

NestWorks C500 Desktop Precision CNC Milling Machine C500 桌面级精密CNC铣削设备

Operation and Maintenance Manual 操作与维护说明书

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WARNING / 警告

Read this manual carefully before operating the machine. Failure to follow the instructions may result in equipment damage, personal injury or even death.

操作机器前必须仔细阅读本说明书。未遵循操作指引可能导致设备损坏、人身伤害甚至死亡。

This manual is an integral part of the equipment and shall be kept with the machine for the entire service life.

本说明书为设备不可分割的一部分，需随设备终身留存。

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1. Safety Warnings and Instructions 安全警告与指示说明

1.1 General Safety Rules 通用安全规则

This machine is designed for precision milling, drilling, tapping and engraving of metal and non-metal materials. Any use beyond the intended function is considered improper use.

本设备设计用于金属、非金属材料的精密铣削、钻孔、攻丝、雕刻加工，任何超出预期功能的使用均为不当操作。

All operators must read this manual fully and receive professional training before operation. Unauthorized personnel are prohibited from operating the equipment.
所有操作人员必须完整阅读本说明书并接受专业培训后方可操作，禁止未经授权的人员操作设备。

1.2 Safety Sign Identification 安全标识说明

All safety signs on the machine are fully explained in this section. The signs must be kept clear and legible during the entire service life of the machine.

设备上所有安全标识均在本节完整说明，设备全生命周期内必须保持标识清晰、可识别。

Safety Sign 安全标识	Meaning 含义	Operation Requirements 操作要求
 Warning: Rotating Parts	警告：旋转部件	Do not touch the spindle during operation, keep hands away from the processing area
 Warning: Crushing Hazard	警告：挤压风险	Do not put hands into the moving range of the gantry and worktable during operation
 Warning: Electric Shock	警告：触电风险	Do not open the electrical compartment with power on, ensure the power is cut off before maintenance
 Warning: Flying Chips	警告：切屑飞溅	The protective door must be fully closed during processing, prohibit opening the door during operation

 Class-4 laser: danger: Avoid eye or skin exposure to direct or scattered radiation.	警告： 避免眼睛或皮肤直接 或间接暴露于辐射。	Class-4 laser: danger: Avoid eye or skin exposure to direct or scattered radiation. 避免眼睛或皮肤直接或间 接暴露于辐射。
 Emergency Stop	紧急停止	Press the red mushroom emergency stop button in case of emergency, reset after troubleshooting
 Safety Interlock	安全联锁	The machine stops all movements when the protective door is opened, do not bypass the interlock function

1.3 Personal Protection Requirements 个人防护要求

1. Must wear safety goggles during operation to prevent flying chips from hurting eyes;

操作时必须佩戴护目镜，防止切削飞溅伤眼；

2. Must wear anti-slip work shoes, prohibit wearing loose clothes, gloves, jewelry, or long hair without binding during operation;

必须佩戴防滑工作鞋，禁止穿宽松衣物、佩戴手套/首饰、长发未束起时操作设备；

3. Must wear earplugs in long-term processing scenarios to reduce noise damage;

长期加工场景必须佩戴耳塞，降低噪音伤害；

4. Prohibit operating the equipment under the influence of alcohol, drugs, or fatigue.

禁止在酒精、药物影响下或疲劳状态下操作设备。

2. Machine Description 机器说明

2.1 Machine Definition and Intended Use 机器定义与预期功能

The NestWorks C500 is a desktop-level precision CNC milling machine with fully enclosed protection design. It is suitable for prototype production, small batch processing, teaching and training in office buildings, maker workshops, small manufacturing enterprises and educational institutions. It supports milling, drilling, tapping, engraving of aluminum alloy, 45# steel, stainless steel, wood, acrylic and other materials.

NestWorks C500是一款定龙门结构、全封闭防护设计的桌面级精密CNC铣削设备，适用于写字楼、创客工坊、小型制造企业、教育机构的原型制作、小批量加工、教学实训场景，支持铝合金、45号钢、不锈钢、木材、亚克力等材料的铣削、钻孔、攻丝、雕刻加工。

2.2 Working Principle 工作原理

The main controller parses G-code, sends pulse and direction signals to the closed-loop stepper motor driver, drives the X/Y/Z axis to achieve precise linear feed, and cooperates with the high-speed spindle to complete the cutting of the workpiece. 主控系统解析G代码，向闭环步进电机驱动器发送脉冲+方向信号，驱动X/Y/Z轴实现精准直线进给，配合高速主轴完成工件切削加工。

2.3 Machine Nameplate 设备铭牌

The machine nameplate is fixed on the back lower right corner of the equipment. The nameplate content, material and installation meet the requirements of 2006/42/EC and EN 60204-1:2018. The full content of the nameplate is shown in Section 1 of this document.

设备铭牌固定于设备背面右下角，铭牌内容、材质、安装均符合2006/42/EC与EN 60204-1:2018要求，铭牌完整内容详见本文件第一部分。

2.4 Technical Parameters 技术参数表

Parameter 项目	Specification 参数值
Overall Dimension 整机尺寸	590mm (L) × 550mm (W) × 744mm (H)
Footprint 占地面积	≤0.5m ²
Total Weight 总重量	100kg

Effective Travel 有效行程	X-axis: 240mm (manual tool change) / 210mm (ATC mode); Y-axis: 235mm; Z-axis: 125mm
Positioning Accuracy 定位精度	±0.02mm (full travel)
Repeat Positioning Accuracy 重复定位精度	±0.008mm
Spindle Parameters 主轴参数	800W brushless motor, speed range 6000–18000rpm, radial runout ≤0.01mm
Max Feed Speed 最大进给速度	5000mm/min (Blitz mode)
Power Supply 电源参数	110–220V AC, 50/60Hz, single phase, rated power 1.6kW, full-load current 10A Max
Protection Class 防护等级	IP54 (processing area), IP55 (electrical compartment)
Noise Level 噪音等级	≤70dB(A) at full load operation

2.5 Operating Environment 使用环境要求

Environmental Item 环境项目	Requirement 要求
Ambient Temperature 环境温度	+5°C ~ +40°C (normal operation); –20°C ~ +60°C (storage)
Relative Humidity 相对湿度	50% RH at +40°C, 90% RH at +20°C, no condensation
Altitude 海拔高度	Below 1000m above sea level
Power Supply 电源	Stable 110–220V AC, voltage fluctuation ≤±10%, with reliable grounding

Atmosphere 大气环境	No corrosive, flammable gas, no excessive dust, oil mist or electromagnetic interference
Vibration 振动	No continuous strong vibration, installation surface flatness $\leq 0.05\text{mm/m}$

2.6 Storage, Transportation and Handling 存放、运输、搬运要求

1. **Storage 存放:** The equipment must be stored in a dry, ventilated, dust-free environment, with temperature $-20^{\circ}\text{C}\sim+60^{\circ}\text{C}$, humidity $\leq 90\%$ RH. The equipment must be fixed with original packaging, and the storage period shall not exceed 12 months.

设备需存放于干燥、通风、无尘环境，温度 $-20^{\circ}\text{C}\sim+60^{\circ}\text{C}$ ，湿度 $\leq 90\%$ RH，需使用原包装固定存放，存放周期不超过12个月。

2. **Transportation 运输:** The equipment must be transported in the original packaging, with anti-vibration and anti-drop measures. The maximum acceleration during transportation shall not exceed 3g, and it is forbidden to invert or place the equipment sideways.

设备需使用原包装运输，做好防震、防摔措施，运输过程最大加速度不超过3g，禁止倒置、侧放设备。

3. **Handling 搬运:** The equipment must be handled by 4 people, holding the bottom of the frame, and it is forbidden to lift the spindle, gantry, protective door or interface panel. The handling process must be kept horizontal to avoid tipping.

设备需4人协同搬运，握持机架底部，禁止提拉主轴、龙门、防护门、接口面板，搬运过程必须保持水平，避免倾倒。

2.7 Noise Emission 噪音说明

The equipment noise level is $\leq 70\text{dB(A)}$ during full-load operation, measured at 1m from the equipment at a height of 1.2m. Long-term operation requires wearing earplugs to protect hearing.

设备满载运行时噪音等级 $\leq 70\text{dB(A)}$ ，测试位置为设备1米外、1.2米高度处。长期运行需佩戴耳塞保护听力。

3. Installation Guide 安装说明

3.1 Personnel Requirements 安装人员要求

1. The installation personnel must have professional electrical and mechanical knowledge, and be familiar with the installation requirements of CNC equipment;

安装人员必须具备专业的电气、机械知识，熟悉CNC设备的安装要求；

2. Electrical wiring must be operated by a certified electrician, in compliance with local electrical safety regulations;

电气接线必须由持证电工操作，符合当地电气安全法规；

3. Unauthorized personnel are prohibited from disassembling and installing the equipment.

禁止未经授权的人员拆装、安装设备。

3.2 Site and Space Requirements 场地与空间要求

1. **Site Foundation 场地基础:** The equipment must be installed on a solid, flat workbench or ground, with load-bearing capacity $\geq 200\text{kg}$, surface flatness $\leq 0.05\text{mm/m}$, no obvious vibration.

设备必须安装于坚固、平整的工作台或地面，承重能力 $\geq 200\text{kg}$ ，表面平面度 $\leq 0.05\text{mm/m}$ ，无明显振动。

2. **Space Requirements 空间要求:** Reserve $\geq 500\text{mm}$ of operation space on the front and both sides of the equipment, $\geq 300\text{mm}$ of heat dissipation space on the back, and no obstacles within the full travel of the gantry.

设备正面、两侧预留 $\geq 500\text{mm}$ 操作空间，背面预留 $\geq 300\text{mm}$ 散热空间，龙门全行程范围内无障碍物。

3. **Lighting 照明:** The installation site must have sufficient lighting ($\geq 300\text{lux}$) to observe the processing process clearly.

安装场地需具备充足照明 ($\geq 300\text{lux}$)，可清晰观察加工过程。

4. **Environment 环境:** The installation site must be away from flammable and explosive materials, strong electromagnetic interference sources, and corrosive gas.

安装场地需远离易燃易爆物品、强电磁干扰源、腐蚀性气体。

3.3 Power Supply Requirements and Connection 电源要求与连接

1. **Power Supply Requirements 电源要求:** Stable 110–220V AC single-phase power supply, 50/60Hz, voltage fluctuation $\leq \pm 10\%$, with reliable protective grounding, grounding resistance $\leq 4\Omega$.

稳定110–220V AC单相电源，50/60Hz，电压波动 $\leq \pm 10\%$ ，具备可靠的保护接地，接地电阻 $\leq 4\Omega$ 。

2. **Wiring Requirements 接线要求:**

1. The power cable must be $\geq 1.5\text{mm}^2$ copper core cable;
2. 电源线必须采用 $\geq 1.5\text{mm}^2$ 铜芯线缆、
3. All wiring must be firm, with no exposed copper wires, and the cable sheath must be free of damage.
4. 所有接线必须牢固，无铜线外露，线缆护套无破损。

3. **Power On Check 通电前检查**: Before power on, check that the power supply voltage matches the equipment rating, the wiring is correct, the grounding is reliable, and the electrical compartment door is closed and locked.

通电前检查电源电压与设备额定值匹配，接线正确，接地可靠，电气舱门关闭锁紧。

3.4 Installation and Commissioning Steps 安装与调试步骤

1. **Unpacking and Inspection 开箱检查**: Unpack the equipment, check that the appearance is intact, no damage, and the accessories are complete according to the packing list.

开箱检查设备外观完好、无磕碰损伤，对照装箱单检查配件齐全。

2. **Equipment Placement and Leveling 设备放置与调平**: Place the equipment on the workbench, adjust the adjustable feet at the bottom, and use a level to adjust the equipment level to $\leq 0.02\text{mm/m}$.

将设备放置于工作台，调节底部可调脚座，使用水平仪将设备水平度调至 $\leq 0.02\text{mm/m}$ 。

3. **Power and Grounding Connection 电源与接地连接**: Complete the power wiring and protective grounding connection by a certified electrician, and check that the wiring is correct.

由持证电工完成电源接线与保护接地连接，检查接线无误。

4. **Peripheral Connection 外设连接**: Connect the air compressor, vacuum cleaner, 4th axis, handwheel and other peripherals according to the interface instructions.

按照接口说明连接空压机、吸尘器、第四轴、手轮等外设。

5. **Power On and Self-Test 通电自检**: Turn on the main power switch, the equipment will automatically perform a full self-test. After the self-test is passed, the equipment enters the standby state.

打开总电源开关，设备自动执行全机自检，自检通过后进入待机状态。

6. **Homing and Calibration 回零与校准**: Perform the axis homing operation, and complete the automatic calibration of the spindle, tool magazine and backlash according to the prompts on the screen.

执行轴回零操作，按照屏幕提示完成主轴、刀库、反向间隙的自动校准。

7. **No-load Test Run 空载试运行**: Perform no-load jogging and continuous feed of the X/Y/Z axis, check that there is no jamming, abnormal noise or vibration during the full travel.

执行X/Y/Z轴空载点动、连续进给，检查全行程无卡顿、无异响、无振动。

3.5 Disassembly Requirements 拆卸要求

1. The equipment must be completely powered off before disassembly, and the main power plug must be unplugged to ensure no residual power;
设备拆卸前必须完全断电，拔下总电源插头，确保无残余电量；
2. Disassembly must be carried out in the reverse order of assembly, and violent disassembly is prohibited;
拆卸必须按照装配的逆序进行，禁止暴力拆装；
3. The disassembled parts must be properly kept, and the precision parts must be protected to avoid collision and damage.
拆卸后的零部件需妥善保管，精密部件做好防护，避免磕碰损伤。

4. Operation Instructions 操作使用说明

4.1 Operator Requirements 操作人员要求

1. The operator must be over 18 years old, have received professional training, and be familiar with the operation process, safety requirements and emergency handling methods of the equipment;

操作人员必须年满18周岁，接受过专业培训，熟悉设备的操作流程、安全要求与应急处理方式；

2. Prohibit untrained personnel from operating the equipment independently;

禁止未经培训的人员独立操作设备；

3. The operator must strictly follow the operation instructions in this manual, and prohibit any improper operation that may cause equipment damage or personal injury.

操作人员必须严格遵循本说明书的操作指引，禁止任何可能导致设备损坏、人身伤害的不当操作。

4.2 Operation Panel Introduction 操作面板介绍

4.2.1 Physical Buttons 物理按键

Button Name 按键名称	Function 功能	Operation Method 操作方式
Emergency Stop Button 急停按钮	Cut off all power of the moving parts, emergency stop all movements	Press to lock, rotate clockwise to release and reset
Power Switch 电源开关	Main power on/off	Toggle up to power on, toggle down to power off

4.2.2 Touch Screen Interface 触摸屏界面

The 7-inch touch screen is divided into 4 main functional areas:

7英寸触摸屏分为4大功能区：

1. **Home Page 主页**: Display real-time axis coordinates, spindle speed, feed rate, processing progress, equipment status;

显示轴实时坐标、主轴转速、进给速度、加工进度、设备状态；

2. **File Management 文件管理**: G-code file upload, import, preview, delete and other operations;

G代码文件上传、导入、预览、删除等操作；

3. **Manual Control 手动控制:** Jog control of X/Y/Z axis, spindle start/stop, speed adjustment, tool change operation;
X/Y/Z轴点动控制、主轴启停、转速调节、换刀操作;
4. **System Settings 系统设置:** Parameter setting, calibration, maintenance reminder, fault query, firmware upgrade and other functions.
参数设置、校准、维护提醒、故障查询、固件升级等功能。

4.3 Normal Startup and Shutdown Procedure 正常开机、停机顺序

4.3.1 Normal Startup 正常开机

1. Check that the equipment is properly grounded, the protective door is closed, and there are no obstacles in the processing area;
检查设备接地正常、防护门关闭、加工区域无障碍物;
2. Turn on the main power switch, the equipment enters the self-test process, wait for the self-test to complete (about 30 seconds);
打开总电源开关, 设备进入自检流程, 等待自检完成 (约30秒);
3. After the self-test is passed, perform the axis homing operation, and wait for the homing to complete;
自检通过后, 执行轴回零操作, 等待回零完成;
4. Set the spindle speed, feed rate and other parameters according to the processing requirements, load the G-code file;
根据加工需求设置主轴转速、进给速度等参数, 加载G代码文件;
5. Complete the workpiece clamping, tool setting and centering operation, confirm that the processing path is correct through simulation;
完成工件装夹、对刀、分中操作, 通过模拟确认加工路径无误;
6. Close the protective door, press the start button to start processing.
关闭防护门, 按下启动按钮开始加工。

4.3.2 Normal Shutdown 正常停机

1. After the processing is completed, the equipment automatically stops, the spindle stops rotating, and the axis returns to the origin;
加工完成后, 设备自动停机, 主轴停止旋转, 轴回归原点;
2. Clean the processing area, remove the workpiece and chips, and clean the equipment surface;
清理加工区域, 取出工件与切削屑, 清洁设备表面;
3. Perform routine maintenance operations such as lubrication according to the maintenance requirements;
根据维护要求执行润滑等日常保养操作;
4. Press the stop button to exit the processing program, turn off the spindle and other peripheral power supplies;

按下停止按钮退出加工程序，关闭主轴等外设电源；

5. Turn off the main power switch, and lock the equipment if necessary.

关闭总电源开关，必要时对设备进行上锁。

4.4 Emergency Stop Operation 紧急停止操作

1. **Trigger Condition 触发场景**: In case of emergency such as workpiece collision, equipment abnormality, personal injury risk, etc., immediately perform emergency stop operation;

发生工件碰撞、设备异常、人身伤害风险等紧急情况时，立即执行急停操作；

2. **Operation Method 操作方式**: Press the red mushroom emergency stop button firmly, the equipment will immediately cut off all power of the moving parts, stop all movements, and trigger an alarm;

用力按下红色蘑菇头急停按钮，设备立即切断所有运动部件电源，停止全部动作，并触发报警；

3. **Reset Method 复位方式**: After troubleshooting the fault, rotate the emergency stop button clockwise to release the lock, then perform the homing operation again, and confirm that the equipment is normal before resuming operation;

排查并解决故障后，顺时针旋转急停按钮解除锁定，随后重新执行回零操作，确认设备正常后方可恢复运行；

4. **Prohibition 禁止事项**: It is forbidden to use the emergency stop button as a normal stop button, and it is forbidden to bypass the emergency stop function.

禁止将急停按钮作为正常停机按钮使用，禁止屏蔽急停功能。

4.5 Parameter Setting 参数设定

1. **User Accessible Parameters 用户可设置参数**: Feed rate, spindle speed, tool compensation, soft limit, maintenance cycle, etc.;

进给速度、主轴转速、刀具补偿、软限位、维护周期等；

2. **Parameter Setting Requirements 参数设置要求**:

1. Parameter modification must be performed by trained personnel. It is forbidden to modify the underlying parameters of the system without authorization;
2. 参数修改必须由经过培训的人员操作，禁止擅自修改系统底层参数；
3. Before modifying the parameters, back up the original parameters. If the equipment is abnormal after modification, restore the original parameters immediately;
4. 修改参数前必须备份原始参数，修改后设备出现异常需立即恢复原始参数；
5. The soft limit setting must be smaller than the hard limit stroke to ensure the double protection function is effective.
6. 软限位设置必须小于硬限位行程，确保双重保护功能生效。

5. Maintenance Guide 维护保养说明

5.1 Maintenance Personnel Requirements 维护人员要求

- 1. Daily maintenance can be performed by the operator after training;
日常维护可由经过培训的操作人员执行；
- 2. Professional maintenance such as electrical system inspection, parts replacement must be performed by professional technicians with relevant qualifications;

电气系统检修、零部件更换等专业维护必须由具备相关资质的专业技术人员执行；

- 3. All maintenance operations must be performed after the equipment is completely powered off, and the main power plug is unplugged.

所有维护操作必须在设备完全断电、拔下总电源插头后执行。

5.2 Maintenance Cycle and Items 保养周期与检查项目

Maintenance Cycle 维护周期	Maintenance Items 维护项目
After each use 每次使用后	1. Clean the processing area, worktable, chip collection box, remove chips and cutting fluid residue; 2. Wipe the guide rail surface, check for chip accumulation; 3. Check the protective door for damage, the safety interlock function is normal; 4. Check the air path for air leakage, the cooling fluid level is normal; 5. Turn off the power, clean the equipment surface, and record the maintenance content.
	1. 清理加工区域、工作台、集屑盒，清除切削屑与切削液残留；2. 擦拭导轨表面，检查无切屑堆积；3. 检查防护门无破损，安全联锁功能正常；4. 检查气路无漏气，冷却液液位正常；5. 关闭电源，清洁设备表面，记录维护内容。
Weekly 每周	1. Complete the daily maintenance items; 2. Lubricate the guide rails, apply lithium-based grease to the guide rail oil grooves; 3. Clean the cooling water tank, replace the filter element if necessary; 4. Check the limit switch for normal triggering, clean the detection surface; 5. Check the cable and air pipe for damage, loose joints; 6. Check the grounding is reliable, the grounding resistance $\leq 4\Omega$.

	1. 完成日常维护项目； 2. 导轨润滑，向导轨油槽涂抹锂基润滑脂； 3. 清洁冷却水箱，必要时更换滤芯； 4. 检查限位开关触发正常，清洁检测面； 5. 检查线缆、气管无破损，接头无松动； 6. 检查接地可靠，接地电阻$\leq 4\Omega$。
Monthly 每月	1. Complete the weekly maintenance items; 2. Clean and lubricate the ball screw, check the preload is normal; 3. Check the timing belt tension, adjust if necessary; 4. Check the spindle runout, clean the spindle collet; 5. Check the electrical compartment, clean the dust, tighten the wiring terminals; 6. Perform full stroke motion test, check no jamming, abnormal noise; 7. Calibrate the positioning accuracy and backlash compensation if necessary.
	1. 完成每周维护项目； 2. 滚珠丝杆清洁与润滑，检查预紧力正常； 3. 检查同步带张紧度，必要时调整； 4. 检查主轴径向跳动，清洁主轴夹头； 5. 检查电气舱，清理灰尘，拧紧接线端子； 6. 执行全行程运动测试，检查无卡顿、无异响； 7. 必要时校准定位精度与反向间隙补偿。
Every 6 Months 每6个月	1. Complete the monthly maintenance items; 2. Replace the spindle bearing grease, check the bearing wear; 3. Replace the bellows, drag chain if damaged; 4. Replace the filter element of the cooling system, replace the cutting fluid; 5. Inspect the electrical components, replace the aging parts; 6. Full machine calibration by professional technicians, including positioning accuracy, repeat positioning accuracy; 7. Check the safety circuit, emergency stop, interlock function reliability.
	1. 完成每月维护项目； 2. 更换主轴轴承润滑脂，检查轴承磨损情况； 3. 风琴罩、拖链如有破损则更换； 4. 更换冷却系统滤芯，更换切削液； 5. 检查电气元器件，更换老化部件； 6. 由专业技术人员进行全机校准，包括定位精度、重复定位精度； 7. 检查安全回路、急停、联锁功能可靠性。

Every 12 Months 每年	1. Complete the 6-month maintenance items; 2. Comprehensive inspection of the guide rail and screw, replace if the accuracy is attenuated; 3. Inspect the motor and driver, replace the aging parts; 4. Full machine EMC and safety test, ensure compliance with CE requirements; 5. Update the firmware to the latest stable version; 6. Replace all wearing parts according to the service life.
	1. 完成每6个月维护项目; 2. 导轨、丝杆全面检测, 精度衰减则更换; 3. 电机、驱动器全面检测, 更换老化部件; 4. 全机EMC与安全测试, 确保符合CE要求; 5. 固件更新至最新稳定版本; 6. 按照使用寿命更换所有易损件。

5.3 Machine Cleaning 机器清洁

- Daily Cleaning 日常清洁:** Use a clean, lint-free cloth to wipe the equipment surface, worktable, and protective door. Use a low-pressure air gun to clean the chips in the processing area. It is forbidden to use a high-pressure water gun to flush the equipment.

使用干净的无尘布擦拭设备表面、工作台、防护门, 用低压气枪清理加工区域切屑, 禁止使用高压水枪冲洗设备。

- Regular Cleaning 定期清洁:** Clean the cooling water tank every week, remove sediment and impurities; clean the electrical compartment dust every month with a dry air gun; clean the inside of the machine thoroughly every 6 months.

每周清洁冷却水箱, 清除沉淀物与杂质; 每月用干燥气枪清理电气舱灰尘; 每6个月对设备内部进行彻底清洁。

- Cleaning Precautions 清洁注意事项:** All cleaning operations must be performed after power off. It is forbidden to clean electrical components with water or liquid detergent to avoid short circuit.

所有清洁操作必须在断电后执行, 禁止用水或液体清洁剂清洁电气元器件, 避免短路。

5.4 Lubrication Requirements 润滑要求

Lubrication Part 润滑部位	Lubricant Type 润滑脂型号	Lubrication Cycle 润滑周期	Dosage 用量
Linear Guide 直线导轨	Lithium-based grease NLGI 2, high temperature resistance $\geq 120^{\circ}\text{C}$	Weekly 每周	0.5g per side of each guide rail 每条导轨每侧0.5g

Ball Screw 滚珠丝杆	Precision machine screw special lubricating oil ISO VG 32	Every 2 weeks 每2周	Evenly cover the screw surface 均匀覆盖丝杆表面
Spindle Bearing 主轴轴承	High speed bearing special grease NLGI 2, temperature resistance $\geq 150^{\circ}\text{C}$	Every 6 months 每6个月	1g per end 每端1g
Timing Belt Pulley 同步带轮	Mechanical lubricating oil ISO VG 22	Every 6 months 每6个月	1-2 drops on the bearing 轴承处1-2滴
4th Axis Reducer 第四轴减速器	Harmonic reducer special grease	Every 12 months 每年	Fill according to the reducer manual 按减速器说明书填充

5.5 Function Test 功能试验

1. **Safety Function Test 安全功能试验:** Test the emergency stop, protective door interlock, limit switch function before each use, ensure that the protection function is triggered normally and the response is timely.

每次使用前测试急停、防护门联锁、限位开关功能，确保保护功能正常触发、响应及时。

2. **Motion Performance Test 运动性能试验:** Perform full stroke motion test every month, check the motion is smooth, no jamming, no abnormal noise, the positioning accuracy meets the requirements.

每月执行全行程运动测试，检查运动顺畅、无卡顿、无异响，定位精度符合要求。

3. **Electrical Performance Test 电气性能试验:** Test the power supply, grounding, leakage protection function every 6 months, ensure the electrical safety meets the CE requirements.

每6个月测试电源、接地、漏电保护功能，确保电气安全符合CE要求。

5.6 Maintenance Record 维护记录

It is recommended to use the maintenance record form below to record all maintenance operations, which is convenient for fault tracing and equipment life management.

建议使用下表维护记录表，记录所有维护操作，便于故障追溯与设备寿命管理。

Maintenance Date 维护日期	Maintenance Module 维护模块	Maintenance Item 维护项目	Consumable Model/ Dosage 耗材 型号/用量	Operator 操作人员	Remarks 备注 (故障与处理)

6. Troubleshooting 故障分析与处理

All fault handling must be performed after the equipment is completely powered off. For faults that cannot be resolved by the following methods, please contact the after-sales service team, and do not disassemble the equipment without authorization.

所有故障处理必须在设备完全断电后执行，对于以下方法无法解决的故障，请联系售后团队，禁止擅自拆装设备。

Fault Phenomenon 故障现象	Possible Cause 可能原因	Solution 处理方法
The equipment cannot be powered on, the screen is black	1. The main power supply has no power, the air switch is tripped; 2. The power plug is loose, the wiring is poor; 3. The emergency stop button is locked and not reset; 4. The fuse is blown; 5. The power module is faulty.	1. Check the main power supply, reset the air switch and leakage protector; 2. Re-plug the power plug, check the wiring is firm; 3. Rotate the emergency stop button clockwise to reset; 4. Replace the fuse with the same specification; 5. Contact after-sales service to check the power module.
设备无法通电，屏幕黑屏	1. 主电源无电，空气开关跳闸； 2. 电源插头松动，接线不良； 3. 急停按钮锁定未复位； 4. 保险丝熔断； 5. 电源模块故障。	1. 检查主电源，复位空气开关与漏电保护器； 2. 重新插拔电源插头，检查接线牢固； 3. 顺时针旋转急停按钮复位； 4. 更换同规格保险丝； 5. 联系售后检查电源模块。
Axis cannot home, homing failure	1. The limit switch is triggered or damaged, no signal output; 2. The encoder cable is loose or damaged; 3. There are obstacles in the travel range, blocking the movement; 4. The motor driver is faulty, no power output; 5. The homing parameter setting is wrong.	1. Check the limit switch, clean the detection surface, replace if damaged; 2. Re-plug the encoder cable, replace if damaged; 3. Remove obstacles in the travel range; 4. Check the driver status, reset the alarm; 5. Check and correct the homing parameters.
轴无法回零，回零失败	1. 限位开关触发或损坏，无信号输出； 2. 编码器线缆松动或破损； 3. 行程范围内有障碍物，阻挡运动； 4. 电机驱动器故障，无动力输出； 5. 回零参数设置错误。	1. 检查限位开关，清洁检测面，损坏则更换； 2. 重新插拔编码器线缆，破损则更换； 3. 清除行程范围内的障碍物； 4. 检查驱动器状态，复位报警； 5. 检查并修正回零参数。

Axis motion jamming, abnormal noise	1. The guide rail and screw have chip accumulation, lack of lubrication; 2. The timing belt is too tight or too loose, the pulley is loose; 3. The guide rail slider is worn or damaged; 4. The screw preload is too large, the bearing is damaged; 5. The motor is faulty, the driver parameter setting is wrong.	1. Clean the guide rail and screw, re-lubricate; 2. Adjust the timing belt tension, tighten the pulley fixing screw; 3. Replace the guide rail slider; 4. Adjust the screw preload, replace the bearing; 5. Check the motor and driver, correct the parameters.
轴运动卡顿、异响	1. 导轨、丝杆有切屑堆积，润滑不足； 2. 同步带过紧或过松，带轮松动； 3. 导轨滑块磨损或损坏； 4. 丝杆预紧力过大，轴承损坏； 5. 电机故障，驱动器参数设置错误。	1. 清洁导轨与丝杆，重新润滑； 2. 调整同步带张紧度，拧紧带轮固定螺丝； 3. 更换导轨滑块； 4. 调整丝杆预紧力，更换轴承； 5. 检查电机与驱动器，修正参数。
Positioning accuracy is out of tolerance, lost steps	1. The motor encoder is faulty, the signal is lost; 2. The backlash compensation parameter is wrong; 3. The guide rail and screw are worn, the gap is too large; 4. The timing belt slips, the fixing screw is loose; 5. The driver current parameter is set too low.	1. Check the encoder, replace if damaged; 2. Re-calibrate the backlash, correct the compensation parameters; 3. Check the wear of the guide rail and screw, replace if necessary; 4. Adjust the timing belt tension, tighten the fixing screw; 5. Increase the driver current parameter appropriately.
定位精度超差、丢步	1. 电机编码器故障，信号丢失； 2. 反向间隙补偿参数错误； 3. 导轨、丝杆磨损，间隙过大； 4. 同步带打滑，固定螺丝松动； 5. 驱动器电流参数设置过低。	1. 检查编码器，损坏则更换； 2. 重新校准反向间隙，修正补偿参数； 3. 检查导轨、丝杆磨损情况，必要时更换； 4. 调整同步带张紧度，拧紧固定螺丝； 5. 适当提高驱动器电流参数。
Spindle does not rotate, no speed feedback	1. The spindle enable signal is not triggered, the protective door is not closed; 2. The spindle power cable is loose; 3. The spindle driver is faulty, alarm triggered; 4. The spindle encoder is damaged, no speed feedback; 5. The spindle overheats, the over-temperature protection is triggered.	1. Close the protective door, check the spindle enable signal; 2. Re-plug the spindle power cable, ensure the wiring is firm; 3. Check the driver alarm code, reset the fault; 4. Replace the spindle encoder; 5. Stop the machine to cool down, check the spindle bearing and cooling system.

主轴不旋转，无转速反馈	1. 主轴使能信号未触发，防护门未关闭； 2. 主轴电源线松动； 3. 主轴驱动器故障，触发报警； 4. 主轴编码器损坏，无转速反馈； 5. 主轴过热，触发过温保护。	1. 关闭防护门，检查主轴使能信号； 2. 重新插拔主轴电源线，确保接线牢固； 3. 查看驱动器报警代码，复位故障； 4. 更换主轴编码器； 5. 停机冷却，检查主轴轴承与冷却系统。
Protective door interlock function invalid	1. The door sensor is damaged or displaced, no signal output; 2. The sensor cable is loose or broken; 3. The safety relay is faulty; 4. The interlock function is bypassed by unauthorized modification.	1. Adjust the sensor position, replace if damaged; 2. Check the cable, re-plug or replace; 3. Replace the safety relay; 4. Restore the factory settings, prohibit unauthorized modification of the safety function.
防护门联锁功能失效	1. 门磁传感器损坏或位移，无信号输出； 2. 传感器线缆松动或断裂； 3. 安全继电器故障； 4. 擅自修改屏蔽了联锁功能。	1. 调整传感器位置，损坏则更换； 2. 检查线缆，重新插拔或更换； 3. 更换安全继电器； 4. 恢复出厂设置，禁止擅自修改安全功能。
Communication failure between the equipment and the upper computer	1. The network cable/USB cable is loose or damaged; 2. The IP address setting is wrong, not in the same network segment; 3. The communication protocol does not match; 4. The firewall blocks the communication port; 5. The main control board communication module is faulty.	1. Re-plug or replace the communication cable; 2. Check and correct the IP address, ensure it is in the same network segment; 3. Check the protocol settings, match the upper computer requirements; 4. Turn off the firewall or open the corresponding port; 5. Contact after-sales service to check the main control board.
设备与上位机通信失败	1. 网线/USB线松动或损坏； 2. IP地址设置错误，不在同一网段； 3. 通信协议不匹配； 4. 防火墙拦截了通信端口； 5. 主控板通信模块故障。	1. 重新插拔或更换通信线缆； 2. 检查并修正IP地址，确保同一网段； 3. 检查协议设置，匹配上位机要求； 4. 关闭防火墙或开放对应端口； 5. 联系售后检查主控板。

7. Components and Spare Parts List 元器件与备用件清单

7.1 Main Components List 主要元器件清单

No. 序号	Part Name 零部件名称	Model 型号	Specifcation 规格	Quantity 单台数量
1	X/Y/Z Axis Closed-loop Stepper Motor 三轴闭环步进电机	KLI57P-80E T	2-phase, 2.2N·m, DC 24V, 5A	3
2	Spindle Motor 主轴电机	Custom 800W	6000-18000rpm, 110-220V AC	1
3	Motor Driver 电机驱动器	CL57T	DC 20-50V, 5A	3
4	PMI Ball Screw PMI滚珠丝杆	1R15-05T3-1FSDC	C5 grade, lead 5mm	3
5	PMI Linear Guide PMI线性导轨	MSB15S2SSFC	P grade	6
6	Guide Slider 导轨滑块	MSB15SSFC	Matching guide rail	12
7	Proximity Switch (Limit Switch) 接近开关 (限位)	Panasonic GX-F8B	NPN normally closed, 10-30VDC	7
8	Main Control Board 主控板	Custom STM32F407	GRBL-HAL firmware	1
9	Switching Power Supply 开关电源	350W	DC 24V/15A	1
10	4.3-inch Touch Screen 4.3英寸触摸屏	Custom	1080p resolution, Android system	1
11	Emergency Stop Button 急停按钮	Custom	Red mushroom head, self-locking	1
12	Cooling Fan 散热风扇	Delta 12V	0.2A, IP54	2
13	Air Solenoid Valve 气动电磁阀	Custom	DC 24V, 0.8MPa	3
14	Bellows Cover 风琴罩	Custom	PA nylon, IP54	4

15	Drag Chain 拖链	Custom	15×20mm inner size, PA nylon	3
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7.2 Recommended Spare Parts List 推荐备用件清单

No. 序号	Part Name 备件名称	Model 型号	Recommended Quantity 推荐备货量	Service Life 使用寿命
1	Collet 主轴夹头	1/4英寸筒夹	5 pcs	6 months
2	Guide Rail Slider 导轨滑块	MSB15SSFC	4 pcs	5000 hours
3	Ball Screw Nut 丝杆螺母	Matching screw	2 pcs	5000 hours
4	Limit Switch 限位开关	Panasonic GX-F8B	5 pcs	1000000 times
5	Fuse 保险丝	10A, 250V	10 pcs	–
6	Filter Element 过滤芯	5µm	10 pcs	1 month
7	Timing Belt 同步带	2M-200-10mm	2 pcs	2000 hours
8	Sealing Gasket 密封垫圈	Custom	1 set	12 months
9	Lubricating Grease 润滑脂	NLGI 2 lithium-based grease	2 bottles	6 months
10	Power Cable 电源线	1.5mm ² copper core	2 pcs	–

8. Equipment Dismantling, Decommissioning and Scrap 设备拆卸、停用与报废

8.1 Long-term Decommissioning 长期停用

If the equipment is decommissioned for more than 3 months, the following operations must be performed:

设备停用超过3个月，必须执行以下操作：

1. Complete the full maintenance of the equipment, clean all parts, apply anti-rust oil on the guide rail, screw and other metal parts;

完成设备全面保养，清洁所有部件，对导轨、丝杆等金属部件涂抹防锈油；

2. Drain the cooling fluid, clean the water tank, and dry the inside of the equipment;

排空切削液，清洁水箱，干燥设备内部；

3. Unplug the main power plug, wrap the equipment with a dust-proof film, and store it in a dry, ventilated environment with temperature 5°C~30°C and humidity $\leq 70\%$ RH;

拔下总电源插头，用防尘膜包裹设备，存放于干燥、通风环境，温度5°C~30°C，湿度 $\leq 70\%$ RH；

4. Perform a power-on test every 1 month, run the axis for 30 minutes, check the equipment status, and re-apply anti-rust oil if necessary;

每1个月执行一次通电测试，运行轴30分钟，检查设备状态，必要时重新涂抹防锈油；

5. Before reusing the equipment, perform a comprehensive inspection, clean the anti-rust oil, re-lubricate, and perform a full no-load test run.

设备重新使用前，必须全面检查，清洁防锈油，重新润滑，并执行全机空载试运行。

8.2 Equipment Dismantling 设备拆卸

1. The equipment dismantling must be performed by professional technicians, and the power must be completely cut off before dismantling;

设备拆卸必须由专业技术人员执行，拆卸前必须完全切断电源；

2. Dismantling sequence: peripheral accessories → protective cover → electrical system → transmission system → gantry frame → main frame;

拆卸顺序：外设配件→防护罩→电气系统→传动系统→龙门架→主机架；

3. The precision parts must be properly protected during dismantling to avoid collision and damage, and the wiring must be marked to facilitate reassembly;

拆卸过程中必须对精密部件做好防护，避免磕碰损伤，线缆必须做好标记，便于重新装配；

4. It is forbidden to use violent disassembly methods such as hammering and prying to avoid permanent damage to the equipment.

禁止使用锤击、撬动等暴力拆卸方式，避免对设备造成永久性损伤。

8.3 Equipment Scrap and Disposal 设备报废与处置

1. When the equipment reaches the end of its service life and cannot be repaired, it shall be scrapped in accordance with local environmental regulations;

设备达到使用寿命、无法修复时，需按照当地环保法规进行报废处置；

2. Before scrapping, the equipment must be completely dismantled, and the hazardous waste such as circuit boards, electronic components, and batteries must be handed over to a professional hazardous waste disposal agency, and it is forbidden to discard them at will;

报废前必须对设备进行完全拆解，电路板、电子元器件、电池等危险废弃物必须交由专业危废处理机构，禁止随意丢弃；

3. The metal parts, plastic parts and other recyclable materials shall be recycled by a professional recycling agency;

金属件、塑料件等可回收物料交由专业回收机构回收利用；

4. After the equipment is scrapped, the equipment serial number must be written off in the manufacturer's system, and the user shall be responsible for the disposal of the scrapped equipment.

设备报废后，需在厂商系统中注销设备序列号，报废设备的处置责任由用户承担。

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions:

(1) This device may not cause harmful interference

(2) this device must accept any interference received, including interference that may cause unde operation. Any Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

-Reorient or relocate the receiving antenna.

-Increase the separation between the equipment and receiver.

-Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.

-Consult the dealer or an experienced radio/TV technician for help.

FCC Radiation Exposure Statement

This device meets the FCC requirements for RF exposure. The device is designed for normal indoor use and complies with applicable FCC exposure limits.

This equipment should be installed and operated with minimum distance 20cm between the radiator & your body.