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RESTORATION AND MODIFICATION OF FDM 3D PRINTER

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Abstract : The project focuses on investigating the restoration and modification of Fused Deposition Modeling (FDM) 3D printers. The aim is to enhance their performance and extend their lifespan, particularly in light of the rapid growth of 3D printing technology across industries. Maintaining and upgrading existing FDM printers has become essential for cost- effective and sustainable manufacturing processes. The study conducts a comprehensive analysis of common issues faced by FDM printers, including nozzle clogging, bed adhesion problems, and structural wear. It proposes effective restoration techniques to address these issues. Additionally, the research explores modifications for FDM printers, such as integrating advanced materials, precision components, and automated calibration systems. These modifications aim to improve printing accuracy and efficiency. The findings emphasize the importance of implementing restoration and modification strategies to ensure the continuous functionality and competitiveness of FDM 3D printing technology in various industrial applications

I. INTRODUCTION

The "Restoration and Modification of FDM 3D Printers" project aims to address these challenges by rejuvenating aging FDM printers through innovative strategies. Emphasis is placed on implementing restoration and modification techniques to extend printer lifespan, enhance performance, and meet contemporary 3D printing demands. A comprehensive analysis identifies key areas for improvement, including hardware compatibility, firmware upgrades, material selections, and calibration precision. Proposed strategies aim to systematically restore and modify FDM 3D printers, offering practical solutions to mitigate challenges and improve user experience across industries. With a focus on enhancing print quality, durability, and operational reliability, the research aims to contribute to the advancement of FDM 3D printing technology.

II. METHODOLOGY

Fig 1: Methodology Of Restoration and Modification Of FDM 3D Printer

The methodology for the project "Restoration and Modification Of FDM 3D Printer" encompasses asystematic approach aimed at enhancing the performance and longevity of outdated FDM printers.

Step 1: Research and Literature Review

Conduct an extensive literature review on FDM 3D printer restoration and modification techniques to understand the existing state of the art. Identify common challenges faced by users of outdated FDM printers.

Step 2: Identify Problem Areas

Assess the specific issues with the target FDM printer model to be restored and modified. Determine the critical components and systems that require improvement.

Step 3: Hardware Assessment

Examine the hardware components such as extruders, nozzles, beds, and frames for wear and compatibility with modern materials. Create an inventory of replacement and upgrade options.

Step 4: Firmware Analysis

Evaluate the existing firmware for the FDM printer and assess its compatibility with contemporary slicers and software. Investigate open-source firmware solutions and their potential for optimization.

Step 5: Material Selection

Investigate materials suitable for substituting and reinforcing critical parts to improve durability. Analyze the impact of material substitutions on performance and longevity.

Step 6: Calibration Procedures

Develop precise calibration methodologies tailored to the specific printer model. Test and fine-tune calibration settings to improve print accuracy and consistency.

Step 7: Hardware Upgrades and Modifications

Implement the selected hardware upgrades and modifications based on the assessment and inventory created inearlier steps. Ensure that the modifications align with the specific printer model and problem areas identified.

Step 8: Firmware Optimization

Integrate open-source firmware solutions or customize the existing firmware to enhance compatibility with modern software. Test the modified firmware to ensure seamless functionality.

Step 9: Material Substitution and Reinforcement

Substitute critical components with more durable materials, following the selected material options. Assess the impact of material substitutions on component longevity.

Step 10: Calibration Optimization

Implement the developed calibration methodologies and fine-tuned settings. Conduct extensive testing to verify the impact on print accuracy and consistency.

Step 11: Testing and Validation

Perform rigorous testing of the restored and modified FDM printer to evaluate print quality, reliability, and compatibility. Compare the results with industry standards and benchmarks.

Step 12: Documentation and User Guidelines

Create comprehensive documentation and user-friendly guidelines outlining the restoration and modification processes. Ensure that the documentation caters to both novice users and experienced technicians.

This methodology outlines the key steps involved in the project, from initial research and problem identification to the implementation of restoration and modification strategies and the dissemination of findings.

III. PROBLEM STATEMENT

The rapid growth of 3D printing technology necessitates rejuvenating these printers for sustainable manufacturing processes.

FDM printers commonly face issues such as nozzle clogging, bed adhesion problems, and structural wear. These issues hinder performance and reduce print quality, impacting the efficiency of manufacturing processes.

Optimized calibration procedures and smart sensor integration improve print accuracy, reliability, and repeatability.

Understanding the implications of different filament materials on print quality and mechanical properties is crucial for achieving desired outcomes.

IV. OBJECTIVES

1. Find ways to make FDM 3D printers better, faster, and more precise without spending too much money.
2. Check if fixing old FDM 3D printers with hardware upgrades, software updates, or replacing parts.
3. See how changing materials and strengthening parts affects how long FDM 3D printers last and how often they need fixing.
4. Look into using free software and making software changes so that old printers can work smoothly with new 3D printing tools.
5. Create and improve ways to make sure fixed and upgraded FDM 3D printers print accurately and consistently.

V. MODIFICATION IN PROJECT

•Core xyz Mechanism Converted Into Cartesian xyz Mechanism

Core xyz Mechanism Converted : The Core XYZ mechanism is a unique motion system used in certain 3D printers. In a Core XY (or Core XYZ, which is an extension with an additional Z-axis), two motors are typically mounted in a fixed position, while the tool head moves in X and Y directions by means of a belt system. The motion in the Z-direction, representing vertical movement, is usually controlled by another motor or system.

Cartesian xyz Mechanism : A Cartesian XYZ mechanism, also known as a Cartesian coordinate system, is a common configuration used in 3D printers and other CNC (Computer Numerical Control) machines. In this mechanism, each axis (X, Y, and Z) operates independently, allowing for precise control of movement in three dimensions.

The existing Core XYZ mechanism of the 3D printer will be upgraded to a more precise and stable Cartesian XYZ mechanism. This conversion will enhance the printer's accuracy, repeatability, and overall printing quality.

•Manual Extruder Replace Into Automatic Extruder

The manual extruder currently in use will be replaced with an automatic extruder system. This upgrade will streamline the printing process by automating filament feeding, reducing the need for manual intervention, and ensuring consistent filament flow for improved print quality and reliability.

•Manual Bed Leveling Converted Into Automatic Bed Leveling

Manual bed leveling will be upgraded to automatic bed leveling functionality. This enhancement will simplify the setup process for users, improve print bed calibration accuracy, and reduce the likelihood of print failures caused by uneven bed surfaces.

•Operating System Software building (Marlin)

The operating system software, particularly Marlin firmware, will be customized and optimized to suit the specific requirements of the modified printer configuration. This customization will include fine-tuning parameters for improved performance, compatibility with new hardware components, and integration of additional features such as automatic bed leveling and filament sensing.

•Motherboard Configuration

The printer's motherboard will undergo a configuration update to accommodate the new hardware components and software enhancements. This may involve firmware updates, adjusting settings for optimal performance, and ensuring compatibility between the motherboard and other system elements.

•Slicing software Configuration

The slicing software used to prepare 3D models for printing will be configured to align with the modified printer's specifications and capabilities. This includes adjusting settings for filament type, layer height, printing speed, and other parameters to optimize print quality and ensure compatibility with the upgraded hardware and firmware.

VI. DESIGN CALCULATION

Designing a 3D printer involves various considerations, and calculating the specifications for the X, Y, and Z- axis mechanisms is crucial. Here's a basic outline for the design calculations:

Design considerations:

1) 20x20 aluminum extrusion profile

2) Printing dimensions : 220 x 220 x 250 mm

X-Axis Pully Belt Mechanism:

Pulley Diameter: Choose a suitable pulley diameter based on the required resolution and torque requirements. Let's assume a pulley diameter of 20mm.

Belt Pitch: Determine the pitch of the belt. A common pitch for 3D printers is GT2 (2mm pitch).

Steps per mm: Calculate the number of steps per mm your stepper motor needs to move the X-axis. This is determined by the microstepping of your stepper motor driver, the steps per revolution of your motor, and the pulley diameter. For example, if you're using a 1.8° stepper motor with 16x microstepping and 20 teeth pulley, the steps per mm would be:

Steps per mm = $(360° / 1.8°) * 16 / (20 * \pi)$
= 80 steps/mm **(approximately)**

Belt Length: Calculate the required belt length based on the printer's dimensions. Assuming the X-axis spans the full 220mm printing width, the belt length would be:

Belt Length = 2 * (Printing Width + (2 * Pulley Diameter))
= 2 * (220 + (2 * 20))
= 540 mm

Y-Axis Pully Belt Mechanism:

Pulley Diameter : Choose a suitable pulley diameter. Let's select a standard size of 20mm.

Belt Pitch : Choose GT2 belt with a pitch of 2mm. This pitch provides good resolution and accuracy for 3D printing.

Steps per mm : Calculate the steps per mm for the Y-axis using the motor's steps per revolution, microstepping, and pulley diameter.

Belt Length : Calculate the belt length required for the Y-axis. Assuming the Y-axis spans the full 220mm printing width, the belt length would be:

Belt Length = 2 * (Printing Width + (2 * Pulley Diameter))
= 2 * (220 + (2 * 20))
= 540 mm

Z-Axis Screw Mechanism:

Lead Screw Pitch: Choose a lead screw with a suitable pitch. Common pitches range from 1mm to 8mm. Let's assume a pitch of 4mm for this calculation.

Steps per mm: Calculate the number of steps per mm for the Z-axis stepper motor. This is determined similarly to the X- axis calculation, but using the lead screw pitch instead of the pulley diameter. If you're using the same stepper motor and driver settings as before, the steps per mm would be:

Steps per mm = (360° / 1.8°) * 16 / (4 * π)
= 400 steps/mm (approximately)

Travel Distance: The Z-axis travel distance is 250mm, which will be the maximum height of your print. Ensure your lead screw length accommodates this travel distance.

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VII. RESULTS

Before Starting Project

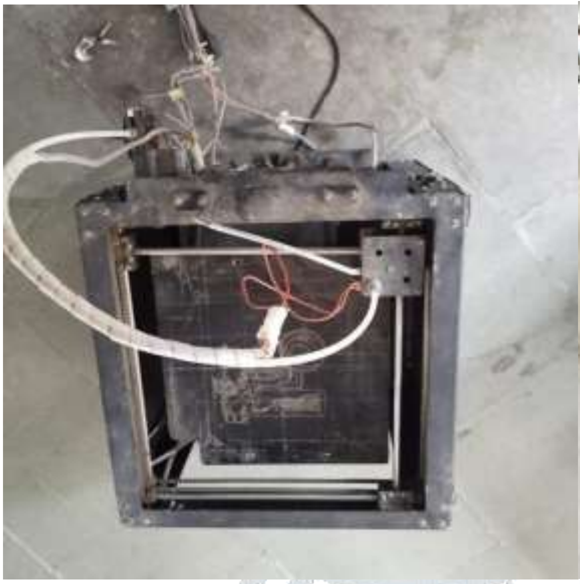

Figure 1 : 3D Printer Before Starting (A)

Figure 2 : 3D Printer Before Starting (B)After Completed Project

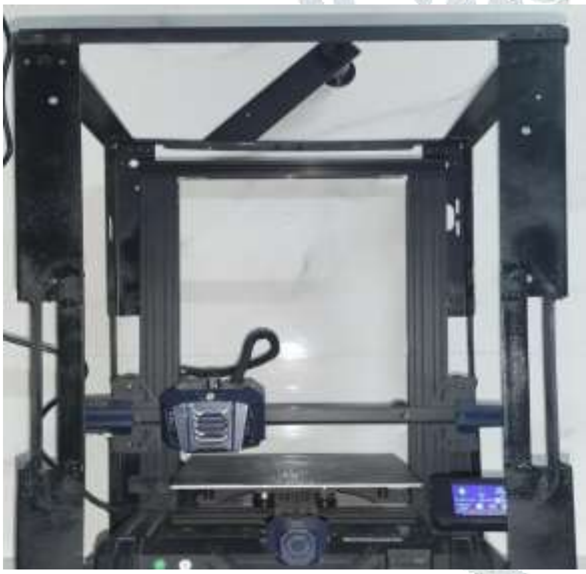

Figure 1 : 3D Printer After Completed (A)

Figure 2 : 3D Printer After Completed (B)

Old 3D Printer Working Temperature			
Sr.No.	**Material**	**Nozzle**	**Bed**
1	**PLA**	**180°C**	**-**
Maximum Temperature Nozzle = 180°C **Maximum Temperature Bed = Heat Bed Not Attached**			

Modified3D Printer Working Temperature			
Sr.No.	**Material**	**Nozzle**	**Bed**
1	PLA	185°C	45°C
2	ABS	255°C	80°C
3	PETG	245°C	70°C
5	TPU	220°C	60°C
Maximum Temperature Nozzle = 260°C **Maximum Temperature Bed = 110**°C			

VIII. CONCLUSION

In conclusion, the restoration and modification of Fused Deposition Modeling (FDM) 3D printers present significant opportunities for enhancing manufacturing processes and sustainability. Through our investigation, we have identified key challenges faced by aging FDM printers, including common issues such as nozzle clogging and structural wear. By implementing innovative restoration techniques and modifications, we can extend the lifespan of these printers while improving their performance and compatibility with modern 3D printing demands.

Our study emphasizes the importance of selecting suitable materials and optimizing printing parameters to achieve superior print quality and mechanical properties. Furthermore, the integration of smart sensors for real-time monitoring and calibration procedures tailored to specific requirements enhances operational reliability and efficiency.

The case studies presented highlight the practical applications of restoration and modification strategies, showcasing their potential to support sustainable manufacturing practices and reduce electronic waste. By refurbishing and reusing aging equipment, we can mitigate environmental impact and contribute to a more sustainable future for additive manufacturing.

In summary, our research underscores the significance of restoration and modification efforts in ensuring the continuous functionality and competitiveness of FDM 3D printing technology. By addressing key challenges and implementing practical solutions, we can propel the advancement of additive manufacturing and foster innovation across industries.

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