHLIGHTS

- The wrinkling factor is used to indicate the wrinkling trend and further predict tube wrinkling.
- A multi-state fusion informer model is proposed for early wrinkling prediction.
- Transfer learning approach enhances the prediction ability of the model.
- The experimental results verify the reliability and feasibility of the proposed method.

ARTICLE INFO

Keywords:
Tube wrinkling
Energy method
Multi-state fusion
Informer-based prediction
Transfer learning approach

ABSTRACT

Wrinkling is one of the most fatal defects of metal tube bending, which may seriously affect the forming quality and even lead to forming failure. Traditional wrinkling prediction methods fail to provide accurate results due to the complexity of multi-die coupling in the bending process and the neglect of time-varying effects. To this end, a novel early wrinkling prediction method is proposed in this paper, distinct from conventional methods, realizing to forecast future wrinkling trends during the bending process and laying the foundation for real-time wrinkling prediction. It leverages the wrinkling factor (WrF), calculated using the energy method, as temporal data during the bending process to indirectly predict future tube wrinkling trends. Since the wrinkling occurs at the beginning of the bending process, a multi-state informer-based early prediction of tube wrinkling is put forward utilizing the limited WrF collected at the start of the bending process. To meet the demand for high accuracy and efficiency of wrinkling early prediction in a dynamic process, the model pre-trained by the multi-state fusion wrinkling data from the fully bent tube is migrated to the target model through the transfer learning approach. A stainless-steel tube bending case is conducted as the verification experiment, which is simultaneously compared with the finite element analysis (FEA) result. The results show the superior prediction accuracy and higher efficiency of the proposed method mainly compared with the traditional Informer model, Transformer model, and Long Short-Term Memory (LSTM).

1. Introduction

Due to the developed demand for metal bent tubes used in various industrial applications, such as equipment lightweight, liquid transportation, and anti-collision buffer [1], the forming quality of tubular components becomes vitally significant. Diverse defects, such as bending springback [2], wall thickness thinning [3], cross-section distortion [4], and wrinkling [5], may occur in the thin-walled tube bending process, resulting from the extremely complicated forming mechanism caused by multi-mold constraints. Among all these plastic defects, wrinkling is one of the most fatal, which brings irreversible damage to the bent-tube. It is crucial to effectively predict and control the tube wrinkling.

Wrinkling is the external macroscopic manifestation of plate or shell buckling and large post-buckling deformation under some local compressive stress. In the process of bending, the concave side of the tube wall shrinks along the bending direction due to the tangential compressive stress [6], which will inevitably cause an increase in tube wall thickness while the excessive increase will cause wrinkling. Up to now, great efforts have been put into the detection and control of wrinkling during the process of thin-walled tube bending by using

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ORIGINAL ARTICLE

A hierarchical prediction method based on hybrid-kernel GWO-SVM for metal tube bending wrinkling detection

Shuyou Zhang[1,2] · Yujun Yuan[1] · Zili Wang[1,2] · Yaochen Lin[3] · Lanfang Jiang[4] · Mengyu Fu[1]

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Abstract

Metal bending tube is widely used in industry while its forming defects extremely affect the bending quality. Among all defects, the bending-inside wrinkling caused by the non-uniform compressive stress is a zero-tolerated defect, particularly when the tube is for transportation. However, the current wrinkling detection approach, suffering from the lack of insight into wrinkling mechanism, is normally posteriori. To obtain the priori wrinkling condition for a certain go-to-bend tube, we put forward a metal tube bending wrinkling hierarchical prediction method based on hybrid-kernel gray wolf optimizer (GWO) support vector machine (SVM). Three typical kernel combinations are utilized for the GWO-SVM prediction model. To verify the proposed wrinkling prediction method, aluminum alloy series tubes are tested. By constructing the 12 typical designations of aluminum alloy tubes' finite element bending simulation case base, the prediction model is trained through three hybrid-kernel GWO-SVMs, respectively. The results are compared with the traditional SVM and GWO-SVM, which show that the proposed hybrid-kernel GWO-SVM model has the best performance for hierarchically predicting bending wrinkling. Analysis of the predicted results shows that when the relative wall thickness is less than 0.015, wrinkling is very likely to occur with any relative bending radius within the range. On the contrary, there is less tendency to wrinkle. At the same time, the smaller the R/D, the higher the hierarchy of wrinkling. This proposed prediction method lays the foundation for metal tube bending wrinkling detection and prevention.

Keywords Metal tube bending · Wrinkling · Hierarchical prediction method · Hybrid-kernel · GWO-SVM

1 Introduction

With a hollow structure and good mechanical properties, different shapes of metal bending tubes are usually used for equipment lightweight, liquid transportation, and anti-collision buffer [1]. Under the combined action of one side tension and one side pressure, the tube blank is formed into a bending tube [2]. Due to the complex deformation conditions, it will inevitably produce diverse forming defects, such as bending springback [3], wall thickness thinning [4], cross-section distortion [5], and wrinkling [6].

The tube bending deformation defects can be generally categorized into axial defects and radial defects. Axial defects, mainly caused by unloading springback and elongation, will directly affect the tube assembly performance in service. Springback refers to the actual bending angle that becomes lower than the set bending angle [7]. The bending tube produces a certain amount of springback angle along the axial direction, which is due to the recovery of elastic deformation of the tube. The yield strength and elastic modulus of the tube material are important factors that affect the springback angle [8]. At the same time, radial defects are distributed along the diameter of the tube. The thinning of the tube wall is caused by the stretching of the tube after receiving the tangential tensile stress in the process of bending. The elongation length and the relative bending radius have a great influence on the wall thickness reduction during the forming process. The smaller the relative bending radius and the larger the elongation, the more serious the thinning

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证书号第6002351号

发明专利证书

发 明 名 称：一种用于薄壁管弯曲成形的直管段内撑外夹式夹持助推装置

发　明　人：张树有;袁毓珺;王自立;李杰;谭建荣

专　利　号：ZL 2022 1 0403885.4

专利申请日：2022年04月18日

专 利 权 人：浙江大学

地　　址：310058 浙江省杭州市西湖区余杭塘路866号

授权公告日：2023年05月26日　　　授权公告号：CN 114798938 B

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局长
申长雨

国家知识产权局
2023年05月26日

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