1NF, 2NF – Factory Monitoring & Predictive Maintenance System

MACHINE

MachineID	MachineName	Location	Status	InstallationDate	Furnace	RollingMachine	CoolingUnit	Cutter

PRODUCTION_BATCH

BatchID	StartTime	EndTime	PlannedTime	Attribute	TotalUnitsProduced	GoodUnits	BatchStatus

MACHINE_PROCESSES

MachineID	**BatchID**

PERFORMANCE_DATA (WEAK)

MachineID	**BatchID**	**PerformanceID**	OperatingTime	Downtime	UpTime	ActualOutput	IdealOutput

MAINTENANCE_LOG

MaintenanceID	Status	IssueDescription	MaintenanceType	CompletedDate	ScheduledDate	Attribute	**MachineID**	**AnomalyID**

ANOMALY_DETECTION_LOG

DetectionID	DetectedAt	AnomalyType	DeviationScore	IsolationForestScore	ActionTaken	**MachineID**	**PerformanceID**

BLOCKCHAIN_LOG

TransactionID	Timestamp	ActionType	Hash	LocationPreviousHash	**MaintenanceID**	**MachineID**	**BatchID**	**PerformanceID**

1NF: All attributes are atomic, no repeating groups, and each table has a primary key.

2NF: No partial dependency exists. Composite key tables (MACHINE_PROCESSES, PERFORMANCE_DATA) contain only attributes dependent on the full key.

3NF – Factory Monitoring & Predictive Maintenance System

MACHINE

MachineID	MachineName	Location	Status	InstallationDate

LOCATION_UNIT

Location	Furnace	RollingMachine	CoolingUnit	Cutter

Transitive Dependency Identified:
MachineID → Location → (Furnace, RollingMachine, CoolingUnit, Cutter)

Decomposition Performed:
MACHINE split into MACHINE and LOCATION_UNIT.
All relations now satisfy Third Normal Form (3NF).

BCNF – Factory Monitoring & Predictive Maintenance System

Definition (BCNF):
A relation is in Boyce–Codd Normal Form (BCNF) if, for every functional dependency X → Y, X is a super key.

BCNF Verification:

• MACHINE: MachineID → (MachineName, Location, Status, InstallationDate)
MachineID is a primary key → ✓ BCNF

• LOCATION_UNIT: Location → (Furnace, RollingMachine, CoolingUnit, Cutter)
Location is a primary key → ✓ BCNF

• PRODUCTION_BATCH: BatchID → all attributes → ✓ BCNF

• PERFORMANCE_DATA: (MachineID, BatchID, PerformanceID) → performance attributes → ✓ BCNF

• MAINTENANCE_LOG, ANOMALY_DETECTION_LOG, BLOCKCHAIN_LOG:
All determinants are primary keys → ✓ BCNF

Conclusion:
After decomposition, all relations satisfy BCNF. The database design is free from redundancy and update anomalies.