

Choco Matic

Graduation Project Summary: An Automated Chocolate Bar Production Line with Tempering and Topping Systems
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1. Project Overview

Choco Matic is the design and implementation of a compact production line for customized chocolate bars. It combines a real, food-safe stainless-steel tempering machine with a mold-filling and topping system for nuts and raisins. It can be operated locally through keypads or remotely through a mobile app connected over Wi-Fi.

2. Problem and Objectives

Small-scale chocolate making needs precise temperature control during tempering to avoid bloom and a grainy texture, and toppings are usually added by hand, which limits speed and scalability. Commercial machines are costly, while most student projects stay at a simulation level. The main objectives are to:

- Automate tempering with real-time temperature monitoring (PT100 sensor with a MAX31865 module) and a 1950 W heating element switched by a solid-state relay (SSR) and an ESP32.
- Support three chocolate types (milk, dark and white), each with its own temperature profile.
- Let the user choose raisins, nuts or no topping through a dedicated keypad.
- Control mold filling with a stainless-steel pipe valve and IR sensors that detect mold position, followed by a vibration motor to level the chocolate.
- Drive the conveyor with a windshield-wiper motor through a BTS7960 driver.
- Monitor chocolate and topping levels with ultrasonic sensors shown on LCDs.
- Use heat-transfer calculations to estimate heating time and energy use.

3. System Architecture

The system has two main sections:

- Tempering machine:** a double-layer stainless-steel vessel; the lower layer holds 8 L of water and the upper layer melts up to 10 kg of chocolate. The water bath is heated by the element; chocolate temperature is read by a PT100 sensor and water temperature by an NTC sensor.
- Production line prototype:** a belt-driven line that receives tempered chocolate, fills polycarbonate/silicone molds, dispenses toppings, and vibrates the mold tray.

Work is split across three microcontrollers for modularity and to avoid timing conflicts:

Controller	Role
ESP32	Heating logic, temperature reading, Wi-Fi link to the mobile app
Arduino Mega 2560	Production line logic: conveyor, IR sensor, keypads, motors, 20x4 status LCD
Arduino Uno	Three ultrasonic sensors and three 16x2 LCDs showing fill levels

4. Key Components

- 1950 W / 230 V washing-machine heating element with an SSR-40DA relay that isolates mains voltage from the logic circuits.
- PT100 RTD sensor with a MAX31865 converter for precise temperature measurement.
- Three NEMA23 stepper motors with YS-DIV268N-5A drivers for chocolate, nut and raisin dispensing.
- 2430 vibration motor to remove air bubbles and level the chocolate.
- 300 W power supply (5 V and 12 V), IR sensor, two 1x4 keypads and I2C LCD displays.

5. How It Works

- Startup:** the ESP32 initializes Wi-Fi and heating; the Mega initializes motors and keypads.

- **User input:** chocolate type and topping are selected by keypad or app.
- **Tempering:** the ESP32 reads the PT100 and switches the SSR to hold the target temperature.
- **Dispensing:** when the IR sensor detects a mold, chocolate is released, toppings are dispensed, and the mold is briefly vibrated.
- **Monitoring:** the Uno continuously updates the fill-level displays.

Chocolate type	Initial target	Cooling	Working temp.
Milk	42°C	27°C	32°C
Dark	45°C	28°C	30°C
White	40°C	26°C	29°C

6. Thermal Calculations

For 8 kg of water and 5 kg of chocolate heated from 25°C to 42°C, the energy required is about 712,980 J. At 1950 W this gives an ideal heating time of roughly 6 minutes. In practice, heat losses, slow heat transfer from the outside of the chocolate inward, and the lack of stirring lengthen this considerably; the calculations were used to tune control parameters and plan delay loops.

7. Main Challenges and Solutions

- **Safe switching of the heater:** an isolated SSR with a heat sink.
- **Noisy temperature readings:** the MAX31865 module, proper grounding, and shielded wiring kept away from the high-voltage path.
- **Processor overload:** tasks distributed across several microcontrollers.
- **Topping jams:** a wider dispenser valve and tuned motor speed.
- **Conduction through stainless steel:** a thick non-conductive layer behind every electronic component.

8. Testing and Results

- PT100 readings matched reference thermometers, and the system reached 42°C in about 4.5 minutes at roughly a 50% duty cycle.
- Dispensing accuracy was within ±5 ml per cycle; ultrasonic fill-level accuracy was within ±10%.
- The IR sensor detected molds reliably within 2 cm, and the pipe valve opened and closed without leaking.
- Topping flow improved noticeably with vibration, and the system worked both locally (keypads) and remotely (app).

9. Conclusion and Future Work

The project delivers a low-cost, modular, semi-industrial prototype that combines real hardware, embedded control and physics-based modeling. Proposed improvements include full PID control, a richer mobile app (temperature logging and alerts), automated mold handling, multi-chocolate modes, power optimization, formal food-safety certification, and AI-based quality control using computer vision.