

# 弹药安全生产智能工艺装备与预测控制系统技术研发及推广应用

# Technology Development and Application of Intelligent Process Equipment and Predictive Control System for Ammunition Safety Production

## 成果简介:

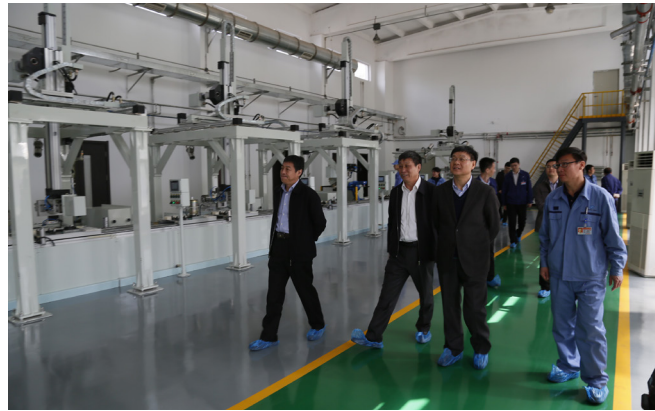
项目成果主要针对炮弹、航空炸弹、火箭弹及导弹等弹药的危险制造过程，攻克了危险作业仿真、危险状态预测及互锁与防爆设计等一系列关键技术，形成集“安全工艺、安全预测控制、高可靠防爆设备”三位一体的弹药安全生产保障技术体系；开发了3类18种安全生产智能工艺装备及预测型控制系统，并集成成套智能生产线；在中国兵器工业集团等12家行业龙头企业进行了推广应用，实现了常规攻坚炮弹、制导炮弹、导弹战斗部等装药总装的安全智能生产，使行业关键生产指标大幅提升：达到危险工序无人化生产，恶劣环境生产人员减少75%以上，产品性能一致性达到99%以上。研制的国内首套“末制导炮弹智能生产线”，成为行业样板工程及兵器工业集团2016、2017年度安全升级改造唯一交流学习现场。

## Introduction:

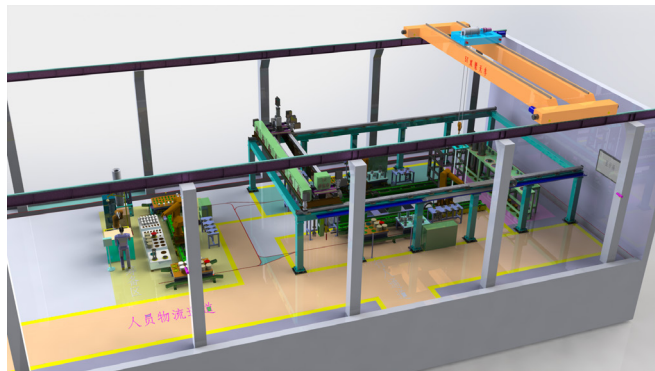
Mainly aiming at the dangerous manufacturing process of artillery shells, aircraft bombs, rockets, missiles and other ammunition, a series of key technologies including the dangerous operation simulation, dangerous state prediction and interlock and explosion-proof design, have been overcome in the project. A trinity technology system of ammunition safety production, including security technology, safety prediction control and high reliable explosion-proof equipment, has been formed. Three categories and eighteen kinds of safe production intelligent process equipment and prediction control system are developed, and complete sets of intelligence production line are integrated. The achievements of the project have been promoted and applied in twelve leading enterprises such as China Weapons Industry Group. The safe and intelligent production of conventional artillery, guided cartridge and missile warhead has been realized, which has dramatically improved the key production indexes of the industry. The unmanned production in the hazardous process has been achieved. Operators in harsh production environment are reduced by more than 75%, and the consistency of product performance is more than 99%. The first "intelligent production line of terminal guided shells" has been developed in China, which has become the demonstration project and the only communication and learning paradigm for the annual security and industry upgrading of China Weapons Industry Group in 2016-2017.



航天科工四院与沈自所签订危险品智能制造战略合作协议  
No. 4 Academe, China Aerospace Science & Industry Corporation signed a strategic cooperation agreement in intelligent manufacturing of dangerous goods with Shenyang Institute of Automation



兵器工业集团副总经理“罗乾宜”带队参观学习“M产品智能总装生产线”  
Vice general manager of China North Industries Group Corporation Qianyi Luo led to visit "The intelligent assembly line of M product"



无人化智能装药系统仿真平台  
Simulation Platform of Unmanned Intelligent Charge System

## 推荐单位 / Recommended Units

中国科学院沈阳自动化研究所  
Shenyang Institute of Automation, Chinese Academy of Sciences

## 完成单位 / Accomplished Units

中国科学院沈阳自动化研究所  
Shenyang Institute of Automation, Chinese Academy of Sciences

## 合作单位 / Cooperation units

西北工业集团有限公司  
Northwest Industrial Group CO., LTD  
山东特种工业集团有限公司  
Shandong Special Industry Group CO., LTD  
辽沈工业集团有限公司  
Liaoshen Industrial Group CO., LTD

## 社会效益和经济效益:

项目打破国外技术封锁，形成变革性的弹药安全生产新模式，在国内实现行业首创应用。通过智能工艺装备及生产线替代人工进行危险作业，使传统的弹药生产安全由人为控制转变为技术手段控制，破除了危险作业人员数量限制等安全因素对弹药效率产能提升的制约，有效提升了基础国防制造水平及保障能力。推广的12套生产线应用效果良好，近三年新增产值30.8亿元，新增利润近5.84亿元。



辽沈工业集团M产品装配检测生产线  
Assembly and inspection line of M product of Liaoshen Industrial Group



搬运机器人防爆合格证  
Conformity Certificate of Explosion Proof Transport Robot



中国自动化学会产业年会2015年十大最有影响力工程项目  
2015 Top Ten Most Influential Projects Award at the China Automation Industry Annual Conference

## Economic and Social Benefits:

The project formed a revolutionary system for ammunition safe production, which is first applied in China and breaks the blockade of foreign technology. Replacing human in ammunition production by intelligent process equipment and production line changes the traditional artificial safety control to automation control. The technology increased ammunition productivity by lifting safety restrictions such as maximum endangered operators and effectively enhanced the basic level of national defense manufacturing and security capabilities. The twelve sets of production lines promoted have achieved excellent application results and have increased output value of CNY 3.08 billion and profits of CNY 584 million over the past three years.



西北工业集团产品总装生产线  
Product assembly line of Northwest Industrial Group



## 团队成员 / Team Members:



徐志刚  
Xu Zhigang

中国科学院沈阳自动化研究所

主要贡献：项目总体负责人，国防科工局火炸药智能制造领域专家，对弹药安全生产开展了集顶层规划、装备研发及工程实施于一体的系统性研究，构建了弹药安全生产总体技术框架及体系。

Shenyang Institute of Automation, Chinese Academy of Sciences

Project Leader, expert of State Administration of Science, Technology and Industry for National Defence in propellant and explosive intelligent manufacturing field. Dr. Xu carried out systematic research on top level planning, equipment development and project implementation in ammunition safety production, and established general technical framework and system.



徐永利  
Xu Yongli

中国科学院沈阳自动化研究所

主要贡献：控制分系统技术负责人，负责生产线控制系统的总体设计和调试。深入研究了弹药制造安全需求，建立了危险状态预测模型，研制了预测型控制系统。

Shenyang Institute of Automation, Chinese Academy of Sciences

He established dangerous condition prediction model, and developed predictive control system and completed overall design and commissioning of ammunition assembly line control system.



贺云  
He Yun

中国科学院沈阳自动化研究所

主要贡献：研制了某战斗部全无人智能装药总装生产线控制系统，开发了与工艺深度融合的参数化控制算法，实现了不同产品的柔性自适应生产。

Shenyang Institute of Automation, Chinese Academy of Sciences

He developed intelligent control system for warhead assembly line and parametric control algorithm deep integrated with process, achieving flexible adaptive production of different products.



刘勇  
Liu Yong

中国科学院沈阳自动化研究所

主要贡献：机械系统主要负责人，参与多种典型弹药生产线总体规划，研发多种本质可靠互锁机构，为弹药行业装备设计提供了通用安全机构。

Shenyang Institute of Automation, Chinese Academy of Sciences

He participated in various typical ammunition assembly lines overall planning, and developed intrinsically reliable interlocking mechanism and general security device for ammunition industry equipment.



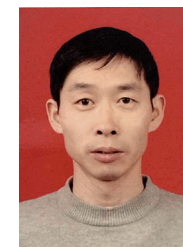
王军义  
Wang Junyi

中国科学院沈阳自动化研究所

主要贡献：建立基于工艺参数的燃爆敏感度仿真分析模型，设计了典型工艺过程数字化仿真平台，为研制及改进弹药制造工艺提供高效的预测预知能力。

Shenyang Institute of Automation, Chinese Academy of Sciences

He built simulation model of explosion sensitivity based on process parameters, and designed digital simulation platform for typical process, and predictability improved ammunition manufacturing process.



赵学龙  
Zhao Xuelong

西北工业集团有限公司

主要贡献：对首套弹药生产线实际使用进行了系统性安全验证，提出弹药总装生产线多项安全使用规范。

Northwest Industrial Group CO. LTD

He conducted systematic safety verification of actual use of first set of ammunition assembly line, and puts forward several safety rules of ammunition general assembly line.



李峰  
Li Feng

中国科学院沈阳自动化研究所

主要贡献：制导弹药总装生产线机械系统主要负责人，研发了压药、拧紧、喷码及搬运机器人等多种安全智能装配工艺装备。

Shenyang Institute of Automation, Chinese Academy of Sciences

He designed several safety and intelligent assembly process equipment, including powder pressing device, tightening machine, flexible Inkjet printer and transfer robot.



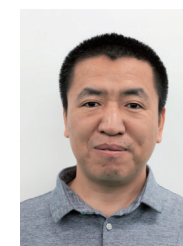
辛敏艳  
Xin Minyan

辽沈工业集团有限公司

主要贡献：生产过程安全规范研究。将传统手工作业安全要求与自动化装配生产相结合，提出了机器人化装配生产过程的安全作业规范。

Liaoshen Industrial Group CO. LTD

Combining traditional manual operation safety requirements with automated assembly production, she proposed safety specifications of the robot assembly production process.



张延利  
Zhang Yanli

中国科学院沈阳自动化研究所

主要贡献：常规炮弹总装生产线机械系统负责人，研发了弹药称量加料、几何特性参数、电性能参数等多种智能检测工艺装备。

Shenyang Institute of Automation, Chinese Academy of Sciences

He studies intelligent detection technology including ammunition weighing and feeding, geometric characteristic parameters and electrical performance parameter, and developed corresponding intelligent detection process equipment.



景宽  
Jing Kuan

中国科学院沈阳自动化研究所

主要贡献：生产线控制系统现场调试负责人，完成了多条生产线现场调试与试生产工作，实现了生产线顺利交付使用。

Shenyang Institute of Automation, Chinese Academy of Sciences

He complete on-site commissioning and trial production work of several ammunition assembly lines, and successfully delivered production lines.