STATISTICAL ANALYSIS OF MARKET DEMAND OF INDUSTRIAL BATTERY: A CASE STUDY

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TABLE OF CONTENTS

	Page
Declaration	iii
Disclaimer	iv
Acknowledgement	v
List of Table	x
List of Figure	xi
List of Abbreviations	xiii
Abstract	xiv
CHAPTER 1 INTRODUCTION	1
1.1 Introduction	1
1.2 Objectives	2
1.3 Methodology	2
1.4 Limitation	2
CHAPTER 2 COMPANY PROFILE AND PRODUCT	3
2.1 Introduction	3
2.2 Strategic Business Units	3
2.2.1 Rahimafrooz Batteries Limited (RBL)	4
2.2.2 Rahimafrooz Renewable Energy Limited	4
2.2.3 Rahimafrooz Distribution Limited	4
2.2.4 Rahimafrooz Superstores Limited	4
2.2.5 Rahimafrooz CNG Limited	5
2.2.6 Rahimafrooz Energy Services Limited	5
2.2.7 Excel Retread Limited	5
2.2.8 Joint Venture	5
2.2.9 Academic Affiliation	5

2.3 Rahimafrooz Batteries Limited 5
2.4 Types of Battery 8
2.5 Basis on Automotive Battery 9
2.6 How an automotive battery works 10
2.7 Safety precautions when handling a battery 10
2.8 Maintenance of battery 11
2.9 How to charge a battery 12
2.10 Commitment to recycle 12
2.11 Industrial Battery (IB) 12
2.12 Types of Industrial Battery 13
2.12.1 Deep Cycle Battery 14
2.12.2 Electric Vehicle Battery 14
2.12.3 IPB Battery 15
2.12.4 Standby Stationary Battery 15
2.12.5 Traction Battery 16
2.13 Some definitions 16

CHAPTER 3 THEORETICAL CONSIDERATIONS 19

3.1 Forecasting 19
3.2 Demand Management 19
3.3 Components of Demand 20
3.4 Types of Forecasting 20
3.4.1 Qualitative 20
3.4.2 Time Series Analysis 21
3.4.3 Casual 22
3.4.4 Simulation Models 22
3.5 Regression Analysis 22
3.5.1 Least Square Method 23
3.5.2 The Least-Squares Parabola 24
3.5.3 The Least-Squares m^{th} Degree Polynomials 25
3.6 Multiple Regression 26
3.7 Coefficient of Determination (r^2) 27
3.8 Regression Identity 28

3.9 Linear Correlation 28
3.9.1 Various Degree of Correlation 29
3.9.2 Relationship between Correlation Coefficient and Coefficient of Determination 29
3.9.3 Correlation Is Not Casual 30
3.9.4 Assumptions for Regression Inferences 30
3.9.5 Inferences in Correlation 30
3.10 Tests of Hypothesis 31
3.10.1 The Null Hypothesis, H_0 31
3.10.2 The Alternative Hypothesis, H_1 32
3.10.3 Simple Hypothesis 33
3.10.4 Composite Hypothesis 33
3.10.5 Type I and Type II Errors 33
3.10.6 Significance Level, α 34
3.10.7 Critical Value(s) 35
3.10.8 Critical Region 35
3.10.9 P-Value 35
2.10.10 Power of a Test 36
3.10.11 One-sided Test 36
3.10.12 Two-Sided Test 37
3.10.13 One Sample t-test 37
3.10.14 Two Sample t-test 37

CHAPTER 4 FORECASTING & STATISTICAL ANALYSIS 39

4.1 Introduction 39
4.2 Analysis for IB-Local Type Battery 39
4.2.1 Discussion 40
4.2.2 Statistical Analysis 47
4.2.3 Seasonal Factor 49
4.3 Analysis for IB-IPS Type Battery 51
4.3.1 Discussion 52
4.3.2 Statistical Analysis 59

4.3.3 Seasonal Factor 61
4.4 Analysis for IB-Solar Type Battery 63
4.4.1 Discussion 64
4.4.2 Statistical Analysis 71
4.4.3 Seasonal Factor 73
4.5 Analysis for IB-Export Type Battery 75
4.5.1 Discussion 76
4.5.2 Statistical Analysis 83
4.5.3 Seasonal Factor 85
4.6 Analysis for IB-VRLA Type Battery 87
4.6.1 Discussion 88
4.6.2 Statistical Analysis 95
4.6.3 Seasonal Factor 97

CHAPTER 5 CONCLUSION & RECOMMENDATION 99

5.1 Conclusion 99
5.2 Recommendation 99

References 100
Appendix-A Yearly demand 101
Appendix-B t-Distribution Table 104

LIST OF TABLE

Table 4.1	Actual Demand for IB-Local Type Battery	39
Table 4.2	Seasonal Factor for IB-Local Type Battery	49
Table 4.3	Forecasted Production for IB-Local Type Battery	50
Table 4.4	Actual Demand for IB-IPS Type Battery	51
Table 4.5	Seasonal Factor for IB-IPS Type Battery	61
Table 4 6	Forecasted Production for IB-IPS Type Battery	62
Table 4.7	Actual Demand for IB-Solar Type Battery	63
Table 4.8	Seasonal Factor for IB-Solar Type Battery	73
Table 4.9	Forecasted Production for IB-Solar Type Battery	74
Table 4.10	Actual Demand for IB-Export Type Battery	75
Table 4.11	Seasonal Factor for IB-Export Type Battery	85
Table 4.12	Forecasted Production for IB-Export Type Battery	86
Table 4.13	Actual Demand for IB-VRLA Type Battery	87
Table 4.14	Seasonal Factor for IB-VRLA Type Battery	97
Table 4.15	Forecasted Production for IB-VRLA Type Battery	98

LIST OF FIGURE

Figure: 3.1	Various Degree of Correlation	29
Figure: 4.1	IB-Local, Year 2001	40
Figure: 4.2	IB-Local, Year 2002	41
Figure: 4.3	IB-Local, Year 2003	42
Figure: 4.4	IB-Local, Year 2004	43
Figure: 4.5	IB-Local, Year 2005	44
Figure: 4.6	IB-Local, Year 2006	45
Figure: 4.7	IB-Local, Production per year	46
Figure: 4.8	IB-Local, Total six years production per month	48
Figure: 4.9	IB-IPS, Year 2001	52
Figure: 4.10	IB-IPS, Year 2002	53
Figure: 4.11	IB-IPS, Year 2003	54
Figure: 4.12	IB-IPS, Year 2004	55
Figure: 4.13	IB-IPS, Year 2005	56
Figure: 4.14	IB-IPS, Year 2006	57
Figure: 4.15	IB-IPS, Production per year	58
Figure: 4.16	IB-IPS, Total six years production per month	60
Figure: 4.17	IB-Solar, Year 2001	64
Figure: 4.18	IB-Solar, Year 2002	65
Figure: 4.19	IB-Solar, Year 2003	66
Figure: 4.20	IB-Solar, Year 2004	67
Figure: 4.21	IB-Solar, Year 2005	68
Figure: 4.22	IB-Solar, Year 2006	69
Figure: 4.23	IB-Solar, Production per year	70
Figure: 4.24	IB-Solar, Total six years production per month	72
Figure: 4.25	IB-Export, Year 2001	76
Figure: 4.26	IB-Export, Year 2002	77
Figure: 4.27	IB-Export, Year 2003	78
Figure: 4.28	IB-Export, Year 2004	79
Figure: 4.29	IB-Export, Year 2005	80

Figure: 4.30 IB-Export, Year 2006 81
Figure: 4.31 IB-Export, Production per year 82
Figure: 4.32 IB-Export, Total six years production per month 84
Figure: 4.33 IB-VRLA, Year 2001 88
Figure: 4.34 IB-VRLA, Year 2002 89
Figure: 4.35 IB-VRLA, Year 2003 90
Figure: 4.36 IB-VRLA, Year 2004 91
Figure: 4.37 IB-VRLA, Year 2005 92
Figure: 4.38 IB-VRLA, Year 2006 93
Figure: 4.39 IB-VRLA, Production per year 94
Figure: 4.40 IB-VRLA, Total six years production per month 96

LIST OF ABBREVIATION

AH	Ampere Hour
CR	Critical Region
CNG	Compressed Natural Gas
EMS	Environmental Management System
ERP	Enterprise Resource Planning
IB	Industrial Battery
IPS	Instant Power Supply
ISO	International Standards Organization
MPS	Master Production Schedule
MRP	Material Requirements Planning
RBL	Rahimafrooz Batteries Limited
RR	Rejection Region
SBUS	Strategic Business Units
SSE	Error Sum of Squares
SSR	Residual Sum of Squares
SST	Total Sum of Squares
VRLA	Valve Regulated Lead Acid
UPS	Uninterrupted Power Supply

ABSTRACT

Forecasting serves as the basis of subsequent planning steps. Although Rahimafrooz Battery Company uses commercial ERP system, it does not have a good qualitative forecasting system. As such, development of a good forecasting system was targeted in this research. Forecasting & statistical analysis have been done by collecting the past six years data of different types of batteries. Five types of industrial batteries such as, IB-Local, IB-IPS, IB-Solar, IB-Export, IB-VRLA are considered for different types of analysis. Moving Average and Least Square Method are applied for forecasting different types of batteries. Different types of trends are carefully examined by correlation test and Hypothesis test is done for statistical analysis. Examining the past six years of data Seasonal Factor is introduced. By using Seasonal Factor and dividing each year into four different quarters, accurate forecasting has been done. According to the different analysis, it is seen that there is a sharp increasing trend of demand of the IB-IPS and IB-Solar type of batteries. On the other hand, there is a decreasing trend of demand of IB-Local, IB-Export, IB-VRLA type of batteries.

CHAPTER 1

INTRODUCTION

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1.1 INTRODUCTION

The battery is an electrochemical device. It uses chemicals to produce electricity. It stores electric energy and dissipate when required. There are different kinds of batteries, such as-Automotive battery, Motorcycle battery, Appliance battery, Deep cycle - Flat plate battery, Industrial tubular battery, VRLA battery, UPS, Solar system battery. Industrial batteries are used for industrial purposes such as Security and monitoring systems, Instrument & medical Equipment, CNC machines and Power plants application etc. Besides, in Bangladesh, recently the demands of industrial batteries are sharply increasing due to demand of Solar PV systems, Power backup system, Railway signaling and telecommunication etc.

There are few companies manufacturing batteries in Bangladesh. Rahimafrooz Batteries Limited (RBL) is the largest lead-acid battery manufacturer in Bangladesh and offers an extensive range of automotive & specialized industrial battery. Besides, it manufactures over 300 different types of automotive and industrial batteries. Its plant is ISO 9001 & ISO 14001 certified. Moreover, it is one of the key players in South Asia in its field. Aftab Automobiles Ltd. introduced a Battery Manufacturing unit, concern of Navana Group in January 2002, and manufacturing different type of automotive batteries.

For the highest quality, the demand of Bangladeshi batteries is increasing day by day in the South Asian region. But the companies always suffer from inappropriate production plan, which is largely attributed to wrong forecast and absence of relevant statistical analysis [1-4].

Estimation of market demand is a perquisite to an initial production plan, which needs fine tuning for detailed Master Production Plan (MPS). For a company producing more than hundred products, forecasting is not an easy task. In case of

error, all subsequent planning functions become invalid. As such, high level of accuracy is essential for developing a forecast. This requires careful data collection, analysis, and application of a suitable forecasting method such that this becomes a valid input to subsequent plans. This again requires adjustment in terms many things, one being rejection amount. This project aims at developing a production plan through demand estimation, by applying a forecasting method, and then adjusting it through design of experiment. Design of Experiment requires a few experimental productions at the laboratory level. This will be done in the Rahimafrooz battery's shop floor area [5, 6, 7]. To achieve a nice production plan, all kinds of demand and supply should be analyzed statistically, check their validity and also select a valid mechanism to achieve the ultimate goal [8, 9]. The study will then apply statistical analysis for verifying validity of the forecast values.

1.2 OBJECTIVES

Specific objectives are:

1. Analysis of current market status
2. Forecasting of future market demand
3. Validity of results through statistical analysis

1.3 METHODOLOGY

1. Collection of data on past sales.
2. Analysis of the trend.
3. Forecast future demand using Least Square method
4. Validity analysis using suitable statistical distribution
5. Suggestion for a suitable forecasting model.

1.4 LIMITATION

Since the production volume and sales volume are equal, production volume has been considered as equivalent to sales volume, taking into consideration limitation of available capacity.

CHAPTER 2
COMPANY PROFILE & PRODUCTS

2.1 INTRODUCTION

Rahimafrooz is one of the respected and reputed business houses in Bangladesh. It has just crossed 50 years of operation. Rahimafrooz has endured turbulences of the last 50 years and has been able to transform itself from a small trading company into a leading diversified business house. This is, indeed, a milestone, which Rahimafrooz has achieved with trust, support and dedication of all stakeholders, past and present, most importantly, its customers.

Today, Rahimafrooz has emerged as a respected national company by upholding high ideals and values, solemn integrity & honesty, excellence, service and innovation in all spheres of the company's activities building on the already established foundation.

2.2 STRATEGIC BUSINESS UNITS (SBUS)

Rahimafrooz (Bangladesh) Limited (RAHL) is the group holding and parent company including the group corporate centre that guides the strategic Business Units (SBUs). It insures continuous management innovative, technology adoption, new initiatives, corporate governance and compliance.
Currently it oversees and nurtures around 1500 employees who contribute to its dynamic growth.

SBUs of Rahimafrooz are as follows:

1. Rahimafrooz Batteries Limited (RBL)
2. Rahimafrooz Renewable Energy Limited (RREL)
3. Rahimafrooz Distribution Limited (RDL)
4. Rahimafrooz Superstores Limited (RSL)

5. Rahimafrooz CNG Limited (RACNG)
6. Rahimafrooz Energy Services Limited (RESL)
7. Excel Resources Limited (ERL)

2.2.1 Rahimafrooz Batteries Limited

Rahimafrooz Batteries Limited (RBL) is the largest Lead acid battery manufacturer in Bangladesh. RBL manufactures over 300 different types of automotive and customized industrial batteries. The company is both ISO 9000 and ISO 1400 certified and excellent export growth record has put RBL in a leading position as a regional player in South Asia.

2.2.2 Rahimafrooz Renewable Energy Limited

Rahimafrooz Renewable Energy Limiter (RREL) mainly provides solar power solutions for homes, agriculture, health services, schools and village market places. Solar Home System (SHS) have brightened the lives more than 25000 rural households. Rahimafrooz Solar works closely with NGOs, government bodies and international agencies to deliver renewable energy solutions to rural people.

2.2.3 Rahimafrooz Distribution Limited

Maintains nationwide distribution network with more than 400 outlets covering entire Bangladesh; distributes mainly automotive and appliance battery, tyre, IPS, UPS and lubricants.

2.2.4 Rahimafrooz Superstores Limited

Emerges as leading chain superstore in Bangladesh, mainly covering Dhaka Metropolitan City area; carries more than 25,000 varieties of product.

2.2.5 Rahimafrooz CNG Limited

Involves in setting up CNG stations; facilitates establishing CNG conversion centers; converts automobiles into CNG and provides technical solution and support.

2.2.6 Rahimafrooz Energy Services Limited

Provides uninterrupted and clean power and a fast growing power services company; establishes with objective to meet country's growing demand for power

2.2.7 Excel Retread Limited

Retreads all types of tyres from cars to buses/trucks; one of the leading tyre retread centers

2.2.8 Joint Venture

Metronet Bangladesh Limited:

The first fiber optic network-Metropolitan Area Network (MAN) in Bangladesh: provides internet and data transmission backbone facilities and services. It is a joint venture with Flora Telecom.

2.2.9 Academic Affiliation

Independent University, Bangladesh (IUB):

Sponsor of one of the leading private universities in Bangladesh

2.3 RAHIMAFROOZ BATTERIES LIMITED (RBL)

Rahimafrooz Batteries Limited (RBL) is the largest lead-acid battery manufacturer in Bangladesh and offers an extensive range of automotive & specialized industrial battery. It manufactures over 300 different types of automotive and industrial batteries. Its plant is ISO 9001 & ISO 14001 certified. It is one of the key players in South Asia in its field.

RBL has also extended its product line to secure power solution with UPS, Rectifier and VRLA Batteries with collaboration of Enersys-USA, Eltek-Norway, AEES-France

RBL has a successful story of installing solar power in the remote rural areas of Bangladesh. It has successfully installed more than 10,000 home solar systems in the remote rural areas of Bangladesh

2.3.1 Vision 2010

Be an enterprising group of Taka 2000 Cr. By the year 2010 with a diversified business portfolio focused on dynamic growth, excellence, innovation, customer delight in enriching the world.

2.3.2 Quality Policy

Employees of Rahimafrooz as a team are totally committed to customer delight through intelligent effort and continuous improvement.

2.3.3 Environment Policy

RBL is committed for continual improvement and prevention of pollution to protect the environment, complying with applicable legal and other requirements to which its organization subscribes.

2.3.4 Environmental Management (EMS)

RBL is maintaining Environmental Management System in its Savar Factory, which complies with the requirements of ISO 14001:2004. The company is also certified with ISO 9001:2000. RBL is committed to protect the environment and recognize that environmental performance excellence is consistent with the Group Aspirations and social commitment.

2.3.5 ISO Certification

Rahimafrooz Batteries Limited is maintaining ISO 9001:2000 standards for it's Quality Management System. The company was certified for ISO 9002:1994 in 1997 and subsequently awarded ISO 9001:2000 in 2002

2.3.6 Plant Capacity & Products

Rahimafrooz has state of the art manufacturing plant. It is equipped with all latest technologies with complete air treatment and lead-recycling management. RBL produces different types of batteries to meet the local and international market.

Its capacity in Automotive Battery is 660,000 (N50) units per annum and 15 million AH of Industrial Battery per annum. All the products are manufactured under strict quality control and ensured by international certifications. Its main product range includes:

1. Automotive battery
2. Motorcycle battery
3. Appliance battery
4. Deep cycle – Flat plate battery
5. Industrial tubular battery
6. VRLA battery
7. UPS
8. Solar system

It has different technical collaboration agreements with Lucas Battery Company, U.K, Technical support Group (TSG), Hawker Batteries, UK, Invensys, UK, Hawker Batteries, UK, Eltek – Norway, AEES – France to ensure the quality of battery.

2.3.7 Product Range

Din Standard (German Standard)

Product Range: 2V 100AH-2750AH @ 10HR

BS (British Standard)

Product Range: 2V 100AH-1115AH @ 10HR

JIS (Japanese Standard)

Product Range: 2V 31AH-110AH @ 10HR

2.4 TYPES OF BATTERY

2.4.1 Primary cells or batteries

In this type of batteries the chemical processes that occur during discharging cannot be reversed by applying an external electrical current. These types of batteries are not rechargeable.

Example: Dry cells, alkaline cells.

2.4.2 Secondary cells or batteries

These types of batteries are also called rechargeable batteries, storage batteries, or accumulators. The chemical processes of discharging can be reversed by applying an external electrical current.

Example: Lead-acid, nickel-cadmium, nickel-hydride etc.

According to construction material there are two types of battery:

- Lead-acid Battery
- Nickel-Cadmium Battery

Because of the high cost of Nickel Cadmium Battery, Lead-Acid battery is normally used in solar PV system. According to the formation Lead Acid battery is again classified as:

- Sealed Battery
- Flooded Battery

Sealed battery is costly compared to the other batteries and it gives good result at low temperature (below 20°C). So, considering the above disadvantages the flooded lead acid battery is normally used in solar system.

Depending on the application Flooded Lead acid battery is classified as:

- Automotive battery
- Industrial Battery

2.4.3 Automotive Battery

Automotive batteries are generally used in the automobiles where huge amount of cranking current is required for a few seconds for starting purpose. The thin lead plates in this type of battery are so made that it can deliver large amount of current during startup. When the car gets started, the battery is connected to the charger for restoring the lost power.

2.4.4 Industrial Battery

Industrial batteries are used where small amount of current is required to flow for a long period. For this reason, unlike the automotive batteries, thick or tubular plates are used in the industrial batteries.

2.5 BASIS ON AUTOMOTIVE BATTERY

A Battery is an electrochemical device that can store energy as chemical energy and convert it into electrical energy when needed.

An electrochemical storage cell consists of a liquid which contains dissolved ions (an electrolyte) and two electrodes containing different active materials. When the cell is connected to an electrical load (or circuit), the active materials at both electrodes interact with the electrolyte and undergo a chemical change. At the positive electrode, the active material undergoes chemical reduction, absorbing negatively charged electrons from the external circuit. At the negative electrode, the active material undergoes chemical oxidation, releasing electrons into the external circuit. Between the two electrodes, electrical charge is transported through the cells by ions (H+, OH-) to complete the electrical circuit. The process

of the cell releasing its stored chemical energy into useful electrical energy is called discharging.

A voltage exists between two electrodes which reflect the difference in chemical potential energy of the two active materials. The nominal open-circuit cell voltages are 2V for lead-acid, 1.5V for Zn-carbon cell etc. In order to achieve higher voltages, cells are connected together in series to give a battery. This connection may be made by assembling cells together in one battery package, or it might be made by external interconnections between individual cells. In either case, the assembly of cells is called a battery.

2.6 HOW AN AUTOMOTIVE BATTERY WORKS

When you place the key in your car's ignition and turn the ignition switch to "ON", a signal is sent to the car's battery. Upon receiving this signal, the car battery takes energy that it has been storing in chemical form and releases it as electricity. This electrical power is used to crank the engine. The battery also releases energy to power the car's light and other accessories

2.7 SAFETY PRECAUTIONS WHEN HANDLING A BATTERY

Whenever you are handling or working with a lead-acid battery, consult your vehicle and battery owner's manual for instruction and safety precautions. Lead-acid battery contains hydrogen-oxygen gases that can be explosive and sulfuric acid that can cause severe burn. To help avoid such risk and injury, observe these precautions when handling or working with a lead-acid battery.

1. Wear safety glasses or goggles and a face shield.
2. Wear proper clothing to protect your face, hands and body.
3. Make sure work area is well ventilated.
4. Never lean on battery while boosting, testing or charging.
5. Cigarettes, flames or sparks could cause a battery to explode.
6. Keep all the ignition sources away from the battery.

7. Always shield eyes and face from the battery.
8. Do not charge or use booster cables or adjust post connections without proper instructions and training.
9. Keep vent caps/plugs tight and level.
10. In the event of accident, flush with water and call a physician immediately.
11. Keep out of reach of children.

2.8 MAINTENANCE OF BATTERY

Regular maintenance of your battery will ensure long life. You can consult your vehicles battery maintenance instructions or Rahimafrooz battery guarantee card for ready maintenance tips. These are simple and easy to follow.

1. Test your on a regular basis. Battery should be also tested before you drive for any long trips or before/after car has been serviced.
2. Maintain your vehicle as directed in your owner's manual and/or by your mechanic. This will reduce the chance of other engine components draining power from your battery. It's not always a battery's fault when your car does not start, but often a symptom of other problems.
3. Regularly clean the battery container and terminals.
4. Make sure vent caps/plugs are tight to prevent water or baking soda from entering cells.
5. Apply baking soda to any corrosion and rinse cover with water.
6. Check your battery's electrolyte level before charging. It should always be within the upper and lower limit mark.
7. If electrolyte level is low, add distilled water to bring the electrolyte level close to the upper level mark.
8. If distilled water is not available, add pure drinking water. It is better than adding nothing. Otherwise, the battery plate will dry out and battery could loose its capacity.

2.9 HOW TO CHARGE A BATTERY

Often we charge battery by a wrong charger in a wrong way, this actually sometimes over charge or under charge a battery. Both the instances reduce the life of your car battery. Preferably before charging a battery refers to your car manual and your battery charger manual for instruction.

1. Use a calibrated battery charger appropriate for your battery capacity & size.
2. Set the battery charger at 10% of the battery's total amp hour capacity.
3. In case of multiple batteries charging at a time, charge same type of battery having same amp hour capacity at the same time.
4. Do not over charge or under charge a battery. An automatic battery charger with a timer that turns off after charging is the best fit.

2.10 COMMITMENT TO RECYCLE

Battery acid is recycled by neutralizing it into water or converting it into sodium sulfate for laundry detergent, glass and textile manufacturing. Plastic is recycled by cleaning the battery case, melting the plastic and reforming it into uniform pallets. Lead, which makes up over 50% of every battery, is melted, poured into slabs and purified.

2.11 INDUSTRIAL BATTERY (IB)

Rahimafrooz manufactures specialized Industrial Batteries. The plant is equipped with modern production machineries and testing facilities including those for tubular plates. It conforms to international standard ISO 9001 & ISO 14001 and to JIS, DIN, BS and IEC specification. It produces a wide range of lead-acid industrial batteries with capacities from 20AH to 2500AH. The batteries are used for applications in telecommunication, power station, railway system, electric vehicle, forklift, ship, buoy lighting and solar power system

Applications:

Volta range of industrial cells delivers high power at all rates of discharge and work well in tough and difficult conditions. Principal applications of these ells are:

a. Telecommunication
b. Power and Sub-station backup operation
c. Uninterrupted power supply systems
d. Railway signaling and telecommunication
e. Emergency lighting
f. Security and monitoring systems
g. Solar power systems
h. Marine and Navigational aids

Special Features:

a. Long Life
b. Minimum maintenance
c. Low internal resistance
d. High rate of discharge performance
e. High resistance to adverse mechanical and electrical condition
f. Low self discharge
g. Absolute reliability
h. Simplicity of operation
i. Tolerance to extremes of temperature

2.12 TYPES OF INDUSTRIAL BATTERY

1. Deep Cycle
2. Electric Vehicle Battery
3. IPB Battery
4. Standby Stationary
5. Traction

2.12.1 Deep Cycle Battery

Special Features:

a. Excellent cycling ability provides high reliability and exceptionally long life.
b. Large electrolyte reservoir means high tolerance to water loss and minimal maintenance.
c. High charging efficiency.
d. Low self discharge, dry pre-charged plates
e. Robust, clear case and rugged construction ensures mechanical durability

Applications:

a. Uninterrupted power supply systems
b. Instrument & medical Equipment
c. Railway signaling and telecommunication
d. Security and monitoring systems
e. Solar PV systems

2.12.2 Electric Vehicle Battery

Special Features:

a. Excellent cycling ability provides high reliability and exceptionally long life.
b. Large electrolyte reservoir means high tolerance to water loss and minimal maintenance.
c. High charging efficiency.
d. Low self discharge, dry pre-charged plates
e. Robust, clear case and rugged construction ensures mechanical durability

The quality, dependability, reliability and long service life of thicker Flat Plate deep cycle batteries are the result of balanced design of the plates, separators and incorporation of latest technical developments in lead acid battery technology.

Applications:

a. Electric Vehicle
b. Golf Cart
c. Instrument & Medical Equipment

2.12.3 IPB Battery

Special Features:

a. Excellent cycling ability provides high reliability and exceptionally long life
b. Large electrolyte reservoir means high tolerance to water loss and minimal maintenance.
c. High charging efficiency.
d. Low self discharge, dry pre-charged plates
e. Robust, clear case and rugged construction ensures mechanical durability

Applications:

a. Instant Power System/Inverter
b. PABX System
c. Various appliances (TV, Mike, Cassette players etc)
d. Medical Equipment

2.12.4 Standby Stationary Battery

Special Features:

a. Excellent cycling ability provides high reliability and exceptionally long life.
b. Large electrolyte reservoir means high tolerance to water loss and minimal maintenance.
c. High charging efficiency.
d. Low self discharge, dry pre-charged plates
e. Robust, clear case and rugged construction ensures mechanical durability

Applications:

a. Telecommunication
b. Power and sub-stations back up operation
c. Uninterrupted power supply systems
d. Instrument & medical equipment
e. Railway signaling and telecommunication
f. Security and monitoring systems
g. Solar PV systems

2.12.5 Traction Battery

Special Features:

a. Long life
b. Low maintenance
c. Low internal resistance
d. High discharge rate
e. High resistance adverse
f. Mechanical and electrical condition
g. Low self discharge
h. Absolute reliability
i. Simplicity of operation
j. Tolerance to extreme of temperature

2.13 SOME DEFINITIONS

Active Material:

Chemically active compounds in a cell or battery that convert from one composition to another while producing current (electrical energy) or accepting current from an external circuit.

Battery Polarity:

A battery has two poles or posts. The positive battery post is usually marked POS, P, or + and is larger than the negative post which is usually marked NEG, N, or -. The polarity of the charger and battery must match to avoid damage to the battery and charger.

Container:

The polypropylene or hard rubber case that holds plates, electrolyte and separators.

Cells:

It is the basic electrochemical current producing unit in a battery consisting of a set of positive plates, negative plates, electrolyte, separator and casing. There are six cells in a 12-volt lead-acid battery.

Electrolyte:

It is a solution of sulfuric acid and water that conducts current through the movement of ions (charged particles in the electrolyte solution) between positive and negative plates. It supplies sulfate ions for reaction with the active material of both positive and negative plates.

Plates:

Flat, typically rectangular components that contain the active material and a mechanical support structure called a grid, which also has an electrical function, carrying electrons to and from active material. Plates are either positive or negative, depending on the active material that it holds.

Separator:

PVC/PE separators are used for electrical separation between the plates. They have high acid resistance, low internal electrical resistance, free from organic elements and maintain the required property throughout the life of the battery.

Sealing:

The joint between the container & cover is done by heat sealing method.

Vent Plug:

The float type vent plug employs easy monitoring of electrolyte level. The cap of the vent plug is made of transparent synthetic resin & can be opened or closed with one touch.

Terminal Post:

The terminal post is cast of lead antimonies alloy and has a construction that amply withstands against severe load condition.

Electrolyte:

The electrolyte shall be of the battery grade of dilute sulphuric acid and will be free from arsenic, iron, platinum and other impurities which will impair the life of the battery. The specific gravity shall be 1.280 when fully charged at 25°C.

CHAPTER 3
THEORETICAL CONSIDERATIONS

3.1 FORECASTING

Forecasting is the estimation of the value of a variable (or set of variables) at some future point in time. A forecasting exercise is usually carried out in order to provide an aid to decision-making and in planning the future. Typically all such exercises work on the premise that if we can predict what the future will be like we can modify our behavior now to be in a better position, than we otherwise would have been, when the future arrives. Applications for forecasting include:

- Inventory control/production planning - forecasting the demand for a product enables us to control the stock of raw materials and finished goods, plan the production schedule. etc
- Investment policy - forecasting financial information such as interest rates, exchange rates, share prices, the price of gold, etc This is an area in which no one has yet developed a reliable (consistently accurate) forecasting technique (or at least if they have they haven't told anybody!)
- Economic policy - forecasting economic information such as the growth in the economy, unemployment, the inflation rate, etc is vital both to government and business in planning for the future.

3.2 DEMAND MANAGEMENT

The purpose of demand management is to coordinate and control all of the sources of demand so the productive system can be used efficiently and the product delivered on time. There are two basic source of demand:

a) Dependent Demand - is the demand for a product or service caused by the demand for other products or services.
b) Independent Demand – is the demand that cannot be derived from other products or services.

3.3 COMPONENTS OF DEMAND

In most cases, demand for products or services can be broken down into six components:

i) Average demand for the period

ii) A trend

iii) Seasonal element

iv) Cyclical elements

v) Random variation, and

vi) Autocorrelation

3.4 TYPES OF FORECASTING

Forecasting can be classified into four basic types:

I. Qualitative

II. Time Series

III. Casual Method

IV. Simulation Models

3.4.1 Qualitative

These types of forecasting methods are based on judgments or opinions, and are subjective in nature. They do not rely on any mathematical computations.

a) Gross Roots: Derives a forecast by compiling input from those at the end of the hierarchy who deal with what is being forecast. For example, an overall sales forecast may be derived by combining inputs from each salesperson, who is closest to his or her own territory.

b) Market Research: Sets out to collect data in a variety of ways (surveys, interviews, etc.) to test hypotheses about the market. This is typically used to forecast long-range and new-product sales.

c) Panel Consensus: Free open exchange at meetings. The idea is that discussion by the group will produce better forecasts than any one individual. Participants may be executives, salespeople, or customers.

d) Historical Analysis: Ties what is being forecast to a similar item. Important in planning new products where a forecast may be derived by using the history of a similar product.

e) Delphi Method: Group of experts responds to questionnaire. A moderator compiles results and formulates a new questionnaire which is submitted to the group. Thus, there is a learning process for the group as it receives new information and there is no influence of group pressure or dominating individual.

3.4.2 Time Series Analysis

Based on the idea that the history of occurrences over time can be used to predict the future

a) Simple Moving Average: A time period containing a number of data points is averaged by dividing the sum of the point values by the number of points. Each, therefore, has equal influence.

b) Weighted Moving Average: Specific points may be weighted more or less than the others, as seen fit by experience.

c) Exponential Smoothing: Recent data points are weighted more with weighting declining exponentially as data become older.

d) Regression Analysis: Fits a straight line to past data generally relating the data value to time. Most common fitting technique is least squares.

e) Box Jenkins Technique: Very complicated but apparently the most accurate statistical technique available. Relates a class of statistical models to data and fits the model to the time series by using Bayesian posterior distributions.

f) Shiskin Time Series: (Also called X-11) Developed by Julius Shiskin of the Census Bureau. An effective method to decompose a time series into seasonal, trends, and irregular. It needs at least three years of history. Very good in identifying turning points, for example, in company sales.

g) Trend Projections: Fits a mathematical trend line to the data points and projects it into the future.

3.4.3 Casual

Tries to understand the system underlying and surrounding the items are being forecast. For example, sales may be affected by advertising, quality, and competitors.

a) Regression Analysis: Similar to least squares method in time series but may contain multiple variables. Basis is that forecast is caused by the occurrence of other events.
b) Economical Models: Attempts to describe some sector of the economy by a series of interdependent equations.
c) Input / Output Models: Focuses on sales of each industry to other firms and governments. Indicates the changes in sales that a producer industry might expect because of purchasing changes by another industry.
d) Leading Indicators: Statistics that move in the same direction as the series being forecast but move before the series, such as an increase in the price of gasoline indicating a future drop in the sale of large cars.

3.4.4 Simulation Models

Dynamic models, usually computer-based, that allow the forecaster to make assumptions about the internal variables and external environment in the model. Depending on the variables in the model, the forecaster may ask such questions as: What would happen to my forecast if price increased by 10 percent. What effect would a mild national recession have on the calculated forecast?

3.5 REGRESSION ANALYSIS

Regression analysis is a statistical technique for quantifying the relationship between variables. In simple regression analysis, there is one dependent variable (e.g. sales) to be forecast and one independent variable. The values of the independent variable are typically those assumed to "cause" or determine the values of the dependent variable. Thus, if we assume that the amount of advertising dollars spent on a product determines the amount of its sales, we could

use regression analysis to quantify the precise nature of the relationship between advertising and sales. For forecasting purposes, knowing the quantified relationship between the variables allows us to provide forecasting estimates.

3.5.1 Least Square Method

Estimated or fitted regression line is represented

$$\hat{y} = a + bx$$

Each pair of observations satisfies the relation

$$y = a + bx_i + e_i$$

Where, $e_i = y_i - \hat{y}$, which is called a residual and describes the error in the fit of the model at i[th] data point.

Values of a and b should find, so that the sum of the squares of the residuals is a minimum.

Residual sum of squares = sum of squares of the errors about the regression line (denoted by SSE)

Minimization procedure for estimating parameters is called the method of least squares.

The least-squares line uses a straight line

$$y = a + bx$$

to approximate the given set of data, (x_1, y_1), (x_2, y_2), ..., (x_n, y_n), where, $n \geq 2$. The best fitting curve $f(x)$ has the least square error, i.e.,

$$SSE = \Pi = \sum_{i=1}^{n} [y_i - f(x_i)]^2 = \sum_{i=1}^{n} [y_i - (a + bx_i)]^2 = \min$$

Please note that a and b are unknown coefficients while all x_i and y_i are given. To obtain the least square error, the unknown coefficients a and b must yield zero first derivatives.

$$\frac{\partial \Pi}{\partial a} = 2\sum_{i=1}^{n} [y_i - (a + bx_i)] = 0$$

$$\frac{\partial \Pi}{\partial b} = 2\sum_{i=1}^{n} x_i [y_i - (a + bx_i)] = 0$$

Expanding the above equations, we have:

$$\sum_{i=1}^{n} y_i = a\sum_{i=1}^{n} 1 + b\sum_{i=1}^{n} x_i$$

$$\sum_{i=1}^{n} x_i y_i = a\sum_{i=1}^{n} x_i + b\sum_{i=1}^{n} x_i^2$$

The unknown coefficients a and b can therefore be obtained:

$$a = \frac{(\sum y)(\sum x^2) - (\sum x)(\sum xy)}{n\sum x^2 - (\sum x)^2}$$

$$b = \frac{n\sum xy - (\sum x)(\sum y)}{n\sum x^2 - (\sum x)^2}$$

Where, $\sum$..... stands for $\sum_{i=1}^{n}$...i .

3.5.2 The Least-Squares Parabola

The least-squares parabola uses a second degree curve,

$$y = a + bx + cx^2$$

to approximate the given set of data, (x_1, y_1), (x_2, y_2), ..., (x_n, y_n) where $n \geq 3$. The best fitting curve $f(x)$ has the least square error, i.e.,

$$SSE = \prod = \sum_{i=1}^{n} [y_i - f(x_i)]^2 = \sum_{i=1}^{n} [y_i - (a + bx_i + cx_i^2)]^2 = \min$$

Where a, b, and c are unknown coefficients while all x_i and y_i are given. To obtain the least square error, the unknown coefficients a, b, and a must yield zero first derivatives.

$$\frac{\partial \prod}{\partial a} = 2\sum_{i=1}^{n} [y_i - (a + bx_i + cx_i^2)] = 0$$

$$\frac{\partial \prod}{\partial b} = 2\sum_{i=1}^{n} x_i [y_i - (a + bx_i + cx_i^2)] = 0$$

$$\frac{\partial \prod}{\partial c} = 2\sum_{i=1}^{n} x_i^2 [y_i - (a + bx_i + cx_i^2)] = 0$$

Expanding the above equations, we have

$$\sum_{i=1}^{n} y_i = a\sum_{i=1}^{n} 1 + b\sum_{i=1}^{n} x_i + c\sum_{i=1}^{n} x_i^2$$

$$\sum_{i=1}^{n} x_i y_i = a\sum_{i=1}^{n} x_i + b\sum_{i=1}^{n} x_i^2 + c\sum_{i=1}^{n} x_i^3$$

$$\sum_{i=1}^{n} x_i^2 y_i = a\sum_{i=1}^{n} x_i^2 + b\sum_{i=1}^{n} x_i^3 + c\sum_{i=1}^{n} x_i^4$$

The unknown coefficients a, b, and c can hence be obtained by solving the above linear equations.

3.5.3 The Least-Squares mth Degree Polynomials

When using an mth degree polynomial

$$y = a_0 + a_1 x + a_2 x^2 + \ldots\ldots\ldots + a_m x^m$$

to approximate the given set of data, (x_1, y_1), (x_2, y_2), ..., (x_n, y_n), where $n \geq m+1$, the best fitting curve $f(x)$ has the least square error, i.e.,

$$\Pi = \sum_{i=1}^{n} [y_i - f(x_i)]^2 = \sum_{i=1}^{n} [y_i - (a_0 + a_1 x_i + a_2 x_i^2 + \ldots\ldots + a_m x_i^m)]^2$$

Where a_0, a_1, a_2, ..., and a_m are unknown coefficients while all x_i and y_i are given. To obtain the least square error, the unknown coefficients a_0, a_1, a_2, ..., and a_m must yield zero first derivatives.

$$\frac{\partial \Pi}{\partial a_0} = 2\sum_{i=1}^{n} [y_i - (a_0 + a_1 x_i + a_2 x_i^2 + \ldots\ldots\ldots + a_m x_i^m)] = 0$$

$$\frac{\partial \Pi}{\partial a_1} = 2\sum_{i=1}^{n} x_i [y_i - (a_0 + a_1 x_i + a_2 x_i^2 + \ldots\ldots\ldots + a_m x_i^m)] = 0$$

$$\frac{\partial \Pi}{\partial a_2} = 2\sum_{i=1}^{n} x_i^2 [y_i - (a_0 + a_1 x_i + a_2 x_i^2 + \ldots\ldots\ldots + a_m x_i^m)] = 0$$

$$\vdots$$

$$\vdots$$

$$\frac{\partial \Pi}{\partial a_m} = 2\sum_{i=1}^{n} x_i^m [y_i - (a_0 + a_1 x_i + a_2 x_i^2 + \ldots\ldots\ldots + a_m x_i^m)] = 0$$

Expanding the above equations, we have

$$\sum_{i=1}^{n} y_i = a_0 \sum_{i=1}^{n} 1 + a_1 \sum_{i=1}^{n} x_i + a_2 \sum_{i=1}^{n} x_i^2 + \ldots + a_m \sum_{i=1}^{n} x_i^m$$

$$\sum_{i=1}^{n} x_i y_i = a_0 \sum_{i=1}^{n} x_i + a_1 \sum_{i=1}^{n} x_i^2 + a_2 \sum_{i=1}^{n} x_i^3 + \ldots + a_m \sum_{i=1}^{n} x_i^{m+1}$$

$$\sum_{i=1}^{n} x_i^2 y_i = a_0 \sum_{i=1}^{n} x_i^2 + a_1 \sum_{i=1}^{n} x_i^3 + a_2 \sum_{i=1}^{n} x_i^4 + \ldots + a_m \sum_{i=1}^{n} x_i^{m+2}$$

$$\vdots$$

$$\vdots$$

$$\sum_{i=1}^{n} x_i^m y_i = a_0 \sum_{i=1}^{n} x_i^m + a_1 \sum_{i=1}^{n} x_i^{m+1} + a_2 \sum_{i=1}^{n} x_i^{m+2} + \ldots + a_m \sum_{i=1}^{n} x_i^{2m}$$

The unknown coefficients a_0, a_1, a_2, .., and a_m can hence be obtained by solving the above linear equations.

3.6 MULTIPLE REGRESSION

Multiple regression estimates the outcomes (dependent variables) which may be affected by more than one control parameter (independent variables) or there may be more than one control parameter being changed at the same time.

An example is the two independent variables x and y and one dependent variable z in the linear relationship case:

$$z = a + bx + cy$$

For a given data set (x_1, y_1, z_1), (x_2, y_2, z_2), ..., (x_n, y_n, z_n), where $n \geq 3$, the best fitting curve $f(x)$ has the least square error, i.e.,

$$\Pi = \sum_{i=1}^{n} [z_i - f(x_i, y_i)]^2 = \sum_{i=1}^{n} [z_i - (a + bx_i + cy_i)]^2 = \min$$

Where a, b, and c are unknown coefficients while all x_i, y_i, and z_i are given. To obtain the least square error, the unknown coefficients a, b, and c must yield zero first derivatives.

$$\frac{\partial \Pi}{\partial a} = 2\sum_{i=1}^{n} [z_i - (a + bx_i + cy_i)] = 0$$

$$\frac{\partial \Pi}{\partial b} = 2\sum_{i=1}^{n} x_i [z_i - (a + bx_i + cy_i)] = 0$$

$$\frac{\partial \Pi}{\partial c} = 2\sum_{i=1}^{n} x_i^2 [z_i - (a + bx_i + cy_i)] = 0$$

Expanding the above equations, we have

$$\sum_{i=1}^{n} z_i = a\sum_{i=1}^{n} 1 + b\sum_{i=1}^{n} x_i + c\sum_{i=1}^{n} y_i$$

$$\sum_{i=1}^{n} x_i z_i = a\sum_{i=1}^{n} x_i + b\sum_{i=1}^{n} x_i^2 + c\sum_{i=1}^{n} x_i y_i$$

$$\sum_{i=1}^{n} y_i z_i = a\sum_{i=1}^{n} y_i + b\sum_{i=1}^{n} x_i y_i + c\sum_{i=1}^{n} y_i^2$$

The unknown coefficients a、b, and c can hence be obtained by solving the above linear equations.

3.7 COEFFICIENT OF DETERMINATION (r^2)

The coefficient of determination, r^2 is defined by,

$$r^2 = 1 - \frac{\text{SSE}}{\text{SST}} = \frac{\text{SSR}}{\text{SST}}$$

and equals the percentage reduction obtained in the total squared error by using the regression equation instead of the sample mean, $\bar{y}$ to predict the observed y-values. It also equals to the percentage of the total variation in the observed y-values that is explained by the regression.

r^2 is always lies between 0 and 1 and is a descriptive measure of the utility of the regression equation for making predictions.

r^2 near 0 → regression equation not very useful

r^2 near 1 → regression equation extremely useful.

SST = Total sum of squares

$$= \sum\left(y - \bar{y}\right)^2 = S_{yy} = \frac{\sum y^2 - \left(\sum y\right)^2}{n}$$

SSE = Error Sum of Squares

$$= \sum\left(y - \hat{y}\right)^2 = S_{yy} - S_{xy}^2 / S_{xx}$$

SSR = Regression Sum of Squares

$$= \sum\left(\hat{y} - \bar{y}\right)^2 = \frac{S_{xy}^2}{S_{xx}}$$

It represents the amount of variation in the observed y-values that is explained by the regression.

3.8 REGRESSION IDENTITY

The total sum of squares equals the regression sum of squares plus the error sum of squares,

$$SST = SSR + SSE$$

3.9 LINEAR CORRELATION

We often hear statements pertaining to the correlation or lack of correlation between two variables:

"There is a positive correlation between advertising expenditure and sales"

"IQ and alcohol consumption are uncorrelated"

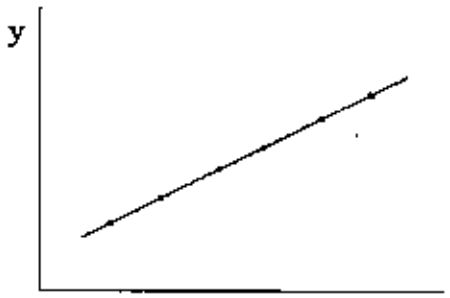
The meaning of such statements, several statistics can be employed to measure the correlation between two variables.

Most commonly used are, linear variable correlation coefficient, r (also called Pearson product moment correlation coefficient).

Linear variable correlation coefficient, r of n data points can be computed by,

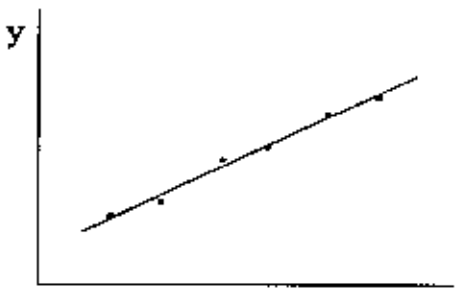
$$r = \frac{S_{xy}}{\sqrt{S_{xx}S_{yy}}} = \frac{\sum xy - \left(\sum x\right)\left(\sum y\right)/n}{\sqrt{\left\{\sum x^2 - \left(\sum x\right)^2/n\right\}\left\{\sum y^2 - \left(\sum y\right)^2/n\right\}}}$$

3.9.1 Various Degree of Correlation



Prefect +ve Correlation

(a)



Strong Positive Correlation

(b)

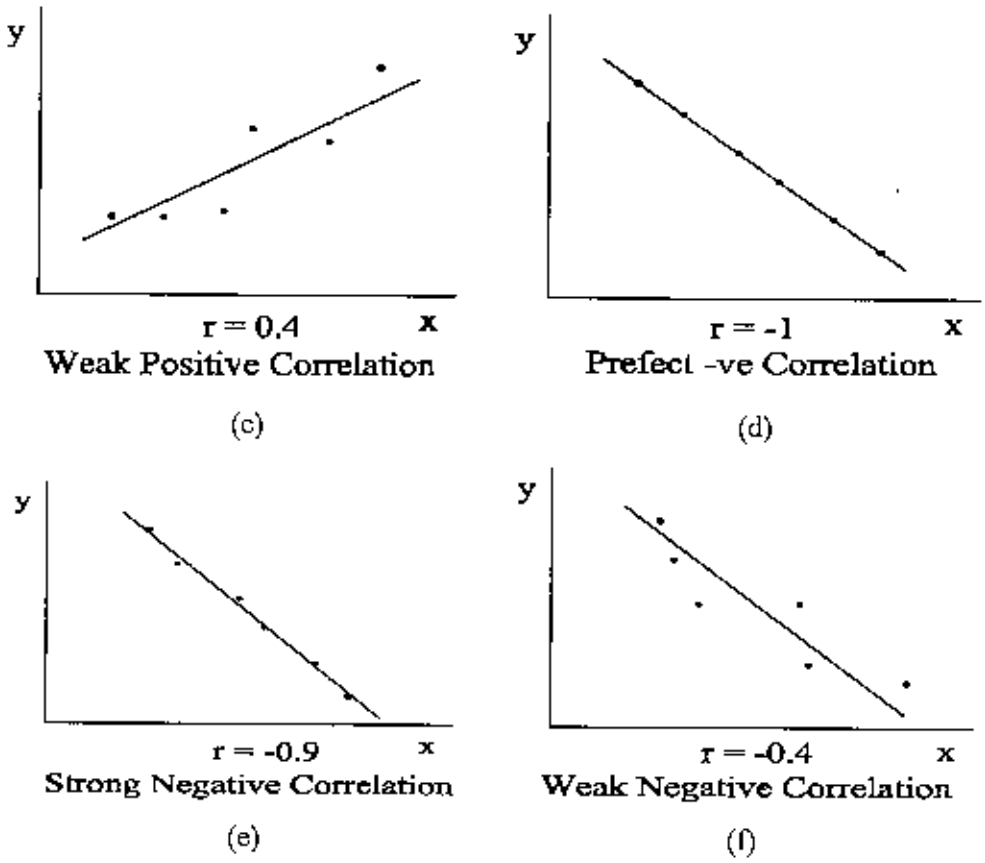


Figure: 3.1 Various Degree of Correlation

Linear Correlation Coefficient always lies between -1 and 1.

Note:

- If r is close to ±1, then the data points are clustered closely about the regeneration line.
- If r is farther from ±1, then the data points are more widely scattered about the regression line.
- If r is near 0, then the slope of the regression line is also near 0, indicating probably there is no relationship between the variables.

3.9.2 Relationship between Correlation Coefficient and Coefficient of Determination

- Coefficient of Determination, $r^2 \rightarrow$ a descriptive measure of the utility of the regression equation for marketing predictions

- Correlation Coefficient, $r \rightarrow$ a descriptive measure of the strength of the linear relationship between two variables.

So, r^2 can be obtained either directly or by first obtaining correlation coefficient, r

3.9.3 Correlation Is Not Casual

"Two variables having a high correlation ", does not at all imply that they are casually related. They may be strongly correlated because they are both associated with other variables, called lurking Variables, that cause changes in the two variables under consideration.

3.9.4 Assumptions for Regression Inferences

1. Population Regression line:

There is a straight line, $y = a + bx$, such that for each x-value, the mean of the corresponding population of y-values lies on the straight line.

Line is referred to as 'Population Regression Line'.

Equation is referred to as 'Population Regression Equation'.

2. Equal Standard Deviations:

The standard deviation, σ of the population of y-values corresponding to a particular x-value is the same, regardless of the a-values.

3. Normality:

For each x-value, the corresponding population of y-values is normally distributed.

3.9.5 Inferences in Correlation

Frequently, we want to decide whether two variables are linearly correlated, that is, whether there is a linear relationship between two variables.

Decision can be made by:

a) Performing a hypothesis test for the slope, b, of the population regression line, or

b) Performing a hypothesis test for the population linear correlation coefficient, ρ.

Note: r is an estimate of ρ

$\rho : (-1, 1)$

$\rho > 0 \rightarrow$ variables are positively linearly correlated (y tends to decrease as x increase)

$\rho < 0 \rightarrow$ negatively linearly correlated.

$\rho = 0 \rightarrow$ variables are linearly uncorrelated.

3.10 TESTS OF HYPOTHESIS

Hypothesis tests are procedures for making rational decisions about the reality of effects.

Most decisions require that an individual select a single alternative from a number of possible alternatives. The decision is made without knowing whether or not it is correct; that is. it is based on incomplete information. For example, a person either takes or does not take an umbrella to school based upon both the weather report and observation of outside conditions. If it is not currently raining, this decision must be made with incomplete information.

Setting up and testing hypotheses is an essential part of statistical inference. In order to formulate such a test, usually some theory has been put forward, either because it is believed to be true or because it is to be used as a basis for argument, but has not been proved.

Typically, a hypothesis test involves two hypothesis, one hypothesis is called the null hypothesis, the other is the alternative hypothesis.

3.10.1 The Null Hypothesis, H_0

It represents a theory that has been put forward, either because it is believed to be true or because it is to be used as a basis for argument, but has not been proved. For example, in a clinical trial of a new drug, the null hypothesis might be that the

new drug is no better, on average, than the current drug. We would write H_0: there is no difference between the two drugs on average.

We give special consideration to the null hypothesis. This is due to the fact that the null hypothesis relates to the statement being tested, whereas the alternative hypothesis relates to the statement to be accepted if / when the null is rejected.

The final conclusion once the test has been carried out is always given in terms of the null hypothesis. We either 'reject H_0 in favor of H_1' or 'do not reject H_0'; we never conclude 'reject H_1', or even 'accept H_1'.

If it is conclude 'do not reject H_0', this does not necessarily mean that the null hypothesis is true, it only suggests that there is not sufficient evidence against H_0 in favor of H_1; rejecting the null hypothesis then, suggests that the alternative hypothesis may be true.

3.10.2 The Alternative Hypothesis, H_1

It is a statement of what a statistical hypothesis test is set up to establish.

For example, in a clinical trial of a new drug, the alternative hypothesis might be that the new drug has a different effect, on average, compared to that of the current drug. We would write H_1: the two drugs have different effects, on average. The alternative hypothesis might also be that the new drug is better, on average, than the current drug. In this case we would write H_1: the new drug is better than the current drug, on average.

The final conclusion once the test has been carried out is always given in terms of the null hypothesis. We either 'reject H_0 in favor of H_1' or 'do not reject H_0'; we never conclude 'reject H_1', or even 'accept H_1'.

If it is conclude 'do not reject H_0', this does not necessarily mean that the null hypothesis is true, it only suggests that there is not sufficient evidence against H_0 in flavor of H_1; rejecting the null hypothesis then, suggests that the alternative hypothesis may be true.

3.10.3 Simple Hypothesis

A simple hypothesis is a hypothesis which specifies the population distribution completely.

3.10.4 Composite Hypothesis

A composite hypothesis is a hypothesis which does not specify the population distribution completely.

3.10.5 Type I and Type II Errors

Whenever statistical inferences methods are employed, it is always possible that the decision reached will be incorrect.

That is because partial information, obtained from the sample, is used to draw conclusions about the entire population.

The following table gives a summary of possible results of any hypothesis test:

		Decision	
		Reject H_0	Don't Reject H_0
Truth	H_0	Type I Error	Right Decision
	H_1	Right Decision	Type II Error

3.10.5.1 Type I Error

In a hypothesis test, a type I error occurs when the null hypothesis is rejected when it is in fact true; that is, H_0 is wrongly rejected.

For example, in a clinical trial of a new drug, the null hypothesis might be that the new drug is no better, on average, than the current drug; that is H_0: there is no difference between the two drugs on average. A type I error would occur if we concluded that the two drugs produced different effects when in fact there was no difference between them.

A type I error is often considered to be more serious, and therefore more important to avoid, than a type II error. The hypothesis test procedure is therefore adjusted so that there is a guaranteed 'low' probability of rejecting the null

hypothesis wrongly; this probability is never 0. This probability of a type I error can be precisely computed as,

$$P\text{ (type I error)} = \text{significance level} = \alpha$$

The exact probability of a type II error is generally unknown. If we do not reject the null hypothesis, it may still be false (a type II error) as the sample may not be big enough to identify the falseness of the null hypothesis (especially if the truth is very close to hypothesis).

- For any given set of data, type I and type II errors are inversely related; the smaller the risk of one, the higher the risk of the other.
- A type I error can also be referred to as an error of the first kind.

3.10.5.2 Type II Error

In a hypothesis test, a type II error occurs when the null hypothesis H_0, is not rejected when it is in fact false.

For example, in a clinical trial of a new drug, the null hypothesis might be that the new drug is no better, on average, than the current drug; that is H_0: there is no difference between the two drugs on average. A type II error would occur if it was concluded that the two drugs produced the same effect, that is, there is no difference between the two drugs on average, when in fact they produced different ones.

- A type II error is frequently due to sample sizes being too small.
- The probability of a type II error is symbolized β by and written:

$$P\text{ (type II error)} = \beta \text{ (but is generally unknown)}$$

- A type II error can also be referred to as an error of the second kind.

3.10.6 Significance Level, α

The significance level of a statistical hypothesis test is a fixed probability of wrongly rejecting the null hypothesis H_0, if it is in fact true.

It is the probability of a type I error and is set by the investigator in relation to the consequences of such an error. That is, we want to make the significance level as small as possible in order to protect the null hypothesis and to prevent, as far as possible, the investigator from inadvertently making false claims.

- The significance level is usually denoted by α

- Significance Level = P (type I error) = α
- Usually, the significance level is chosen to be = 0.05 = 5%.

3.10.7 Critical Value(s)

The critical value(s) for a hypothesis test is a threshold to which the value of the test statistic in a sample is compared to determine whether or not the null hypothesis is rejected.

The critical value for any hypothesis test depends on the significance level at which the test is carried out, and whether the test is one-sided or two-sided.

Test concerning a single mean and variance unknown, critical Values,

a. for a two-tailed test, $\pm Z_{\alpha/2}$ $(\mu \neq \mu_0)$

b. for a left-tailed test, $-Z_{\alpha/2}$ $(\mu \leq \mu_0)$

c. for a right tailed test, $+Z_{\alpha/2}$ $(\mu \geq \mu_0)$

Test statistic,

$$Z = \frac{\bar{x} - \mu_0}{\sigma/\sqrt{n}}$$

3.10.8 Critical Region

The critical region CR, or rejection region RR, is a set of values of the test statistic for which the null hypothesis is rejected in a hypothesis test; that is, the sample space for the test statistic is partitioned into two regions; one region (the critical region) will lead us to reject the null hypothesis H_0', the other not.

So, if the observed value of the test statistic is a member of the critical region, we conclude 'reject H_0'; if it is not a member of the critical region then we conclude 'do not reject H_0.

3.10.9 P-Value

The probability value (p-value) of a statistical hypothesis test is the probability of getting a value of the test statistic as extreme as or more extreme than that observed by chance alone, if the null hypothesis H_0, is true.

It is the probability of wrongly rejecting the null hypothesis if it is in fact true.
It is equal to the significance level of the test for which we would only just reject the null hypothesis. The p-value is compared with the significance level and, if it is smaller, the result is significant. That is, if the null hypothesis were to be rejected at $\alpha = 0.05$, this would be reported as '$p < 0.05$'.
Small p-values suggest that the null hypothesis is unlikely to be true. The smaller it is, the more convincing is the rejection of the null hypothesis. It indicates the strength of evidence for say, rejecting the null hypothesis H_0, rather than simply concluding 'reject H_0' or 'do not reject H_0'.

3.10.10 Power of a Test

The power of a statistical hypothesis test measures the test's ability to reject the null hypothesis when it is actually false - that is, to make a correct decision.
In other words, the power of a hypothesis test is the probability of not committing a type II error. It is calculated by subtracting the probability of a type II error from 1, usually expressed as:

$$\text{Power} = 1 - P\,(\text{type II error}) = (1-\beta)$$

The maximum power a test can have is 1, the minimum is 0. Ideally we want a test to have high power, close to 1.

3.10.11 One-sided Test

A one-sided test is a statistical hypothesis test in which the values for which we can reject the null hypothesis, H_0 are located entirely in one tail of the probability distribution.
In other words, the critical region for a one-sided test is the set of values less than the critical value of the test, or the set of values greater than the critical value of the test.

- A one-sided test is also referred to as a one-tailed test of significance.

3.10.12 Two-Sided Test

A two-sided test is a statistical hypothesis test in which the values for which we can reject the null hypothesis, H_0 are located in both tails of the probability distribution.

In other words, the critical region for a two-sided test is the set of values less than a first critical value of the test and the set of values greater than a second critical value of the test

- The choice between a one-sided test and a two-sided test is determined by the purpose of the investigation or prior reasons for using a one-sided test.
- A two-sided test is also referred to as a two-tailed test of significance.

3.10.13 One Sample t-test

A one sample t-test is a hypothesis test for answering questions about the mean where the data are a random sample of independent observations from an underlying normal distribution:

$$N(\mu, \sigma^2), \text{ where } \sigma^2 \text{ is unknown}$$

The null hypothesis for the one sample t-test is:

$$H_0 : \mu = \mu_0 \text{ (where } \mu_0 \text{ known)}$$

That is, the sample has been drawn from a population of given mean and unknown variance (which therefore has to be estimated from the sample).

This null hypothesis, H_0 is tested against one of the following alternative hypotheses, depending on the question posed:

$$H_1 : \mu \neq \mu_0$$
$$H_1 \quad \mu > \mu_0$$
$$H_1 : \mu < \mu_0$$

3.10.14 Two Sample t-test

A two sample t-test is a hypothesis test for answering questions about the mean where the data are collected from two random samples of independent observations, each from an underlying normal distribution:

$$N(\mu_i, \sigma_i^2), \text{ where } i = 1,2$$

When carrying out a two sample t-test, it is usual to assume that the variances for the two populations are equal, that is:

$$\sigma_1^2 = \sigma_2^2 = \sigma^2$$

The null hypothesis for the two sample t-test is:

$$H_0 : \mu_1 = \mu_2$$

That is, the two samples have both been drawn from the same population.

This null hypothesis is tested against one of the following alternative hypotheses, depending on the question posed.

$$H_1 \quad \mu_1 \neq \mu_2$$
$$H_1 \; . \; \mu_1 > \mu_2$$
$$H_1 : \mu_1 < \mu_2$$

CHAPTER 4

FORECASTING & STATISTICAL ANALYSIS

4.1 INTRODUCTION

Battery is a source of energy in which electrical energy is stored as chemical energy and also converts chemical energy into electrical energy when needed. Rahimafrooz Batteries Limited manufactures customized Industrial Batteries. The factory is well equipped with modern production machinery and testing facilities including tubular plates. It produces a wide range of Lead Acid Batteries with capacities from 31AH to 3000AH in a single cell. Industrial Battery delivers high power at all rates of discharge and work well in tough and difficult conditions. Industrial Battery is mainly used for power & sub station backup operation, Railway signaling, Telecommunication, Security monitoring system and Emergency lighting system.

4.2 ANALYSIS FOR IB-LOCAL TYPE BATTERY

Production of Industrial Battery (IB) Local during the 12 months of the last six years has shown in the Table 4.1:

Table 4.1 Actual Demand for IB-Local Type Battery

		Production Per Year						
	Month	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**Total**
1	Jan	425	175	60	297	306	12	1275
2	Feb	174	314	157	48	144	255	1092
3	Mar	2358	1348	160	191	328	742	5127
4	Apr	367	133	186	197	133	74	1090
5	May	419	267	295	569	294	220	2064
6	Jun	499	219	524	1741	333	180	3496
7	Jul	192	232	495	138	366	247	1670
8	Aug	208	83	192	156	289	182	1110
9	Sep	93	13	215	411	24	325	1081
10	Oct	82	327	425	224	38	72	1168
11	Nov	124	207	156	289	238	40	1054
12	Dec	171	207	434	156	24	178	1170
Total		**5112**	**3525**	**3299**	**4417**	**2517**	**2527**	**21397**

4.2.1 Discussion

Production of IB-Local per month for the year 2001 has shown in the Figure 4.1 where continuous line represents the moving average curve of two months period and dotted line represent the linear regression line.

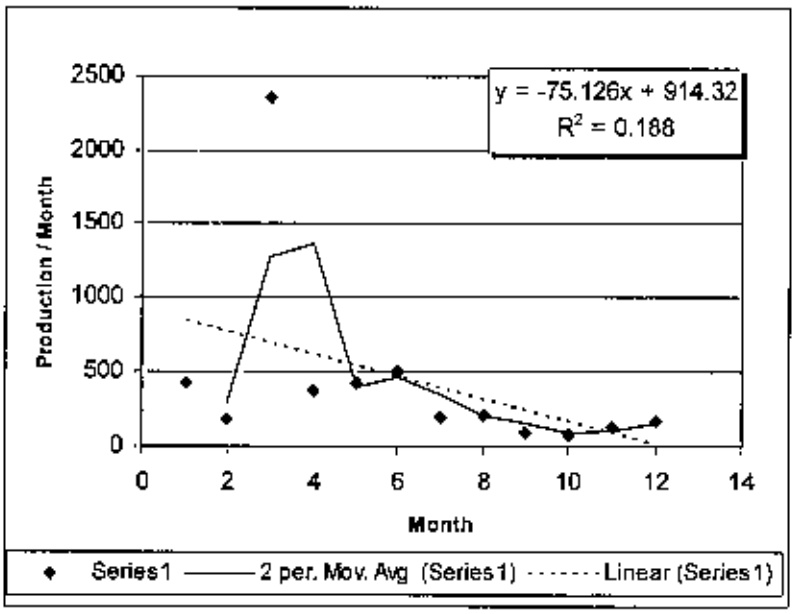


Figure: 4.1 IB-Local, Year 2001

For the year 2001, observing the moving average curve, it can be said that, there was a dramatic increase of IB-Local battery production from month February-March and also dramatic decrease from month March-April. After month April, there was a downward trend of IB-Local type battery production with some fluctuation up to month December.

For IB-Local battery type the linear equation for the year 2001 is,

$$y = -75.126x + 914.32$$

And value of the Coefficient of Determination is,

$$R^2 = 0.188,$$

Which shows that, the value of R^2 (0.188) is near to Zero.

So, regression equation is not very useful.

Production of IB-Local per month for the year 2002 has shown in the Figure 4.2 where continuous line represents the moving average curve of two months period and dotted line represent the linear regression line.

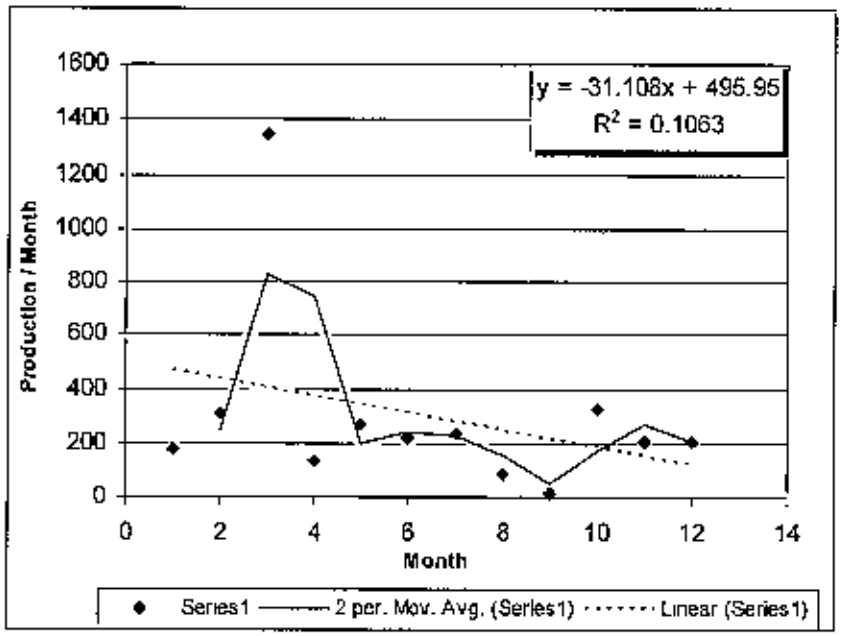


Figure: 4.2 IB-Local, Year 2002

For the year 2002, IB-Local battery production increased rapidly hitting a peak at just below 1400 units in March. After month March battery production was fluctuated with small deviation. Battery production was lowest in month September in amounting only 13 units. In general, there was a downward trend of battery production with some vacillation from month April to December.

For IB-Local battery type the linear equation for the year 2002 is,

$$y = -31.108x + 495.95$$

And value of the Coefficient of Determination is,

$$R^2 = 0.1063,$$

Which shows that, the value of R^2 (0.1063) is near to Zero.

So, regression equation is not useful.

Production of IB-Local per month for the year 2003 has shown in the Figure 4.3 where continuous line represents the moving average curve of two months period and dotted line represent the linear regression line.

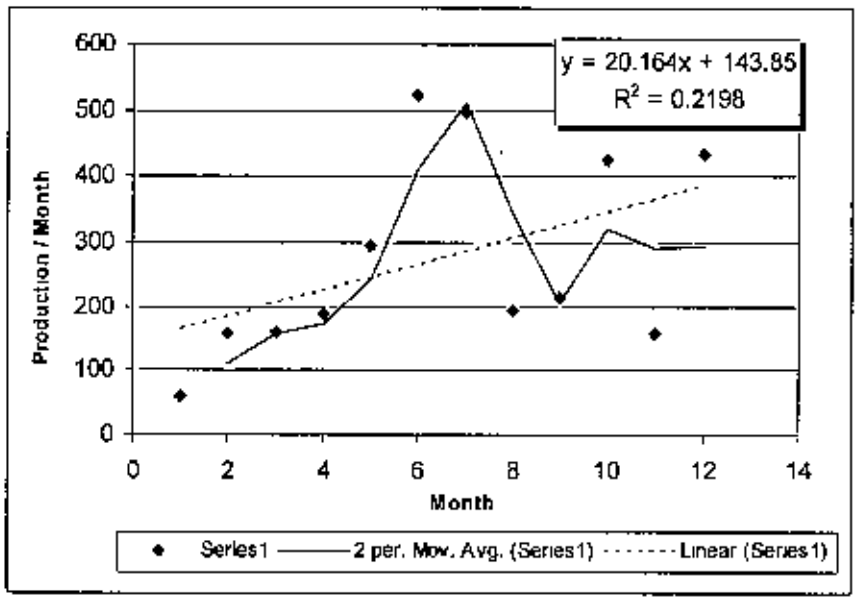


Figure: 4.3 IB-Local, Year 2003

For the year 2003, battery production was gradually increased from the beginning of the year. From month March to July there was a sharp increase of IB-Local type battery production. Battery production peaked at well above 500 units in June. After month June battery production was vacillated. As is observed, battery production got an upward trend with some fluctuation up to December.

For IB-Local battery type the linear equation for the year 2003 is,

$$y = 20.164x + 143.85$$

And value of the Coefficient of Determination is,

$$R^2 = 0.2193$$

Which shows that, the value of R^2 (0.2193) is slightly higher then Zero.

So, regression equation is not very useful.

Production of IB-Local per month for the year 2004 has shown in the Figure 4.4 where continuous line represents the moving average curve of two months period and dotted line represent the linear regression line.

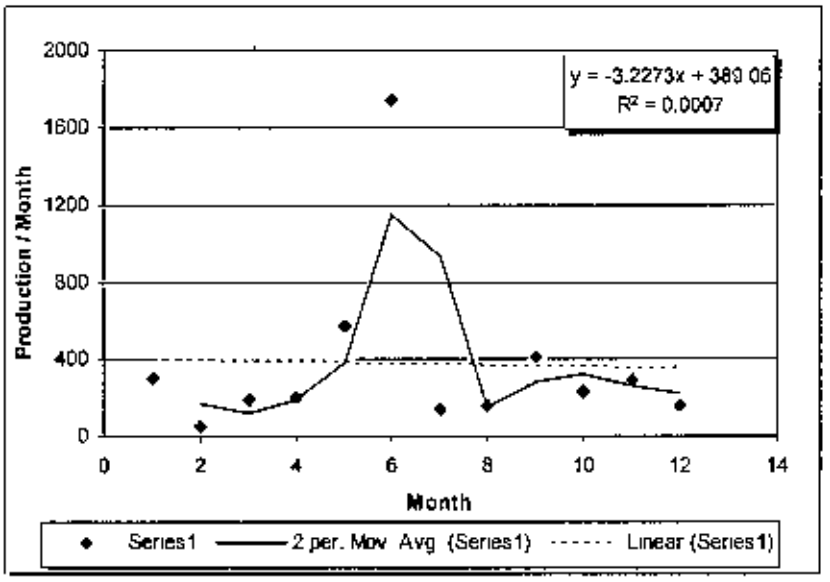


Figure: 4.4 IB-Local. Year 2004

For the year 2004, battery production increased quickly from April to June. In June there was a abrupt change of battery production and it peaked at well above 1700 units. Observing the linear regression line it can be said, battery production for year 2004 reached almost a plateau.

For IB-Local battery type the linear equation for the year 2004 is,

$$y = -3.2273x + 389.06$$

And value of the Coefficient of Determination is,

$$R^2 = 0.0007$$

Which shows that, the value of R^2 (0.0007) is almost zero.

So, regression equation is not very useful.

Production of IB-Local per month for the year 2005 has shown in the Figure 4.5. Where continuous line represents the moving average curve of two months period and dotted line represent the linear regression line.

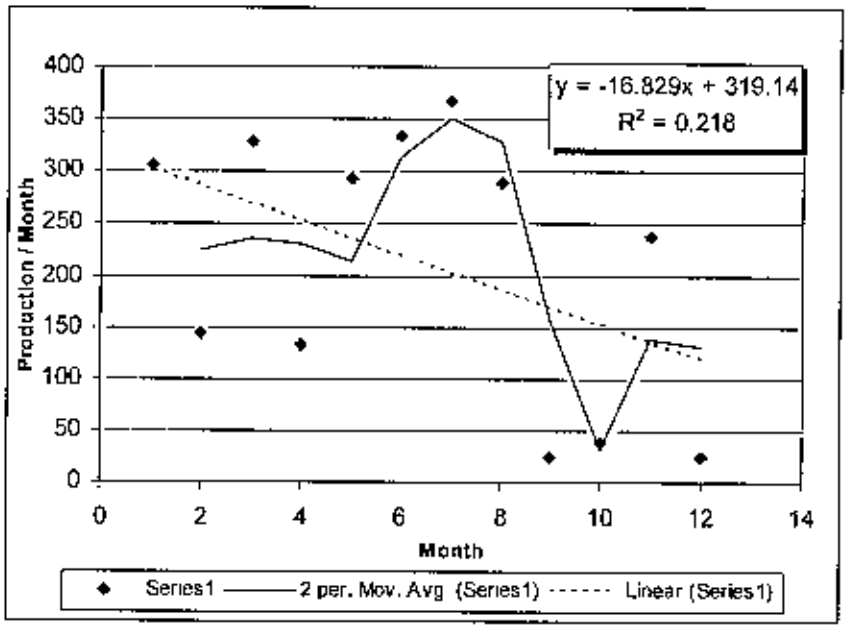


Figure: 4.5 IB-Local, Year 2005

For the year 2005, there was an abrupt change of battery production entire the year. The highest and the lowest amount of battery production were 366 units in July and 24 units in October. From month January to March and September to December battery production was fluctuated. But after month March there was a gradual increase of battery production up to month July. In general, there was a downward trend of IB-Local type battery production for the year 2005.

For IB-Local battery type the linear equation for the year 2005 is,

$$y = -16.829x + 319.14$$

And value of the Coefficient of Determination is,

$$R^2 = 0.218$$

Which shows that, the value of R^2 (0.2187) is slightly higher than zero.
So, regression equation is not very useful.

Production of IB-Local per month for the year 2006 has shown in the Figure 4.1.6. Where continuous line represents the moving average curve of two months period and dotted line represent the linear regression line.

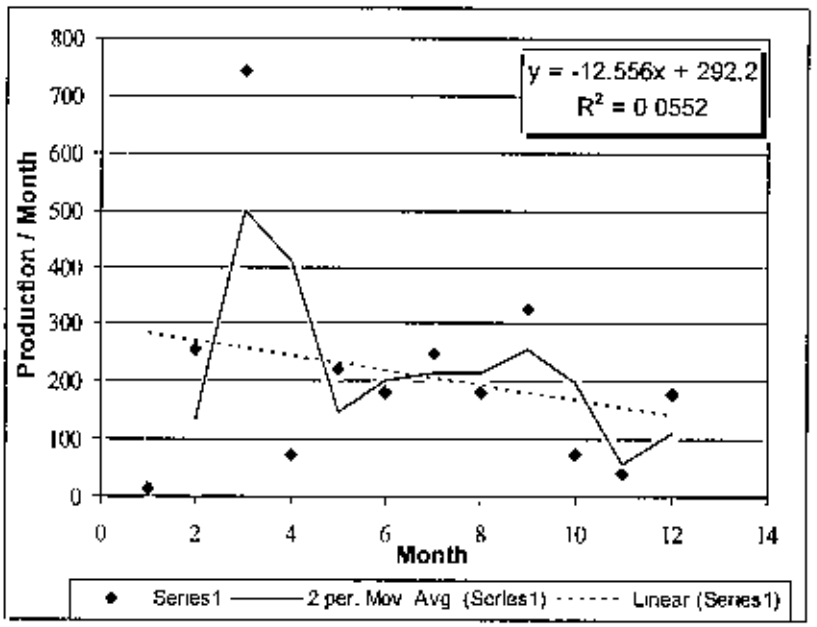


Figure: 4.6 IB-Local, 2006

For the year 2006, battery production increased rapidly from January-March and after March there was a sharp decrease of battery production. From month April to December battery production fluctuated. There was a abrupt change of battery production in month March amounting well above 700 units. In common, there was a downward trend of battery production from month January to December.

For IB-Local battery type the linear equation for the year 2006 is,

$$y = -12.556x + 292.2$$

And value of the Coefficient of Determination is,

$$R^2 = 0.0552$$

Which shows that, the value of R^2 (0.0552) is near to Zero.

So, regression equation is not useful.

From year 2001-2006, production of Industrial Battery-Local per year has shown in the Figure 4.7 where continuous line represents the moving average curve of two months period and dotted line represent the linear regression line.

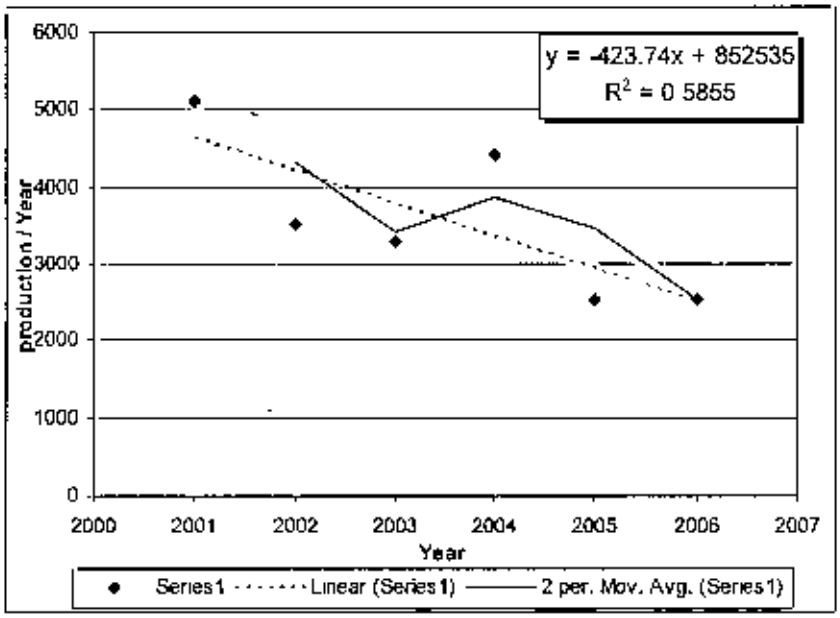


Figure: 4.7 IB-Local, Production per year

As it is observed from the graph, initially at the month of January, about 5000 units of IB-Local type battery produced from year 2001 to 2006. Then a gradual decrease the battery production with some fluctuation between year 2001 and 2006.

For IB-Local battery type, the linear equation from year 2001-2006,

$$y = -423.74x + 852535 \quad \text{.....(4.1)}$$

And value of the Coefficient of Determination is,

$$R^2 = 0.5855 \quad \text{.....(4.2)}$$

Which shows that, the value of R^2 (0.5855) is slightly near to 1.

So, regression equation is useful.

By using this linear equation it can be forecast the amount of IB-Local type battery needs to produce for the next year.

4.2.2 Statistical Analysis

The following analysis shows hypothesis testing on the forecast value.

Hypothesis test:

Let, H_0 : $\rho = 0$

H_1: $\rho > 0$ (for right-tailed test)

Significance Level, $\alpha = 5\% = 0.05$

Now,

t_α with df = n - 2

Where, n = 6 (From year 2001 to 2006)

From t-distribution Table (From Appendix),

$$t_\alpha = t_{0.05} = 2.132$$

It is known that,

t-distribution for a correlation test, $t = \dfrac{R}{\sqrt{\dfrac{1-R^2}{n-2}}}$

Where,

$R^2 = 0.5855$

n = 6

t = 2.377

Since,

$t > t_{0.05}$, Reject H_0

So, at 5% significance level, the data provides sufficient evidence to conclude that production from year 2001-2006 for IB-Local type battery is linearly correlated.

It is assumed that, next year production rate will increase 15% then using equation (4.1),

$$y = (-423.74x + 852535) + (-423.74x + 852535)*15\%$$

So, Forecasted Production for the year 2007.

$$y = (-423.74*2007 + 852535) + (-423.74*2007 + 852535)*15\%$$

y = 2402 units

From year 2001-2006, production of Industrial Battery-Local per month has shown in the figure 4.8 where continuous line represents the moving average curve of two years period and dotted line represent the linear regression line.

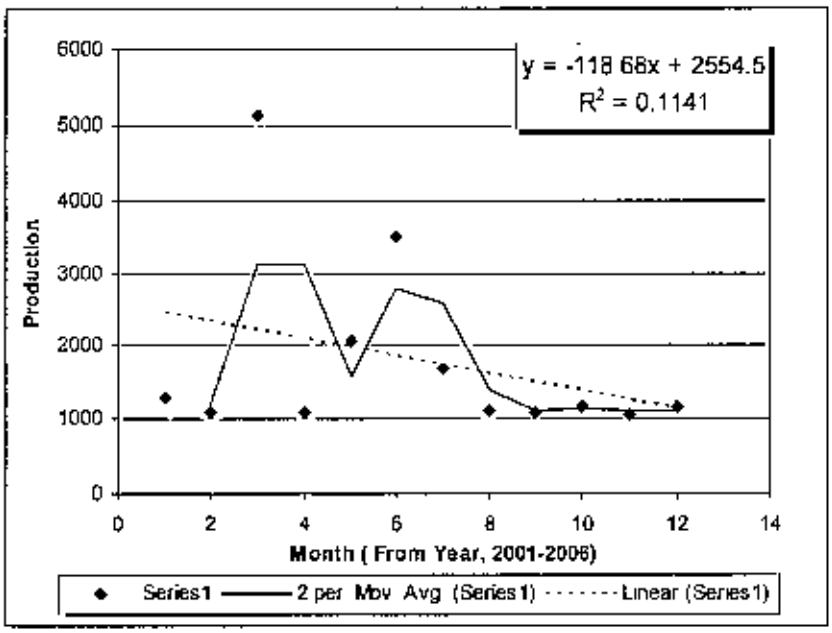


Figure: 4.8 IB-Local, Total six years production per month

From year 2001-2006, total number of battery production per month was illustrated the above graph. According to the illustration, there was a seasonal effect of the IB-Local battery production rate. From year 2001-2006, the highest total number of battery produced in month March, which was 5127 units and the second highest was in month June, which was 3496 units. After month June battery production rate was almost steady.

For IB-Local battery type, the linear equation for total production per month from year 2001-2006,

$$y = -118.68x + 2554.5$$

And value of the Coefficient of Determination is,

$$R^2 = 0.1141$$

Which shows that, the value of R^2 (0.1141) is almost near to Zero.

So, regression equation is not very useful.

So, for making decision or forecasting this type of battery production seasonal effect should be considered. First, it needs to forecast the demand for the year 2007 by using the equation (4.1). Then it needs to find out the seasonal factor for per month production. Finally, by using this seasonal factor forecasting can be done for IB-Local type battery production per month.

4.2.3 Seasonal Factor

A seasonal factor is the amount of correlation needed in a time series to adjust for the season of a year or a period of time. If a year is divided equally into four quarter then.

January-March = Quarter I
April-June = Quarter II
July-September = Quarter III
October-December = Quarter IV

By using average past production from year 2001-2006 seasonal factor can be find out for different quarters, which has shown in the Table: 4.2.

Table 4.2 Seasonal Factor

Quarter	Past Production	Avg. Production for Each Season	Seasonal Factor
(a)	(b)	(c) = 7132 / 4	(b) / (c)
I	2498	1783	1.40
II	2217	1783	1.24
III	1287	1783	0.72
IV	1131	1783	0.63
Total	7132		

Forecasting of Production by Using Seasonal Factor:

It can be forecast the number of battery needs to produce in different quarters in the year 2007 by using seasonal factor of table: 4.2

Forecasting of production in different quarters by using seasonal factor has shown in Table 4.3

Table 4.3 Forecasted Productions

Quarter	Expected Production for next year	Avg. Production for Each Session	Seasonal Factor	Next year Forecast
(a)	(b)	(c) = (b) / 4	(d)	(c) x (d)
I		601	1.40	841
II		601	1.24	747
III		601	0.72	433
IV		601	0.63	381
Total	2402			

So, For IB-Local type battery forecasted production for the year 2007 is given below:

January-March	= 841	units
April-June	= 747	units
July-September	= 433	units
October-December	= 381	units
Total	= 2402	units

4.3 ANALYSIS FOR IB-IPS TYPE BATTERY

IB-IPS type batteries are mainly used for Instant Power Supply (IPS) system and power backup system. It is a deep cycle type battery. For long life, low maintenance and low self discharge this type of battery is reliable. Due to the interrupted power supply demand of this type of battery is increasing rapidly and the effect of seasonal factor is highest for this type of battery.

Production of Industrial Battery (IB) Instant Power Supply (IPS) during the 12 months of the last six years has shown in the Table 4.4:

Table 4.4 Actual Demand for IB-IPS Type Battery

		Production Per Year						
	Month	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**Total**
1	Jan	592	400	141	270	303	19	1725
2	Feb	476	490	40	307	537	978	2828
3	Mar	767	700	459	686	1484	2775	6871
4	Apr	742	960	999	912	1194	2931	7738
5	May	1165	1070	1327	1424	734	2515	8235
6	Jun	1089	1063	1032	1069	1743	2077	8073
7	Jul	733	714	885	254	419	2494	5499
8	Aug	840	52	696	500	626	1693	4407
9	Sep	800	443	621	429	996	2453	5742
10	Oct	899	422	286	489	647	3100	5843
11	Nov	720	54	60	369	983	2270	4456
12	Dec	409	136	184	11	252	1118	2110
Total		**9232**	**6504**	**6730**	**6720**	**9918**	**24423**	**63527**

4.3.1 Discussion

Production of IB-IPS per month for the year 2001 has shown in the Figure 4.9 where continuous line represents the moving average curve of two months period and dotted line represent the linear regression line.

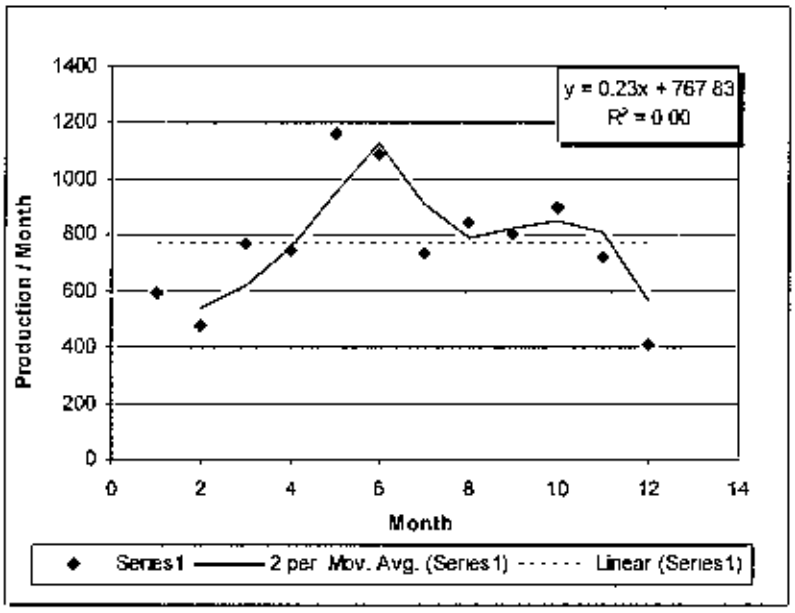


Figure: 4.9 IB-IPS, Year 2001

For the year 2001, observing the moving average curve, it can be said that, there was a dramatic increase of IB-IPS type battery production from month February-May and also sudden decrease from month June. After month June, there was almost a plateau trend of IB-IPS battery production with some fluctuation up to month December. In common, there was almost a perfect horizontal trend of this type of battery production.

For IB-IPS battery type the linear equation for the year 2001 is,

$$y = 0.23x + 767.83$$

And value of the Coefficient of Determination is,

$$R^2 = 0.00$$

Which shows that, the value of R^2 (0.00) is exactly equal to Zero.

So, regression equation is not useful.

Production of IB-IPS per month for the year 2002 has shown in the Figure 4.10 where continuous line represents the moving average curve of two months period and dotted line represent the linear regression line.

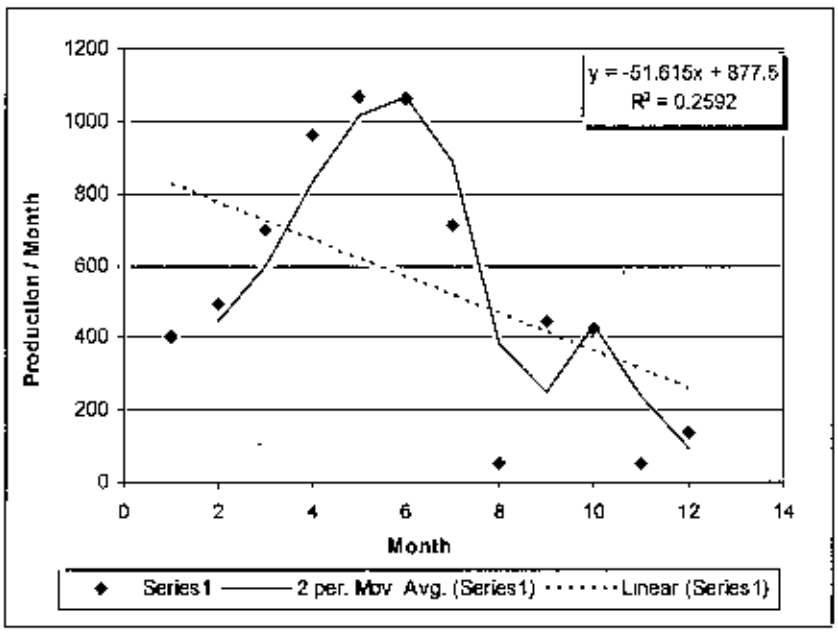


Figure: 4.10 IB-IPS, Year 2002

For the year 2002, IB-IPS battery production increased rapidly hitting a peak at just below 1070 units in May. From month January to June battery production was increased gradually and after month June it was decreased rapidly with some vacillation. In general, there was a moderate downward trend of battery production with some vacillation from month June to December.

For IB-IPS battery type the linear equation for the year 2002 is,

$$y = -51.615x + 877.5$$

And value of the Coefficient of Determination is,

$$R^2 = 0.2592$$

Which shows that, the value of R^2 (0.2592) is near to Zero.

So, regression equation is not useful.

Production of IB-IPS per month for the year 2003 has shown in the Figure 4.11 where continuous line represents the moving average curve of two months period and dotted line represent the linear regression line.

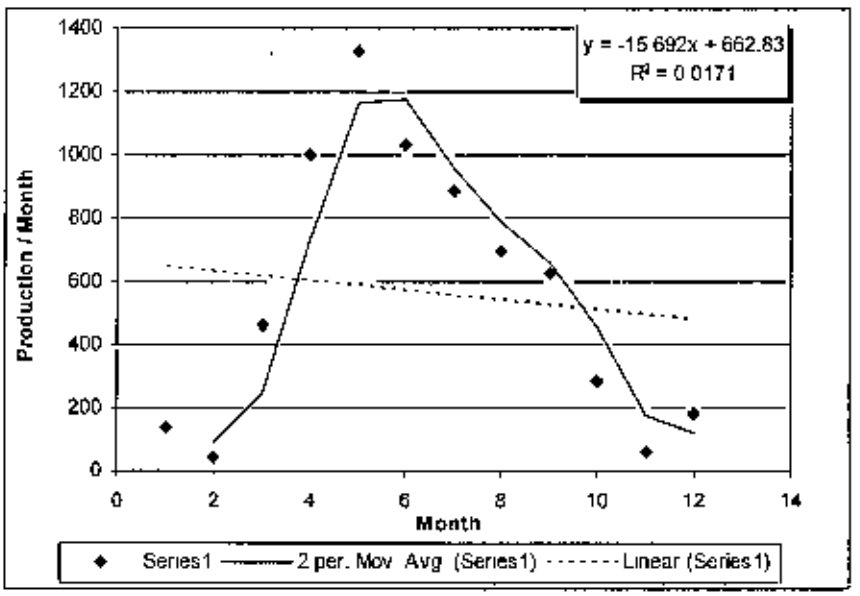


Figure: 4.11 IB-IPS, Year 2003

For the year 2003, form month March to May there was a sharp increase in IB-IPS type battery production. Battery production was peaked at well above 1300 units in May. After Month May there was also a sharp decline of battery production from month June-November. Battery production was lowest in month February amounting only 40 units.

For IB-IPS battery type the linear equation for the year 2003 is,

$$y = -15.692x + 662.83$$

And value of the Coefficient of Determination is,

$$R^2 = 0.0171$$

Which shows that, the value of R^2 (0.0171) is very near to Zero.

So, regression equation is not very useful.

Production of IB-IPS per month for the year 2004 has shown in the Figure 4.12 where continuous line represents the moving average curve of two months period and dotted line represent the linear regression line.

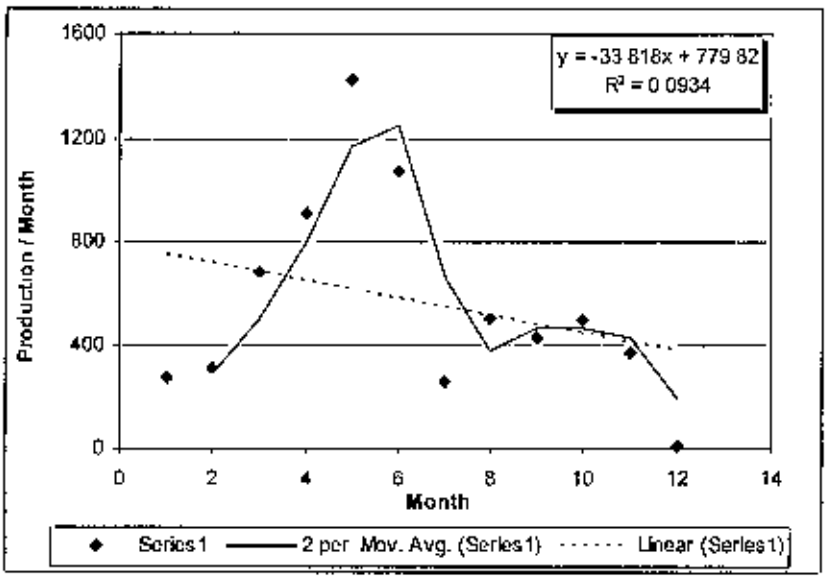


Figure: 4.12 IB-IPS, Year 2004

For the year 2004, battery production increased quickly from January to May. In month May battery production peaked at almost 1400 units. After month May there was a sudden decline of battery production up to month July and after month July battery production increased gradually up to month October. In general, there was a downward trend of battery production.

For IB-IPS battery type the linear equation for the year 2004 is,

$$y = -33.818x + 779.82$$

And value of the Coefficient of Determination is,

$$R^2 = 0.0934$$

Which shows that, the value of R^2 (0.0934) is near to zero.

So, regression equation is not very useful.

Production of IB-IPS per month for the year 2005 has shown in the Figure 4.13 Where continuous line represents the moving average curve of two months period and dotted line represent the linear regression line.

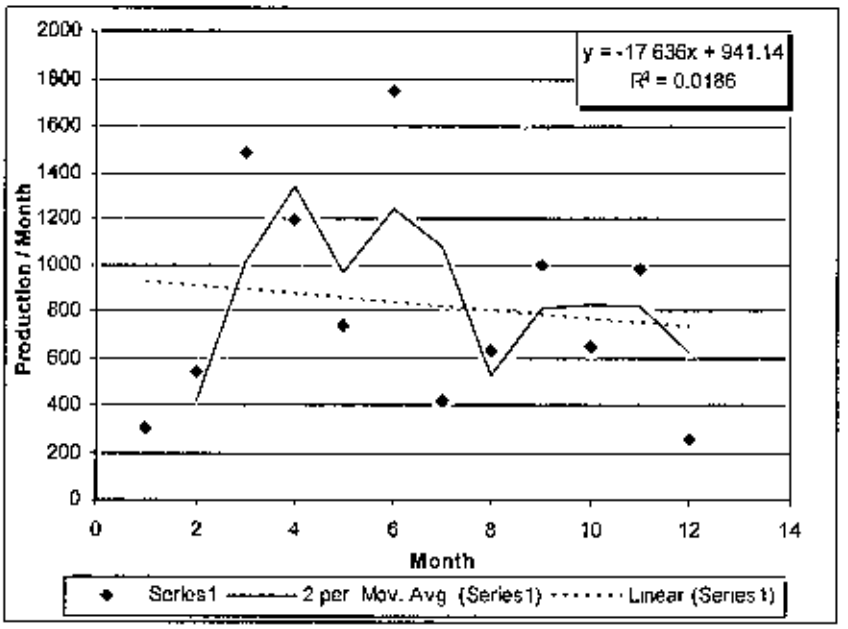


Figure: 4.13 IB-IPS, Year 2005

For the year 2005, there was an abrupt change of battery production entire the whole year. The highest and the lowest amount of battery production were 1743 units in June and 252 units in December. As is observed, there was cyclic effect of seasonal factor of battery production. Battery production was increased and decreased from month January-July and July-December. In common, there was a slight downward trend of battery production for the year 2005.

For IB-IPS battery type the linear equation for the year 2005 is,

$$y = -17.636x + 941.14$$

And value of the Coefficient of Determination is,

$$R^2 = 0.0186$$

Which shows that, the value of R^2 (0.0186) is near to zero.

So, regression equation is not very useful.

Production of IB-IPS per month for the year 2006 has shown in the Figure 4.14 Where continuous line represents the moving average curve of two months period and dotted line represent the linear regression line.

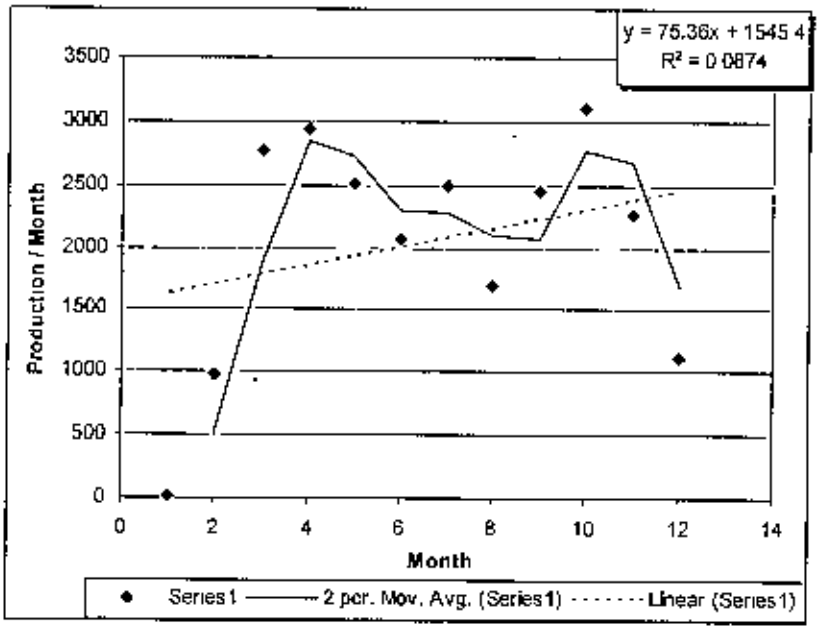


Figure: 4.14 IB-IPS, 2006

For the year 2006, battery production increased rapidly from January-April and after April there was a sudden decrease of battery production. From month June to December battery production fluctuated. In month October battery production peaked at highest level amounting 3100 units. In common, there was a upward trend of battery production from month January to December.

For IB-IPS battery type the linear equation for the year 2006 is,

$$y = 75.36x + 1545.4$$

And value of the Coefficient of Determination is,

$$R^2 = 0.0874$$

Which shows that, the value of R^2 (0.0874) is near to Zero.

So, regression equation is not useful.

From year 2001-2006, production of Industrial Battery-IPS per year has shown in the Figure 4.15 where continuous line represents the moving average curve of two years period and dotted line represent the linear regression line.

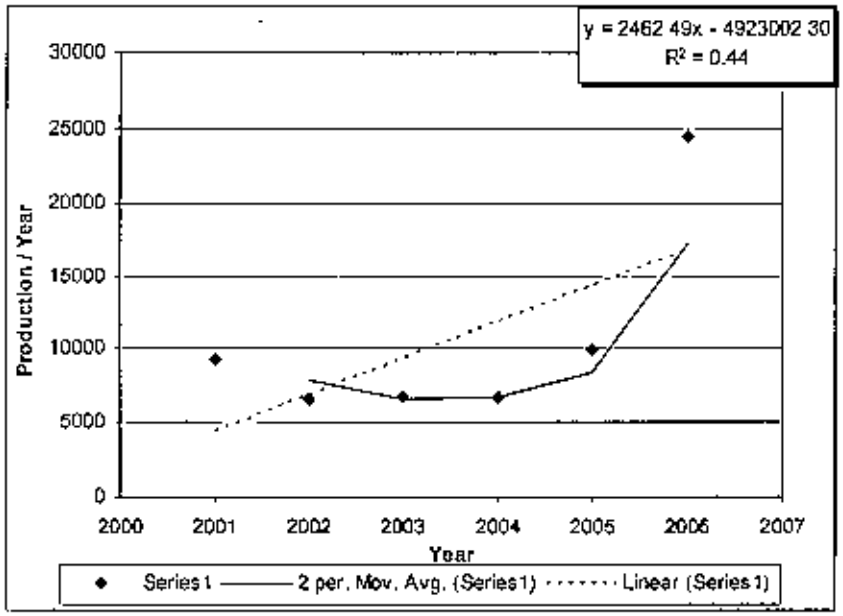


Figure: 4.15 IB-IPS, Production per year

As is observed from the graph, at year 2001 well above 9000 units of IB-IPS type battery produced. After year 2001, there was an exponential increase of battery production from year 2002 to 2006.

For IB-IPS battery type, the linear equation from year 2001-2006.

$$y = 2462.49x - 4923002.30 \quad \text{.....(4.3)}$$

And value of the Coefficient of Determination is,

$$R^2 = 0.44 \quad \text{.....(4.4)}$$

Which shows that, the value of R^2 (0.44) is not near to 1.

So, regression equation may be useful.

By using this linear equation it can be forecasted the amount of IB-IPS type battery needs to produce for the next year.

4.3.2 Statistical Analysis

The following analysis shows hypothesis testing on the forecast value.

Hypothesis test:

Let, H_0: $\rho = 0$

H_1: $\rho > 0$ (for right-tailed test)

Significance Level, $\alpha = 5\% = 0.05$

Now,

t_α with df = n - 2

Where, n = 6 (From year 2001 to 2006)

From t-distribution Table (From Appendix),

$$t_\alpha = t_{0.05} = 2.132$$

It is known that,

t-distribution for a correlation test, $t = \dfrac{R}{\sqrt{\dfrac{1-R^2}{n-2}}}$

Where,

$R^2 = 0.44$

n = 6

t = 1.773

Since,

$t > t_{0.05}$, Reject H_1

So, at 5% significance level, the data provides sufficient evidence to conclude that production from year 2001-2006 for IB-IPS type battery is not linearly correlated.

It is assumed that, next year production rate will increase 30% then using equation (4.3),

$$y = (2868.97x - 5739224.26) + (2868.97x - 5739224.26)*30\%$$

So, Forecasted Production for the year 2007,

$$y = (2868.97*2007 - 5739224.26) + (2868.97*2007 - 5739224.26)*30\%$$

$$y = 24438 \text{ units}$$

From year 2001-2006, production of Industrial Battery-IPS per month has shown in the Figure 4.16 where continuous line represents the moving average curve of two months period and dotted line represent the linear regression line.

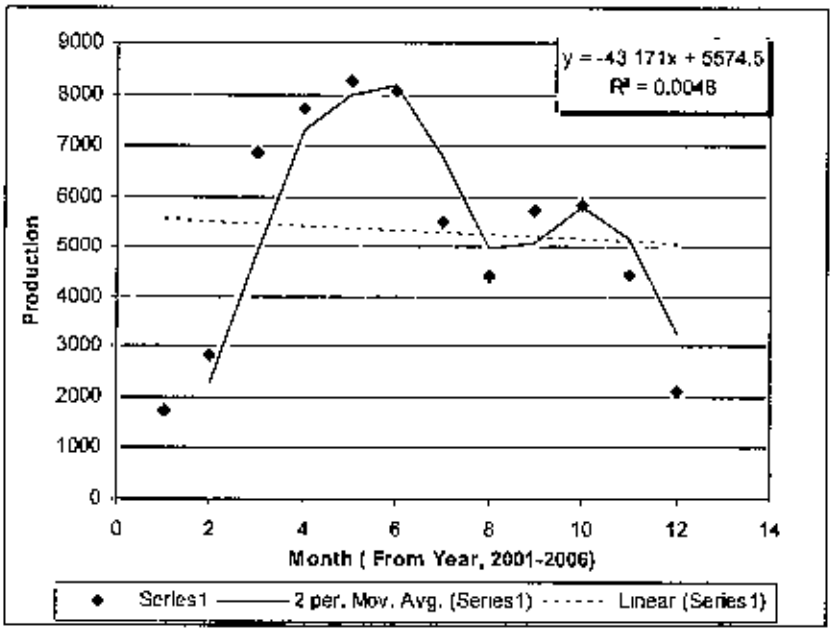


Figure: 4.16 IB-IPS, Total six years production per month

From year 2001-2006, total number of battery production per month was illustrated the above graph. According to the illustration, there was a seasonal effect of the IB-IPS battery production rate. From year 2001-2006, the highest total number of battery produced in month June, which was 8235 units and the second highest was in month April, which was 8073 units. In common, there was a slight downward trend of battery production from month January-December.

For IB-IPS battery type, the linear equation for total production per month from year 2001-2006,

$$y = -43.171x + 5574.5$$

And value of the Coefficient of Determination is,

$$R^2 = 0.0048$$

Which shows that, the value of R^2 (0.0048) is very near to Zero.

So, regression equation is not very useful.

So, for making decision or forecasting this type of battery production seasonal effect should be considered. First, it needs to forecast the demand for the year 2007 by using the equation (4.3). Then it needs to find out the seasonal factor for per month production. Finally, by using this seasonal factor forecasting can be done for IB-IPS type battery production per month.

4.3.3 Seasonal Factor

A seasonal factor is the amount of correlation needed in a time series to adjust for the season of a year or a period of time. If a year is divided equally into four quarter then.

January-March = Quarter I
April-June = Quarter II
July-September = Quarter III
October-December = Quarter IV

By using average past production from year 2001-2006 we can find out the seasonal factor of different quarters, which shows in the Table: 4.5

Table 4.5 Seasonal Factor

Quarter	Past Production	Avg. Production for Each Season	Seasonal Factor
(a)	(b)	(c) = 21176 / 4	(b) / (c)
I	3808	5294	0.72
II	8015	5294	1.51
III	5216	5294	0.99
IV	4136	5294	0.78
Total	**21176**		

Forecasting of Production by Using Seasonal Factor:

It can be forecast the number of battery needs to produce in different quarters in the year 2007 by using seasonal factor of table: 4.5

Forecasting of production in different quarters by using seasonal factor has shown in Table 4.6

Table 4.6 Forecasted Production for IB-IPS Type Battery

Quarter	Expected Production for next year	Avg. Production for Each Session	Seasonal Factor	Next year Forecast
(a)	(b)	(c) = (b) / 4	(d)	(c) x (d)
I		6110	0.72	4395
II		6110	1.51	9250
III		6110	0.99	6020
IV		6110	0.78	4774
Total	24438			

So, For IB-IPS type battery forecasted production for the year 2007 is given below:

January-March	= 4395	units
April-June	= 9250	units
July-September	= 6020	units
October-December	= 4774	units
Total	= 24438	units

4.4 ANALYSIS FOR IB-SOLAR TYPE BATTERY

Production of Industrial Battery (IB) Solar during the 12 months of the last six years has shown in the Table 4.7:

Table 4.7 Actual Demand for IB-Solar Type Battery

	Month	Production Per Year						Total
		2001	2002	2003	2004	2005	2006	
1	Jan	98	18	1155	2061	2117	2821	8270
2	Feb	111	61	1707	2129	2869	3016	9893
3	Mar	135	294	829	2172	2516	2951	8897
4	Apr	163	97	2654	1873	2582	5880	13249
5	May	165	143	1213	2493	3236	3525	10775
6	Jun	338	494	1581	2684	4357	3471	12925
7	Jul	582	619	3696	2710	2836	3360	13803
8	Aug	301	1231	2113	3005	3973	3434	14057
9	Sep	156	639	2534	2014	5026	3732	14101
10	Oct	945	501	2610	2193	4793	3701	14743
11	Nov	157	2080	2152	1860	4205	6282	16736
12	Dec	32	1340	2597	3143	3125	5246	15483
Total		**3183**	**7517**	**24841**	**28337**	**41635**	**47419**	**152932**

Acc. 107361

4.4.1 Discussion

Production of IB-Solar per month for the year 2001 has shown in the Figure 4.17 where continuous line represents the moving average curve of two months period and dotted line represent the linear regression line.

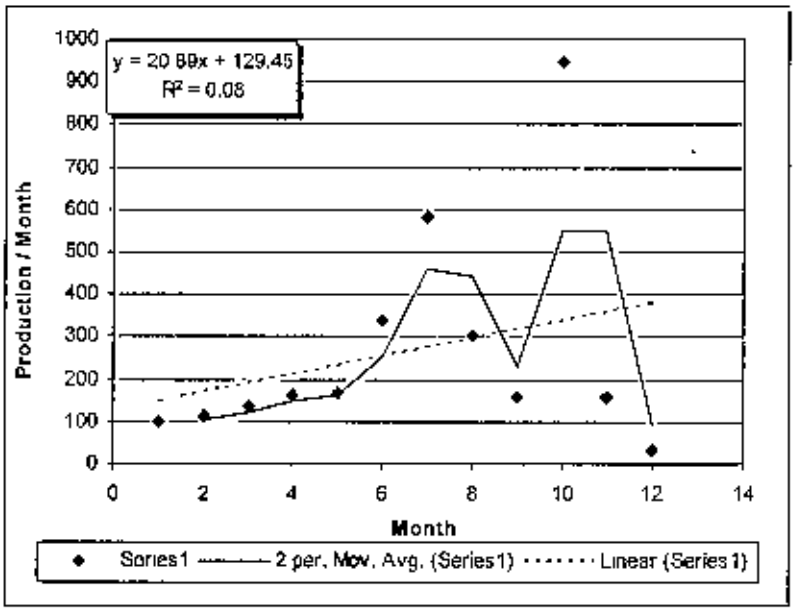


Figure: 4.17 IB-Solar, Year 2001

For the year 2001, observing the moving average curve, there was an exponential growth of IB-Solar type battery production from month January to July and also sudden decrease after month July. After month September, there was a sudden increased of this type of battery production hitting a peak at well above 900 units.

For IB-Solar battery type the linear equation for the year 2001 is,

$$y = 20.89x + 129.45$$

And value of the Coefficient of Determination is,

$$R^2 = 0.08$$

Which shows that, the value of R^2 (0.08) is almost equal to Zero.

So, regression equation is not useful.

Production of IB-Solar per month for the year 2002 has shown in the Figure 4.18 where continuous line represents the moving average curve of two months period and dotted line represent the linear regression line.

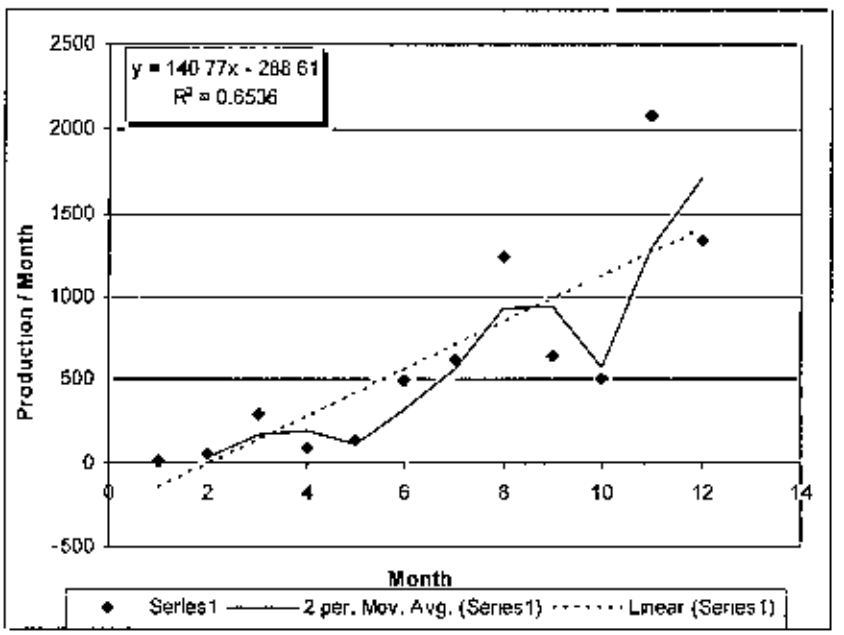


Figure: 4.18 IB-Solar, Year 2002

For the year 2002, IB-Solar type battery production increased rapidly hitting a peak at well above 2000 units in November. At the beginning of this year battery production was almost zero and then gradually increased with some fluctuation. In general, there was a sharp upward trend of battery production with some vacillation for the year 2002.

For IB-Solar battery type the linear equation for the year 2002 is,

$$y = 140.77x - 288.61$$

And value of the Coefficient of Determination is,

$$R^2 = 0.6536$$

Which shows that, the value of R^2 (0.6536) is slightly near to 1.

So, regression equation is useful.

Production of IB-Solar per month for the year 2003 has shown in the Figure 4.19 where continuous line represents the moving average curve of two months period and dotted line represent the linear regression line.

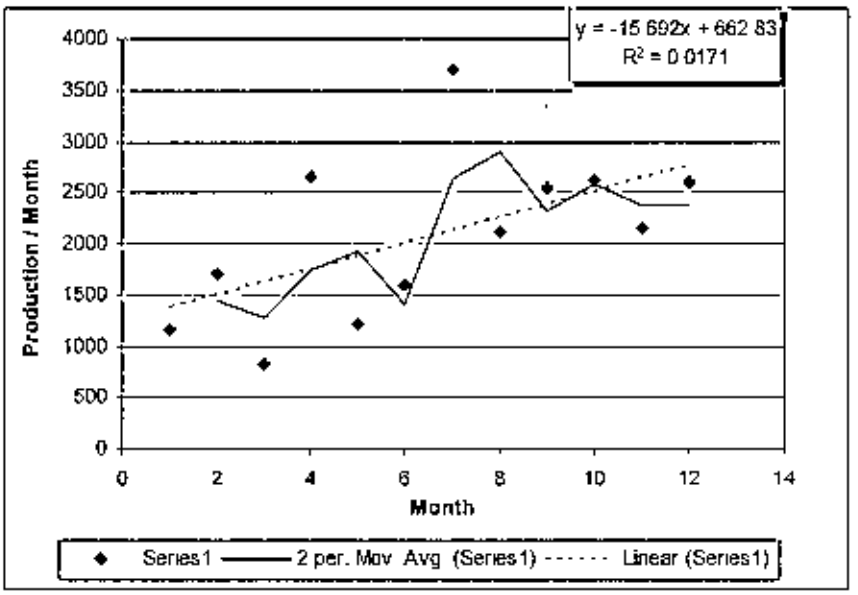


Figure: 4.19 IB-Solar, Year 2003

For the year 2003, IB-Solar type battery production was unsteady and also fluctuated very much entire the whole year. In month March lowest amount of battery was produced amounting 829 and Battery production peaked at well above 3500 units in July. The most significant thing was that. battery production for year 2003 was almost three times greater then the battery production of year 2002. In general, there was an upward trend of battery production with some vacillation.

For IB-Solar battery type the linear equation for the year 2003 is,

$$y = -15.692x + 662.83$$

And value of the Coefficient of Determination is,

$$R^2 = 0.0171$$

Which shows that, the value of R^2 (0.0171) is very near to Zero.

So, regression equation is not very useful.

Production of IB-Solar per month for the year 2004 has shown in the Figure 4.20 where continuous line represents the moving average curve of two months period and dotted line represent the linear regression line.

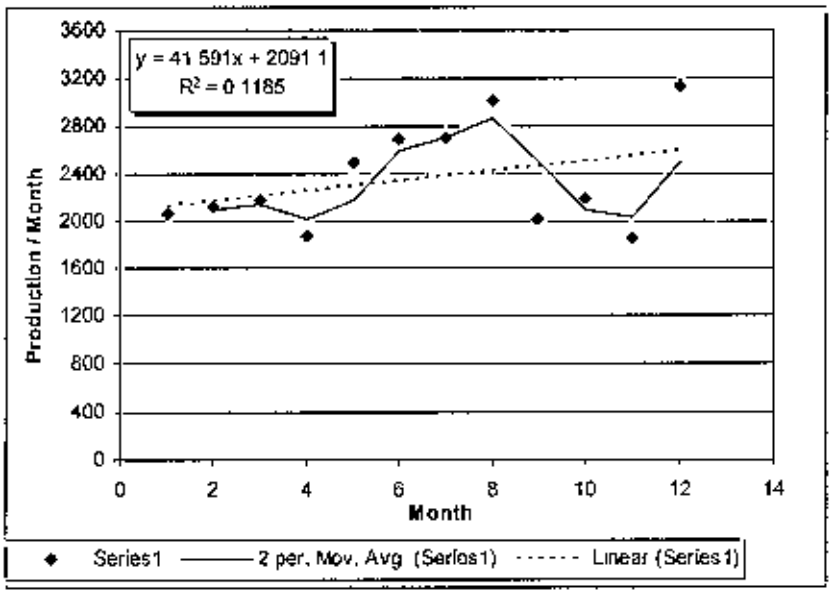


Figure: 4.20 IB-Solar, Year 2004

For the year 2004, battery production increased gradually from January to August. After month August there was a sudden decline of battery production up to month November. In month May battery production peaked at almost 3200 units. In general, there was an upward trend of battery production for the year 2004.

For IB-Solar battery type the linear equation for the year 2004 is,

$$y = 41.591x + 2091.1$$

And value of the Coefficient of Determination is,

$$R^2 = 0.1185$$

Which shows that, the value of R^2 (0.1185) is near to zero.

So, regression equation is not very useful.

Production of IB-Solar per month for the year 2005 has shown in the Figure 4.21 Where continuous line represents the moving average curve of two months period and dotted line represent the linear regression line.

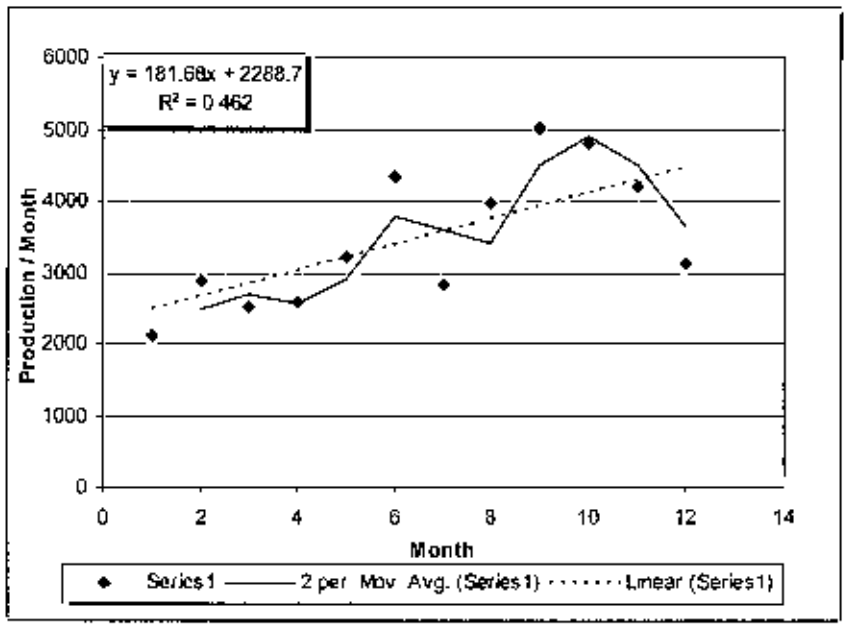


Figure: 4.21 IB-Solar, Year 2005

For the year 2005, there was an abrupt change of battery production entire the whole year. The highest and the lowest amount of battery production were almost 5000 units in September and 2117 units in December.

For IB-Solar battery type the linear equation for the year 2005 is,

$$y = 181.68x + 2288.7$$

And value of the Coefficient of Determination is,

$$R^2 = 0.462$$

Which shows that, the value of R^2 (0.462) is moderately near 1

So, regression equation is moderately useful.

Production of IB-JPS per month for the year 2006 has shown in the Figure 4.22 Where continuous line represents the moving average curve of two months period and dotted line represent the linear regression line.

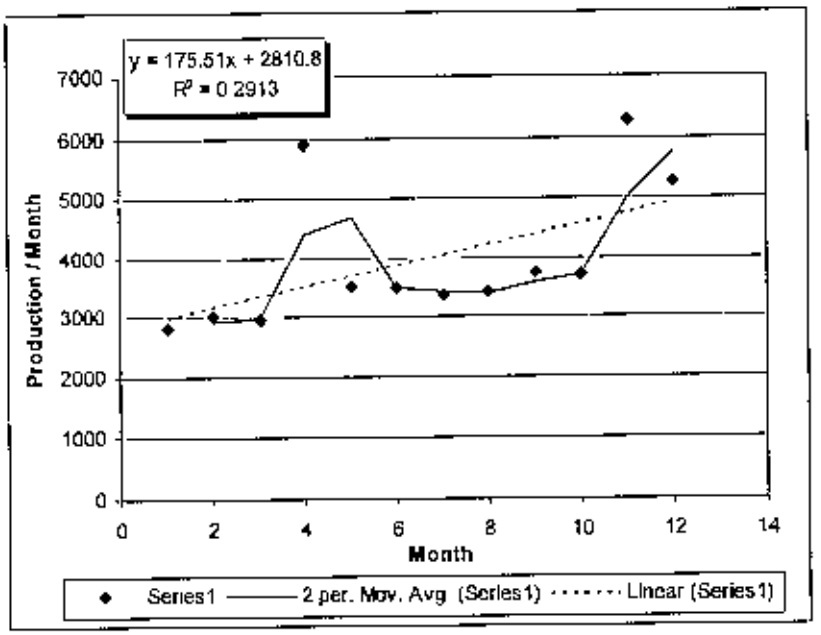


Figure: 4.22 IB-Solar, 2006

For the year 2006, from January-March battery production was almost constant. In month April there was a sudden increase of battery production amounting 5880 units after month April production was almost constant with some fluctuation. In month November battery production peaked at highest level amounting 6282 units. In common, there was an upward trend of battery production for the year 2006.

For IB-Solar battery type the linear equation for the year 2006 is,

$$y = 175.51x + 2810.8$$

And value of the Coefficient of Determination is,

$$R^2 = 0.2913$$

Which shows that, the value of R^2 (0.2913) is not near to zero.

So, regression equation is very useful.

From year 2001-2006, production of Industrial Battery-Solar per year has shown in the Figure 4.23 where continuous line represents the moving average curve of two years period and dotted line represent the linear regression line.

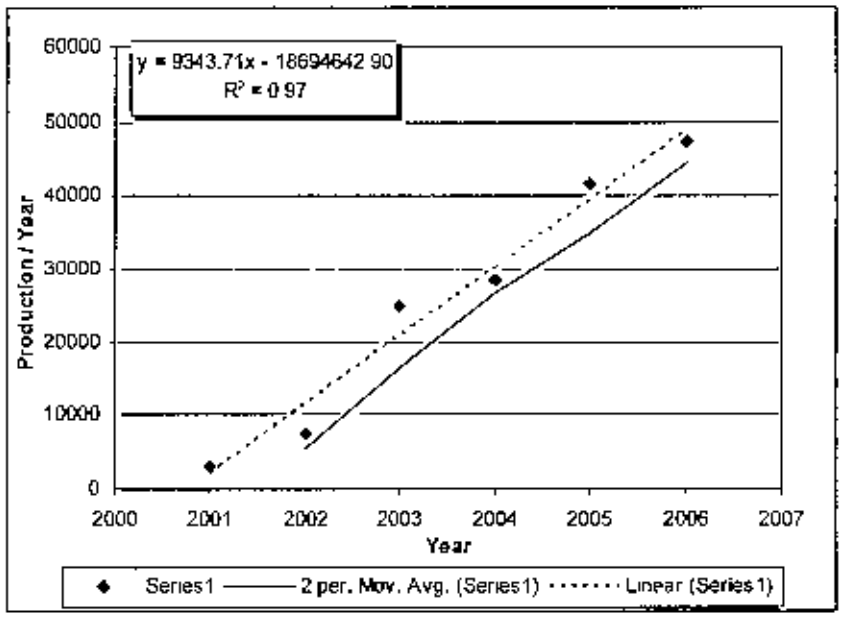


Figure: 4.23 IB-Solar, Production per year

As is observed from the graph, from year 2001 to 2006 there was a sharply increasing of IB-Solar type battery production. In the year 2001 battery production was 3183 units but in the year 2006 battery production was 49419 units, which was well above 1500% greater than year 2001 and 113% greater then year 2005. The most significant thing was that the moving average and regression line were almost parallel.

For IB-Solar battery type, the linear equation from year 2001-2006,

$$y = 9343.71x - 18694642.90 \quad \text{.....(4.5)}$$

And value of the Coefficient of Determination is,

$$R^2 = 0.97 \quad \text{.....(4.6)}$$

Which shows that, the value of R^2 (0.97) is very near to 1.

So, regression equation is very useful.

By using this linear equation it can be accurately forecasted the amount of IB-Solar type battery needs to produce for the next year.

4.4.2 Statistical Analysis

The following analysis shows hypothesis testing on the forecast value.

Hypothesis test:

Let, H_0: $\rho = 0$

H_1: $\rho > 0$ (for right-tailed test)

Significance Level, $\alpha = 5\% = 0.05$

Now,

t_n with $df = n - 2$

Where, $n = 6$ (From year 2001 to 2006)

From t-distribution Table (From Appendix),

$$t_\alpha = t_{0.05} = 2.132$$

It is known that,

t-distribution for a correlation test, $$t = \frac{R}{\sqrt{\frac{1-R^2}{n-2}}}$$

Where,

$R^2 = 0.97$

$n = 6$

$t = 11.372$

Since,

$t > t_{0.05}$, Reject H_0

So, at 5% significance level, the data provides sufficient evidence to conclude that production from year 2001-2006 for IB-Solar type battery is linearly correlated.

According to the tend of the figure 4.23, it is assumed that, next year production rate will increase 40% then using equation (4.5),

$$y = (9343.71x - 18694642.90) + (9343.71x - 18694642.90)*40\%$$

So, Forecasted Production for the year 2007,

$y = (9343.71*2007 - 18694642.90) + (9343.71*2007 - 18694642.90)*40\%$

$y = 81456$ units

From year 2001-2006, production of Industrial Battery-Solar per month has shown in the Figure 4.24 where continuous line represents the moving average curve of two months period and dotted line represent the linear regression line.

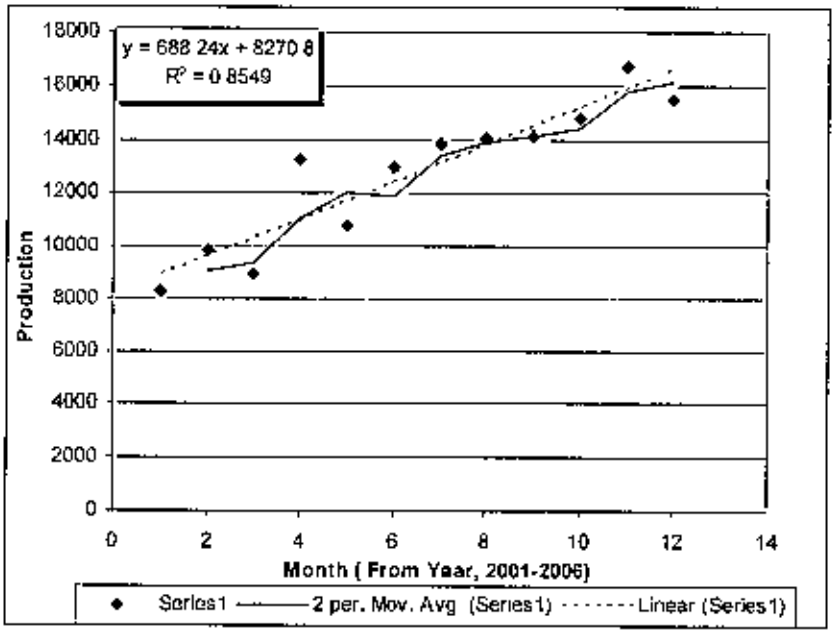


Figure: 4.24 IB-Solar, Total six years production per month

From year 2001-2006, total number of battery production per month was illustrated the above graph. According to the illustration, there was a seasonal effect of the IB-Solar battery production rate. From year 2001-2006, the highest total number of battery produced in month November, which was 16736 units and the second highest was in month December, which was 15483 units. In common, there was a sharp upward trend of battery production from month January-December. The most significant thing is that battery production of month December is as twice as month January.

For IB-Solar battery type, the linear equation for total production per month from year 2001-2006,

$$y = 688.24x + 8270.8$$

And value of the Coefficient of Determination is,

$$R^2 = 0.8549$$

Which shows that, the value of R^2 (0.8549) is near to 1.

So, regression equation is useful.

So, for making decision or forecasting this type of battery production seasonal effect should be considered. First, it needs to forecast the demand for the year 2007 by using the equation (4.5). Then it needs to find out the seasonal factor for per month production. Finally, by using this seasonal factor forecasting can be done for IB-Solar type battery production per month.

4.4.3 Seasonal Factor

A seasonal factor is the amount of correlation needed in a time series to adjust for the season of a year or a period of time. If a year is divided equally into four quarter then,

January-March = Quarter I
April-June = Quarter II
July-September = Quarter III
October-December = Quarter IV

By using average past production from year 2001-2006 it can be find out the seasonal factor of different quarters, which shows in the Table: 4.8

Table 4.8 Seasonal Factor

Quarter	Past Production	Avg. Production for Each Season	Seasonal Factor
(a)	(b)	(c) = 50977 / 4	(b) / (c)
I	9020	12744	0.71
II	12316	12744	0.97
III	13987	12744	1.10
IV	15654	12744	1.23
Total	50977		

Forecasting of Production by Using Seasonal Factor:

It can be forecast the number of battery needs to produce in different quarters in the year 2007 by using seasonal factor of table: 4.8

Forecasting of production in different quarters by using seasonal factor has shown in Table 4.9

Table 4.9 Forecasted Production for IB-Solar Type Battery

Quarter	Expected Production for next year	Avg. Production for Each Session	Seasonal Factor	Next year Forecast
(a)	(b)	(c) = (b) / 4	(d)	(c) x (d)
I		20364	0.71	14413
II		20364	0.97	19680
III		20364	1.10	22350
IV		20364	1.23	25013
Total	81456			

So, For IB-Solar type battery forecasted production for the year 2007 is given below:

January-March	= 14413	units
April-June	= 19680	units
July-September	= 22350	units
October-December	= 25013	units
Total	= 81456	units

4.5 ANALYSIS FOR IB-EXPORT TYPE BATTERY

Production of Industrial Battery (IB) Export during the 12 months of the last six years has shown in the Table 4.10:

Table 4.10 Actual Demand for IB-Export Type Battery

	Month	Production Per Year						Total
		2001	2002	2003	2004	2005	2006	
1	Jan	500	11700	9555	2595	100	600	25050
2	Feb	771	660	1535	2470	0	6748	12184
3	Mar	1560	1134	943	975	1475	0	6087
4	Apr	967	1167	13210	7441	1075	1292	25152
5	May	1190	4919	1900	11000	1111	206	20326
6	Jun	604	3218	2615	350	0	955	7742
7	Jul	980	664	2477	2650	0	2306	9077
8	Aug	1485	1754	1675	2192	584	100	7790
9	Sep	492	1028	0	1594	720	874	4708
10	Oct	1266	1666	4088	1725	0	2050	10795
11	Nov	2416	1056	685	2726	0	1325	8208
12	Dec	11100	1700	36	10380	1806	2892	27914
Total		23331	30666	38719	46098	6871	19348	165033

4.5.1 Discussion

Production of IB-Export per month for the year 2001 has shown in the Figure 4.25 where continuous line represents the moving average curve of two months period and dotted line represent the linear regression line.

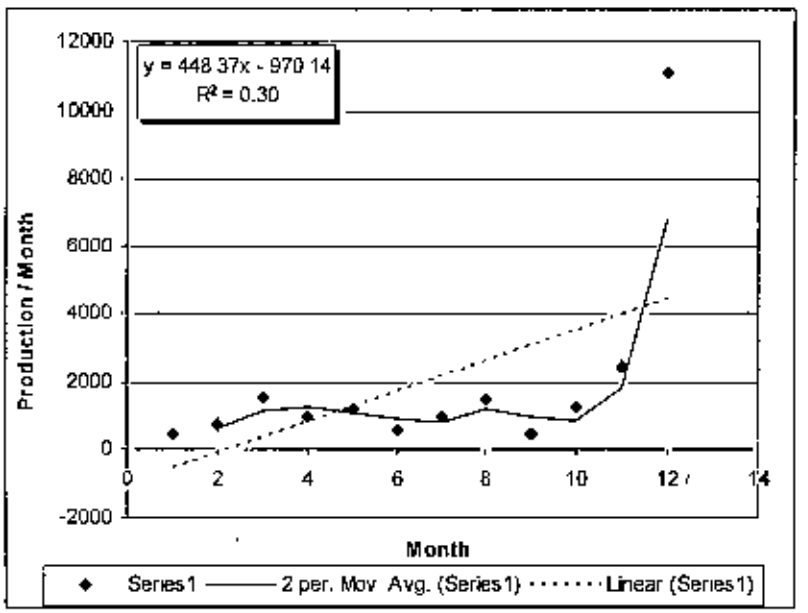


Figure: 4.25 IB-Export, Year 2001

For the year 2001, according to the illustration, there was a cyclic change of IB-Export type battery production from month January to September. But after month September there was an exponential growth of production up to month December. The highest amount of battery was produced in month December, which amount was 11100 units. To sum up, there was a sharp upward trend of IB-Export battery production for year 2001.

For IB-Export battery type the linear equation for the year 2001 is,

$$y = 448.37x - 970.14$$

And value of the Coefficient of Determination is,

$$R^2 = 0.30$$

Which shows that, the value of R^2 (0.30) is near to Zero.

So, regression equation is not useful.

Production of IB-Export per month for the year 2002 has shown in the Figure 4.26 where continuous line represents the moving average curve of two months period and dotted line represent the linear regression line.

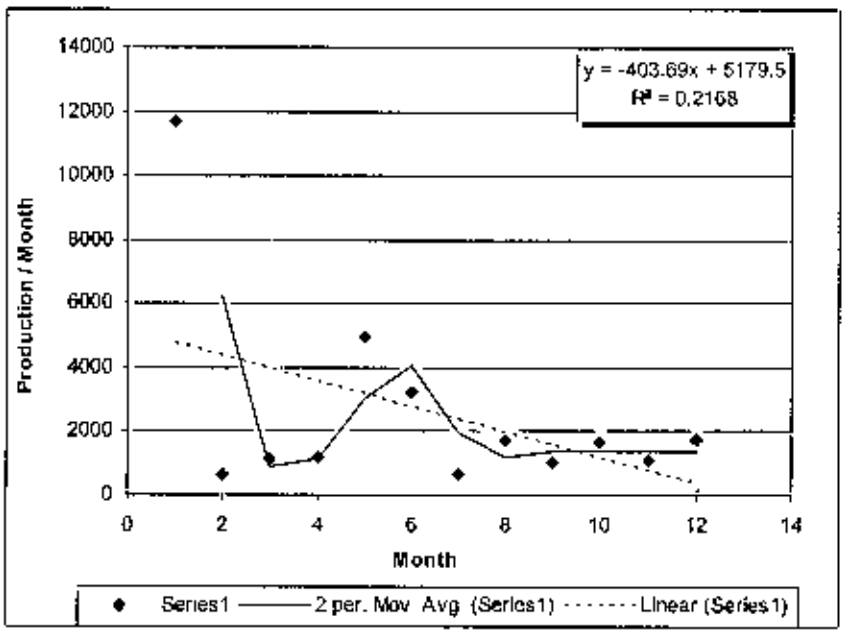


Figure: 4.26 IB-Export, Year 2002

For the year 2002, IB-Export battery production increased rapidly hitting a peak at just below 12000 units in January. But after month January there was a sudden decline of battery production. In general, there was a downward trend of battery production with some vacillation from month February to December.

For IB-Export battery type the linear equation for the year 2002 is,

$$y = -403.69x + 5179.5$$

And value of the Coefficient of Determination is,

$$R^2 = 0.2168$$

Which shows that, the value of R^2 (0.2168) is near to Zero.

So, regression equation is not useful.

Production of IB-Export per month for the year 2003 has shown in the Figure 4.27 where continuous line represents the moving average curve of two months period and dotted line represent the linear regression line.

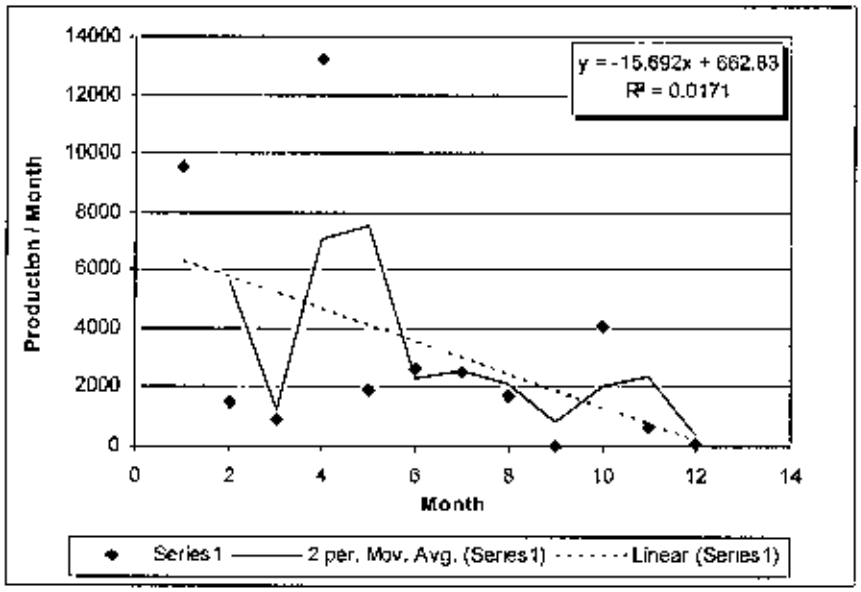


Figure: 4.27 IB-Export, Year 2003

For the year 2003, form month February to March there was a sharp decline of IB-Export type battery production. But, in month April battery production increased suddenly and hitting a peaked at well above 1300 units. After April there was also a sharp decline of battery production with some fluctuations. In brief, there was a decreasing trend of battery production from January to December.

For IB-Export battery type the linear equation for the year 2003 is,

$$y = -15.692x + 662.83$$

And value of the Coefficient of Determination is,

$$R^2 = 0.0171$$

Which shows that, the value of R^2 (0.0171) is very near to Zero.

So, regression equation is very useful.

Production of IB-Export per month for the year 2004 has shown in the Figure 4.28 where continuous line represents the moving average curve of two months period and dotted line represent the linear regression line.

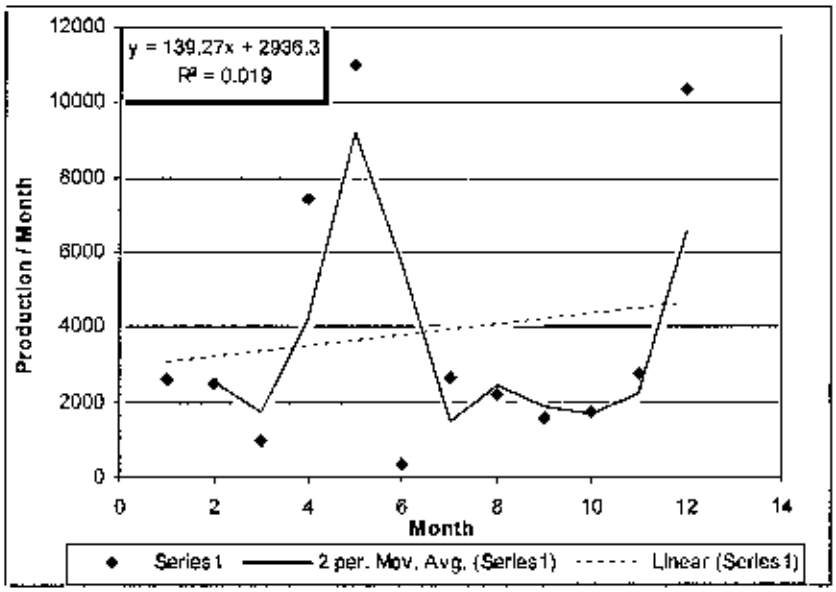


Figure: 4.28 IB-Export, Year 2004

For the year 2004, battery production was almost constant up to February. But after month March there was a dramatic rise of battery production and hitting a peaked at 11000 units in May. After month May there was a sudden decline of battery production and from July to November battery production was changed tediously. In general, there was a gradual upward trend of battery production.

For IB-Export battery type the linear equation for the year 2004 is.

$$y = 139.27x + 2936.3$$

And value of the Coefficient of Determination is,

$$R^2 = 0.019$$

Which shows that, the value of R^2 (0.019) is almost equal to zero.

So, regression equation is not very useful.

Production of IB-Export per month for the year 2005 has shown in the Figure 4.29 Where continuous line represents the moving average curve of two months period and dotted line represent the linear regression line.

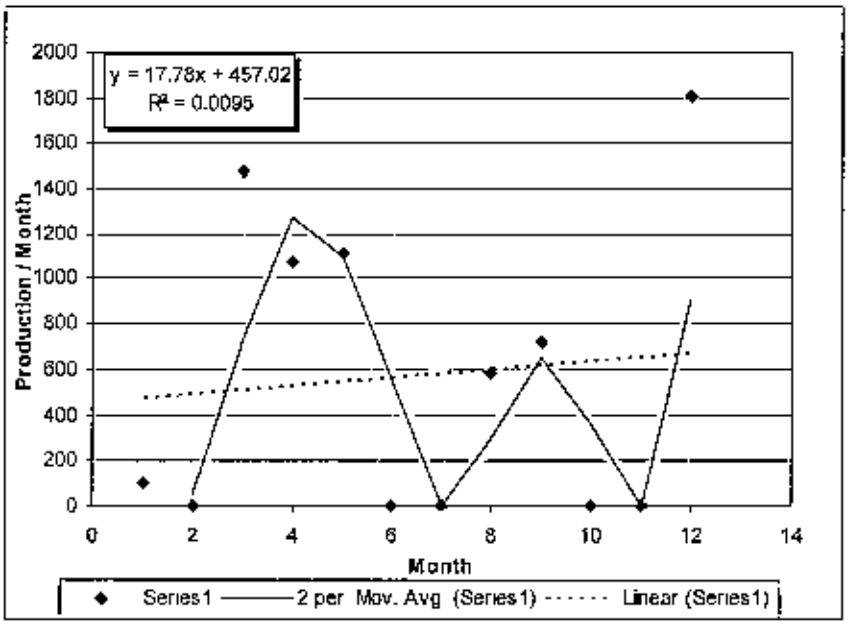


Figure: 4.29 IB-Export, Year 2005

For the year 2005, there was an abrupt change of battery production entire the whole year. The highest amount of battery was produced in June amounting 1806 units. The notable thing was that, there was no IB-Export type battery was produced in month February, June, July, October and November. In common, there was a slight upward trend of battery production for year 2005.

For IB-Export battery type the linear equation for the year 2005 is,

$$y = 17.78x + 457.02$$

And value of the Coefficient of Determination is,

$$R^2 = 0.0186$$

Which shows that, the value of R^2 (0.0095) is equal to zero.

So, regression equation is not useful.

Production of IB-Export per month for the year 2006 has shown in the Figure 4.30 Where continuous line represents the moving average curve of two months period and dotted line represent the linear regression line.

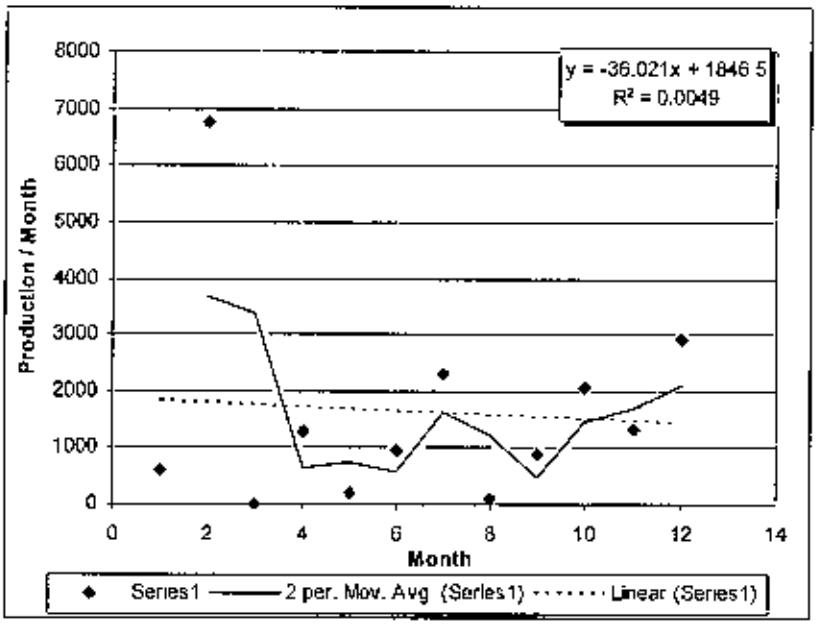


Figure: 4.30 IB-Export, 2006

For the year 2006, battery production increased rapidly from January-February and after February there was a sudden decrease of battery production. From month March to December battery production fluctuated. In month March battery production touched the lowest mark amounting 0 units. In common, there was a downward trend of battery production from month January to December.

For IB-Export battery type the linear equation for the year 2006 is,

$$y = -36.021x + 1846.5$$

And value of the Coefficient of Determination is,

$$R^2 = 0.0049$$

Which shows that, the value of R^2 (0.0049) is almost Zero.

So, regression equation is not useful.

From year 2001-2006, production of Industrial Battery-Export per year has shown in the Figure 4.31 where continuous line represents the moving average curve of two years period and dotted line represent the linear regression line.

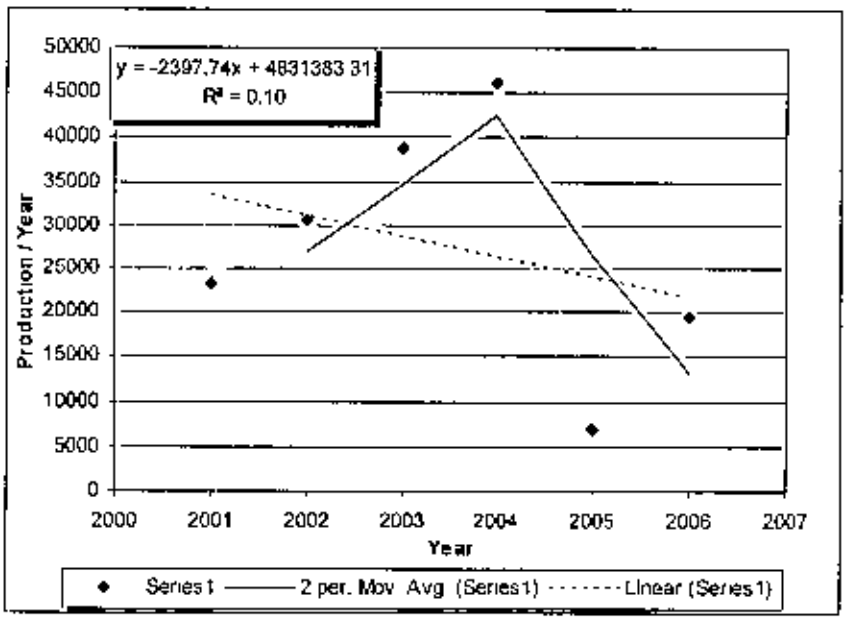


Figure: 4.31 IB-Export, Production per year

According to the graph, almost 25000 units battery was produced at year 2001. But after year 2001, there was a sudden increase of battery production up to year 2004. Highest and lowest amount of battery was produced in year 2004 and 2005 in amounting well above 45000 and 5000 units. In general, there was a downward trend of IB-Export type battery production from year 2001 to 2007

For IB-Export battery type, the linear equation from year 2001-2006,

$$y = -2397.74x + 4831383.31 \quad \text{.....(4.7)}$$

And value of the Coefficient of Determination is,

$$R^2 = 0.10 \quad \text{.....(4.8)}$$

Which shows that, the value of R^2 (0.10) is not near to Zero.

So, regression equation is not useful.

By using this linear equation it can be forecasted the amount of IB-Solar type battery needs to produce for the next year.

4.5.2 Statistical Analysis

The following analysis shows hypothesis testing on the forecast value.

Hypothesis test:

Let, H_0 : $\rho = 0$

H_1 : $\rho > 0$ (for right-tailed test)

Significance Level, $\alpha = 5\% = 0.05$

Now,

t_α with df = n - 2

Where, n = 6 (From year 2001 to 2006)

From t-distribution Table (From Appendix),

$$t_\alpha = t_{0.05} = 2.132$$

It is known that,

t-distribution for a correlation test. $$t = \frac{R}{\sqrt{\frac{1-R^2}{n-2}}}$$

Where,

$R^2 = 0.10$

n = 6

t = 0.667

Since,

$t < t_{0.05}$, Reject H_1

So, at 5% significance level, the data provides sufficient evidence to conclude that production from year 2001-2006 for IB-Export type battery is not linearly correlated.

According to the tend of the figure 4.31, it is assumed that, next year production rate will decrease 10% then using equation (4.7),

$$y = -2397.74x + 4831383.31 - (-2397.74x + 4831383.31)*10\%$$

So, Forecasted Production for the year 2007,

$$y = -2397.74*2007 + 4831383.31 - (-2397.74*2007 + 4831383.31)*10\%$$

y = 17207 units

From year 2001-2006, production of Industrial Battery-Export per month has shown in the Figure 4.32 where continuous line represents the moving average curve of two months period and dotted line represent the linear regression line.

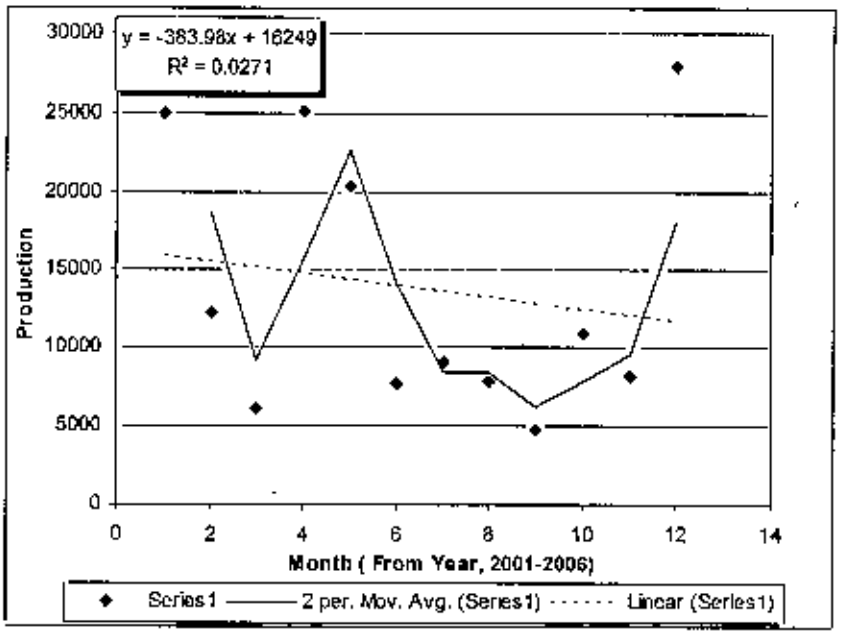


Figure: 4.32 IB-Export, Total six years production per month

From year 2001-2006, total number of battery production per month was illustrated the above graph. According to the illustration, there was a seasonal effect of the IB-Export type battery production. From year 2001-2006, the highest total number of battery produced in month December, which was 27914 units and the second highest was in month April, which was 25152 units. There was a cyclic increase and decrease of battery production from month December to July and after July battery production was fluctuated up to November. In common, there was a slight downward trend of battery production from month January-December.

For IB-Export battery type, the linear equation for total production per month from year 2001-2006,

$$y = -383.98x + 16249$$

And value of the Coefficient of Determination is,

$$R^2 = 0.0271$$

Which shows that, the value of R^2 (0.0271) is very near to Zero.

So, regression equation is not useful.

So, for making decision or forecasting this type of battery production seasonal effect should be considered. First, it needs to forecast the demand for the year 2007 by using the equation (4.7). Then it needs to find out the seasonal factor for per month production. Finally, by using this seasonal factor forecasting can be done for IB-Export type battery production per month.

4.5.3 Seasonal Factor

A seasonal factor is the amount of correlation needed in a time series to adjust for the season of a year or a period of time. If a year is divided equally into four quarter then,

January-March = Quarter I
April-June = Quarter II
July-September = Quarter III
October-December = Quarter IV

By using average past production from year 2001-2006 it can be find out the seasonal factor of different quarters, which shows in the Table: 4.8

Table 4.8 Seasonal Factor

Quarter	Past Production	Avg. Production for Each Season	Seasonal Factor
(a)	(b)	(c) = 55011 / 4	(b) / (c)
I	14440	13753	1.05
II	17740	13753	1.29
III	7192	13753	0.52
IV	15639	13753	1.14
Total	**55011**		

Forecasting of Production by Using Seasonal Factor:

It can be forecast the number of battery needs to produce in different quarters in the year 2007 by using seasonal factor of table: 4.8

Forecasting of production in different quarters by using seasonal factor has shown in Table 4.9

Table 4.9 Forecasted Production for IB-Export Type Battery

Quarter	Expected Production for next year	Avg. Production for Each Session	Seasonal Factor	Next year Forecast
(a)	(b)	(c) = (b) / 4	(d)	(c) x (d)
I		4302	1.05	4517
II		4302	1.29	5549
III		4302	0.52	2249
IV		4302	1.14	4892
Total	17207			

So, For IB-Export type battery forecasted production for the year 2007 is given below:

January-March	= 4517	units
April-June	= 5549	units
July-September	= 2249	units
October-December	= 4892	units
Total	= 17207	units

4.6 ANALYSIS FOR IB-VRLA TYPE BATTERY

Production of Industrial Battery (IB) Valve Regulated Lead-Acid (VRLA) battery during the 12 months of the last six years has shown in the Table 4.13:

Table 4.13 Actual Demand for IB-VRLA Type Battery

	Month	Production Per Year						Total
		2001	2002	2003	2004	2005	2006	
1	Jan	0	2419	1547	693	3	56	4718
2	Feb	641	813	353	844	1	1646	4298
3	Mar	315	3632	2604	5157	3530	1	15239
4	Apr	206	4400	4875	329	586	7583	17979
5	May	1493	424	5340	141	403	3310	11111
6	Jun	4340	1660	2186	3650	442	2890	15168
7	Jul	491	3659	341	1924	0	3177	9592
8	Aug	5616	4156	1673	1521	396	2039	15401
9	Sep	271	2552	4383	992	373	1030	9601
10	Oct	495	1959	1256	3	348	1560	5621
11	Nov	6958	1342	531	1	1635	1579	12046
12	Dec	160	1447	236	0	104	1809	3756
Total		**20986**	**28463**	**25325**	**15255**	**7821**	**26680**	**124530**

4.6.1 Discussion

Production of IB-VRLA per month for the year 2001 has shown in the Figure 4.33 where continuous line represents the moving average curve of two months period and dotted line represent the linear regression line.

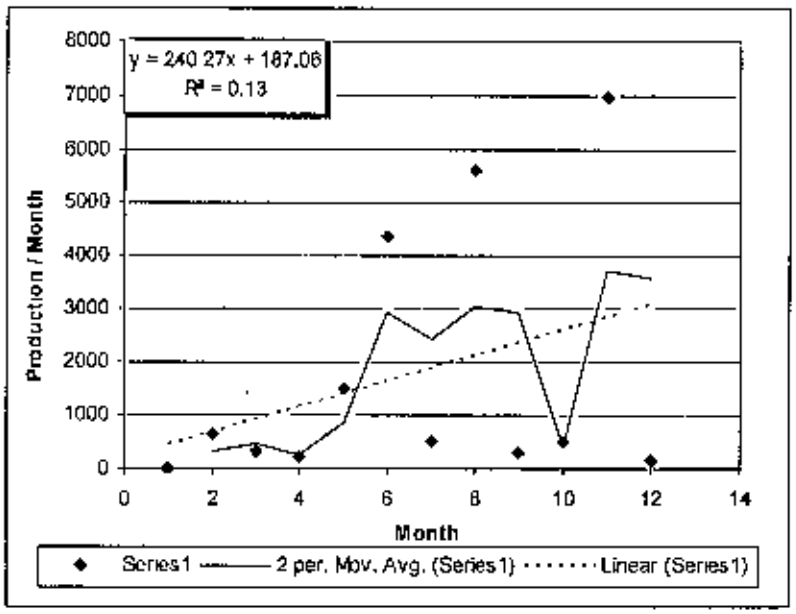


Figure: 4.33 IB-VRLA, Year 2001

For the year 2001, IB-VRLA type battery production increased from month January to February. After month February battery production decreased. But, after month April, there was a sudden increase of this type of battery production with some fluctuation up to month November. In general, there was an increasing trend of this type of battery production.

For IB-VRLA battery type the linear equation for the year 2001 is,

$$y = 240.27x + 187.06$$

And value of the Coefficient of Determination is,

$$R^2 = 0.13$$

Which shows that, the value of R^2 (0.13) is near to Zero.

So, regression equation is not useful.

Production of IB-VRLA per month for the year 2002 has shown in the Figure 4.34 where continuous line represents the moving average curve of two months period and dotted line represent the linear regression line.

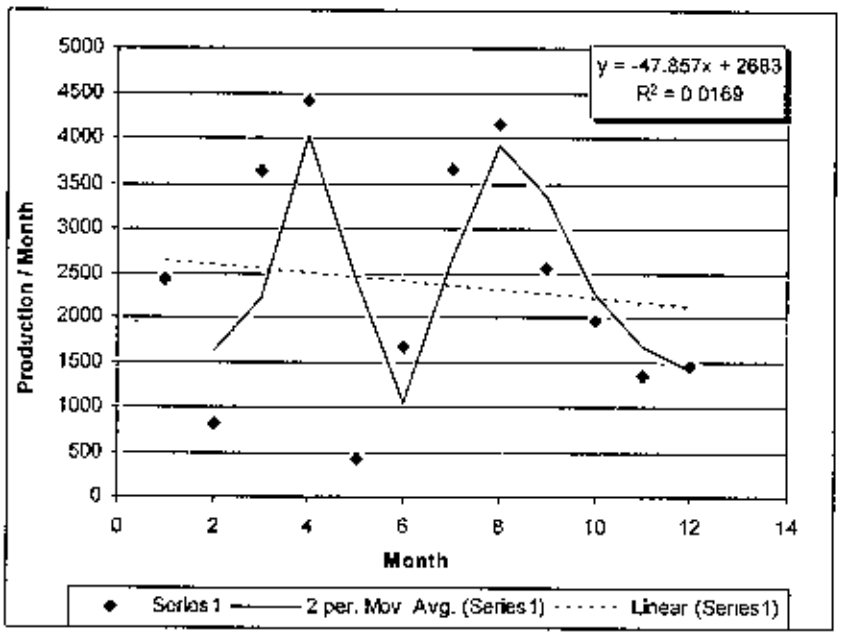


Figure: 4.34 IB-VRLA, Year 2002

For the year 2002, IB-VRLA battery production increased rapidly hitting a peak at just below 4500 units in April. According to the illustration there was two cycles of battery production one was February-May and another was May-December. In general, there was a moderate downward trend of this type of battery production with some vacillation.

For IB-VRLA battery type the linear equation for the year 2002 is,

$$y = -47.857x + 2683$$

And value of the Coefficient of Determination is.

$$R^2 = 0.0169$$

Which shows that, the value of R^2 (0.0169) is near to Zero.

So, regression equation is not useful.

Production of IB-VRLA per month for the year 2003 has shown in the Figure 4.35 where continuous line represents the moving average curve of two months period and dotted line represent the linear regression line.

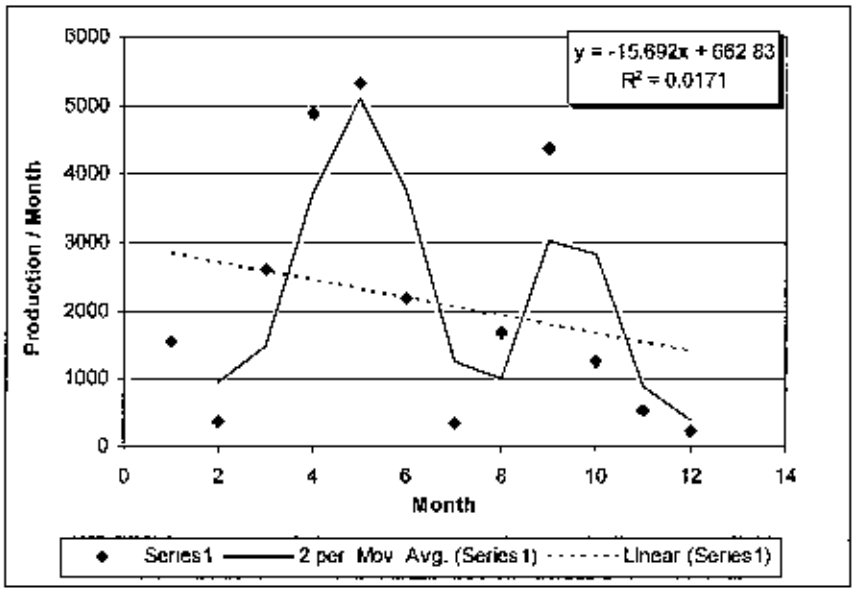


Figure: 4.35 IB-VRLA, Year 2003

For the year 2003, form month February to May there was a sharp increase in IB-VRLA type battery production. Battery production peaked at well above 5000 units in May. After Month May there was also a sharp decline of battery production from month June-July. But after month July again there was sharp increase of battery production. In general, there was decline tend of battery production for year 2003.

For IB-VRLA battery type the linear equation for the year 2003 is.

$$y = -15.692x + 662.83$$

And value of the Coefficient of Determination is,

$$R^2 = 0.0171$$

Which shows that, the value of R^2 (0.0171) is very near to Zero.

So, regression equation is not very useful.

Production of IB-VRLA per month for the year 2004 has shown in the Figure 4.36 where continuous line represents the moving average curve of two months period and dotted line represent the linear regression line.

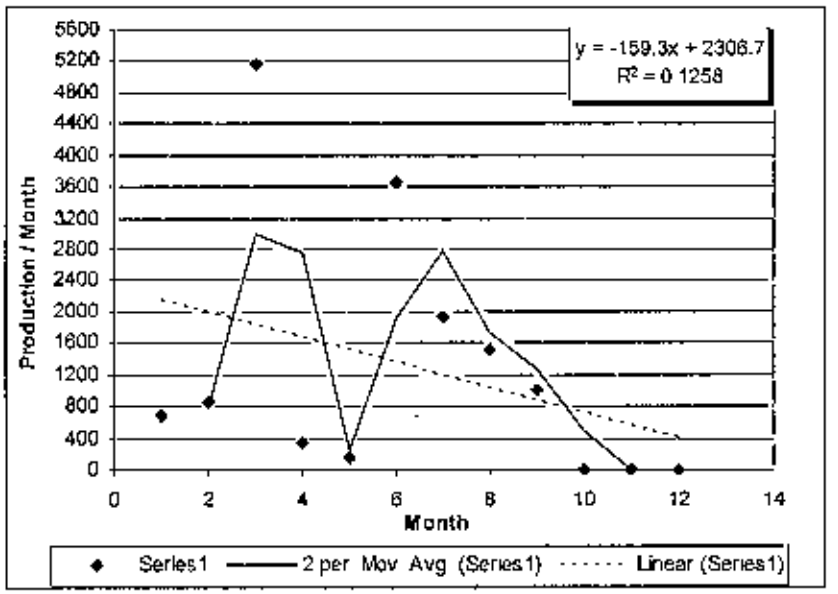


Figure: 4.36 IB-VRLA, Year 2004

For the year 2004, there was abrupt change of battery production from month January to February. In month February battery production was hitting a peak of almost 5200 units. But after month February there was sharp decline of battery production. From month July battery production decreased gradually. There was no battery production from month October to December. In general, there was a downward trend of battery production.

For IB-VRLA battery type the linear equation for the year 2004 is,

$$y = -159.3x + 2306.7$$

And value of the Coefficient of Determination is,

$$R^2 = 0.1258$$

Which shows that, the value of R^2 (0.1258) is near to zero.

Production of IB-VRLA per month for the year 2005 has shown in the Figure 4.37 Where continuous line represents the moving average curve of two months period and dotted line represent the linear regression line.

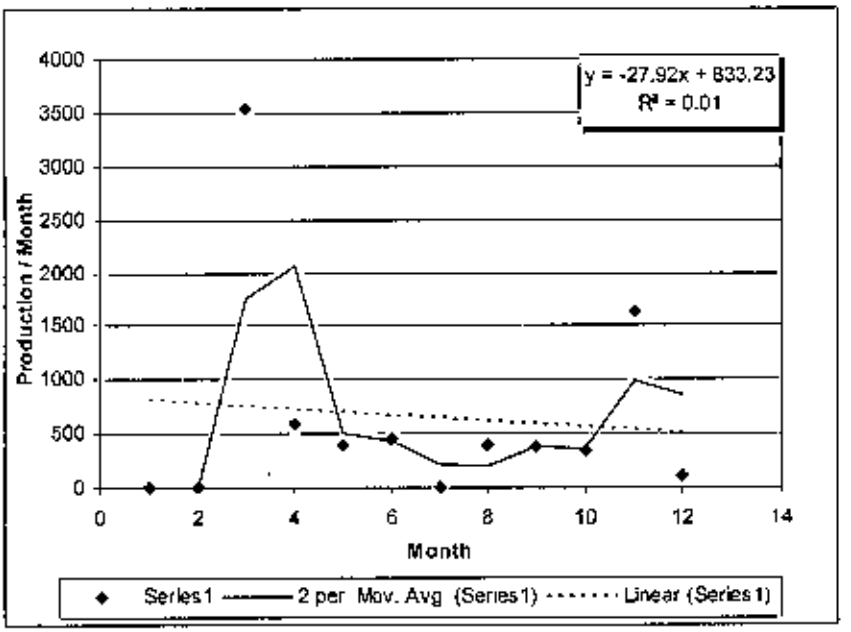


Figure: 4.37 IB-VRLA, Year 2005

For the year 2005, there was an abrupt change of battery production at the beginning of the year. The highest number of battery produced in month February amounting almost 3500 units. From month April to October battery production is almost constant with some fluctuations. There was no battery produced in month January and July. In common, there was decreasing trend of battery production.

For IB-VRLA battery type the linear equation for the year 2005 is,

$$y = -27.92x + 833.23$$

And value of the Coefficient of Determination is,

$$R^2 = 0.01$$

Which shows that, the value of R^2 (0.01) is almost zero.

So, regression equation is not useful.

Production of IB-VRLA per month for the year 2006 has shown in the Figure 4.38 Where continuous line represents the moving average curve of two months period and dotted line represent the linear regression line.

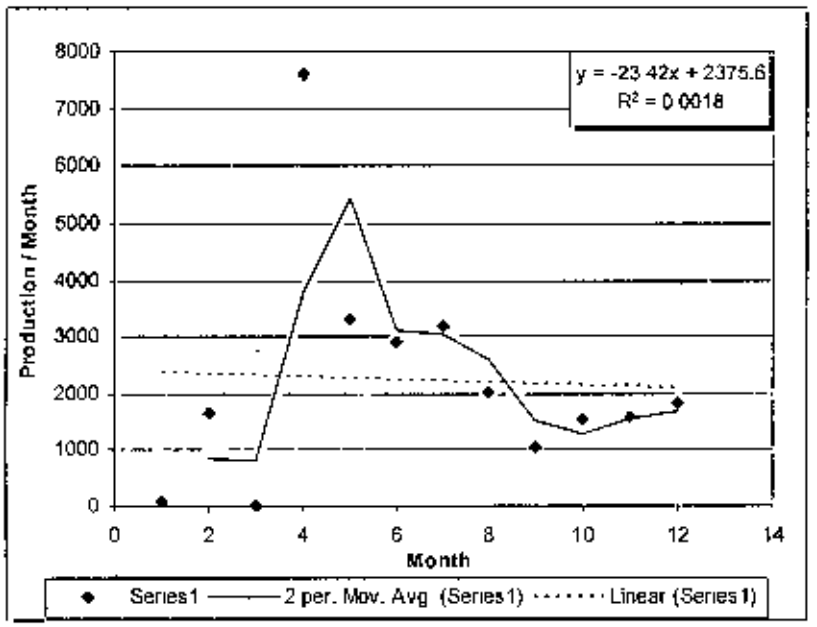


Figure: 4.38 IB-VRLA, 2006

For the year 2006, battery production increased rapidly from January-April. From April to May here was a sudden decrease of battery production. From month May to September battery production decreased gradually. In common, there was a downward trend of battery production from month January to December.

For IB-VRLA battery type the linear equation for the year 2006 is,

$$y = -23.42x + 2375.6$$

And value of the Coefficient of Determination is,

$$R^2 = 0.0018$$

Which shows that, the value of R^2 (0.0018) is Zero.

So, regression equation is not useful.

From year 2001-2006, production of Industrial Battery-VRLA per year has shown in the Figure 4.39 where continuous line represents the moving average curve of two years period and dotted line represent the linear regression line.

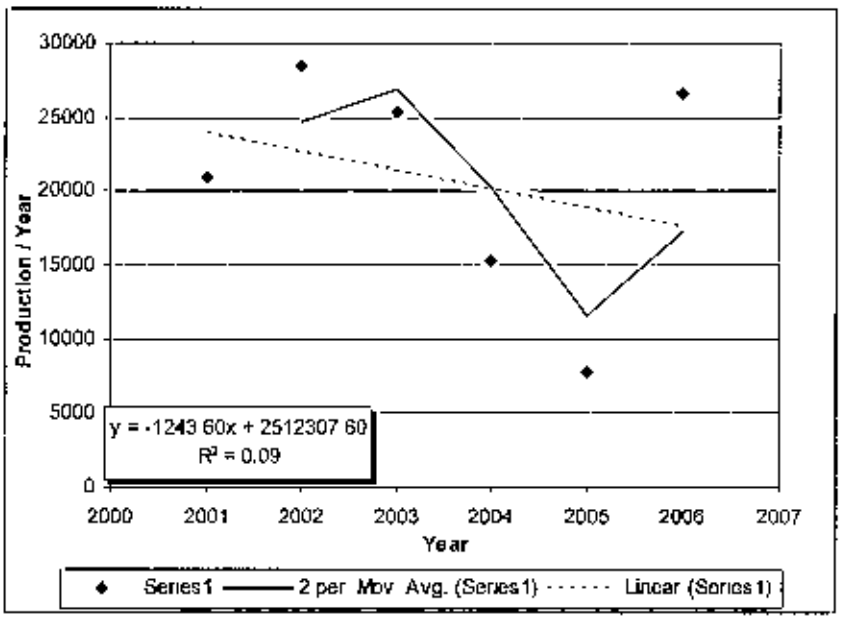


Figure: 4.39 IB-VRLA, Production per year

As is observed from the graph, at year 2001 well above 20000 units of IB-VRLA type battery produced. After year 2001, battery production increased unto year 2002 amounting well below 30000 units. But after year 2002, battery production decreased rapidly up to year 2005 amounting almost 7800 units. In general, there was a decreasing trend of battery production from year 2001 to 2007.

For IB-VRLA battery type, the linear equation from year 2001-2006,

$$y = -1243.60x + 2512307.60 \quad \ldots\ldots\ldots\ldots\ldots\ldots(4.9)$$

And value of the Coefficient of Determination is,

$$R^2 = 0.09 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4.10)$$

Which shows that, the value of R^2 (0.09) is almost 1.

So, regression equation may be useful.

4.6.2 Statistical Analysis

The following analysis shows hypothesis testing on the forecast value.

Hypothesis test:

Let. H_0 : $\rho = 0$

H_1: $\rho > 0$ (for right-tailed test)

Significance Level, $\alpha = 5\% = 0.05$

Now,

t_α with $df = n - 2$

Where, $n = 6$ (From year 2001 to 2006)

From t-distribution Table (From Appendix),

$$t_\alpha = t_{0.05} = 2.132$$

It is known that,

t-distribution for a correlation test, $$t = \frac{R}{\sqrt{\frac{1-R^2}{n-2}}}$$

Where,

$R^2 = 0.09$

$n = 6$

$t = 0.929$

Since,

$t > t_{0.05}$, Reject H_1

So, at 5% significance level, the data provides sufficient evidence to conclude that production from year 2001-2006 for IB-VRLA type battery is not linearly correlated.

It is assumed that. next year production rate will decrease 10% then using equation (4.9),

$$y = (-1243.60x + 2512307.60) - (-1243.60x + 2512307.60)*10\%$$

So, Forecasted Production for the year 2007,

$$y = (-1243.60*2007 + 2512307.60) - (-1243.60*2007 + 2512307.60)*10\%$$

$y = 14762$ units

From year 2001-2006, production of Industrial Battery-VRLA per month has shown in the Figure 4.40 where continuous line represents the moving average curve of two months period and dotted line represent the linear regression line.

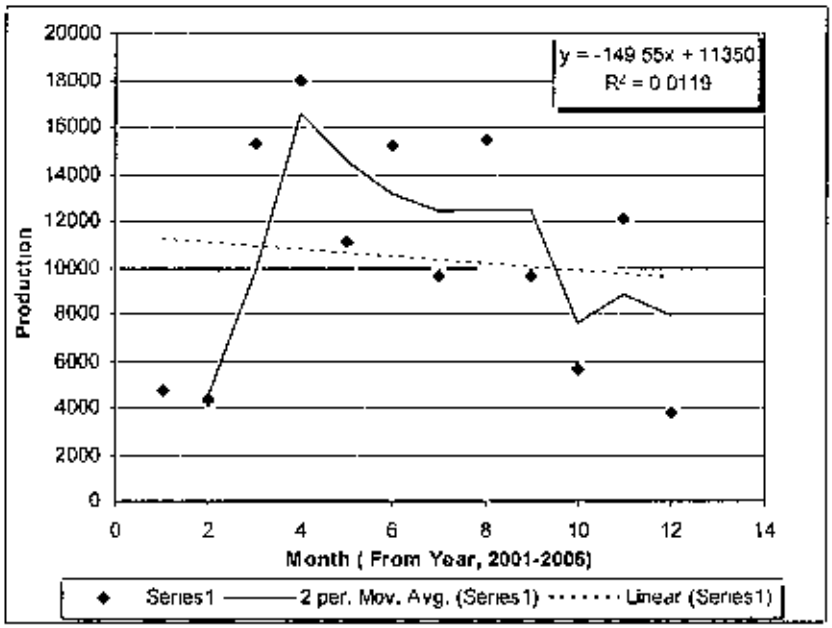


Figure: 4.40 IB-VRLA, Total six years production per month

From year 2001-2006, total number of battery production per month was illustrated the above graph. According to the illustration, battery production of IB-VRLA type was fluctuated every month. From year 2001-2006, the highest total number of battery produced in month April, which was almost 8000 units and the second highest was in month August, which was 15401 units. In common, there was a slight downward trend of battery production from month January-December.

For IB-VRLA battery type, the linear equation for total production per month from year 2001-2006,

$$y = -149.55x + 11350$$

And value of the Coefficient of Determination is,

$$R^2 = 0.0119$$

Which shows that, the value of R^2 (0.0119) is almost Zero.

So, regression equation is not useful.

So, for making decision or forecasting this type of battery production seasonal effect should be considered. First, it needs to forecast the demand for the year 2007 by using the equation (4.9). Then it needs to find out the seasonal factor for per month production. Finally, by using this seasonal factor forecasting can be done for IB-VRLA type battery production per month.

4.6.3 Seasonal Factor

A seasonal factor is the amount of correlation needed in a time series to adjust for the season of a year or a period of time. If a year is divided equally into four quarter then,

January-March = Quarter I
April-June = Quarter II
July-September = Quarter III
October-December = Quarter IV

By using average past production from year 2001-2006 we can find out the seasonal factor of different quarters, which shows in the Table: 4.14

Table 4.14 Seasonal Factor

Quarter	Past Production	Avg. Production for Each Season	Seasonal Factor
(a)	(b)	(c) = 41510 / 4	(b) / (c)
I	8085	10378	0.78
II	14753	10378	1.42
III	11531	10378	1.11
IV	7141	10378	0.69
Total	41510		

Forecasting of Production by Using Seasonal Factor:

It can be forecast the number of battery needs to produce in different quarters in the year 2007 by using seasonal factor of table: 4.14

Forecasting of production in different quarters by using seasonal factor has shown in Table 4.15

Table 4.15 Forecasted Production for IB-VRLA Type Battery

Quarter	Expected Production for next year	Avg. Production for Each Session	Seasonal Factor	Next year Forecast
(a)	(b)	(c) = (b) / 4	(d)	(c) x (d)
I		3691	0.78	2875
II		3691	1.42	5246
III		3691	1.11	4101
IV		3691	0.69	2540
Total	14762			

So, For IB-VRLA type battery forecasted production for the year 2007 is given below:

January-March	= 2875	units
April-June	= 5246	units
July-September	= 4101	units
October-December	= 2540	units
Total	= 14762	units

CHAPTER 5
CONCLUSION & RECOMMENDATION

5.1 CONCLUSION

Although a seasonal variation is observed in the collected production data, it needs statistical analysis for validity, as per standard rule of hypothesis testing. After statistical analysis and observing the trend it was found that there was a huge seasonal effect on the battery demand. The demand of IB-IPS and IB-Solar type batteries were increased rapidly in certain months of a year. So, it should be noted while making master production schedule. But incase of IB-Export and IB-VRLA type battery the effect of seasonal factor was limited. The coefficient of determination (R^2) of IB-Local, IB-Solar type batteries are respectively 0.59 and 0.97. So, the utility of the regression equation for marketing predictions is very strong and forecasting will be perfect. But for IB-IPS, IB-Export, IB-VRLA type battery batteries the value of R^2 are respectively 0.44, 0.10, and 0.09. So, the utility of regression equation for marketing predictions is not strong and there may be deviation of the forecasting demand from the actual demand. Considering all the statistical analysis next year forecasted demand of IB-Local, IB-IPS, IB-Solar, IB-Export and IB-VRLA types batteries will be respectively 2402, 24438, 81456, 17207 and 14762 units.

5.2 RECOMMENDATION

The following recommendations are given:

1) This forecasting system can serve as the basis for their existing ERP system. A more accurate MPS can be prepared from this.

2) As the company is planning to introduce the concepts supply chain management, this forecasting system can help them in this regard.

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APPENDIX 1

YEARLY PRODUCTION

A1.1: Battery Production for Year 2001

Item	Battery Type	Production Per Month												Total
		Jan	Feb	March	April	May	Jun	July	Aug	Sept	Oct	Nov	Dec	
1	IB-Local	425	174	2358	367	419	499	192	208	93	82	124	171	**5112**
2	IB-IPS	592	476	767	742	1165	1089	733	840	800	899	720	409	**9232**
3	IB-Solar	98	111	135	163	165	338	582	301	156	945	157	32	**3183**
4	IB-EXPORT	500	771	1560	967	1190	604	980	1485	492	1266	2416	11100	**23331**
5	VRLA	0	641	315	206	1493	4340	491	5616	271	495	6958	160	**20986**
	Total	**1615**	**2173**	**5135**	**2445**	**4432**	**6870**	**2978**	**8450**	**1812**	**3687**	**10375**	**11872**	**61844**

A1.2: Battery Production for Year 2002

Item	Battery Type	Production Per Month												Total
		Jan	Feb	March	April	May	Jun	July	Aug	Sept	Oct	Nov	Dec	
1	IB-Local	175	314	1348	133	267	219	232	83	13	327	207	207	**3525**
2	IB-IPS	400	490	700	960	1070	1063	714	52	443	422	54	136	**6504**
3	IB-Solar	18	61	294	97	143	494	619	1231	639	501	2080	1340	**7517**
4	IB-EXPORT	11700	660	1134	1167	4919	3218	664	1754	1028	1666	1056	1700	**30666**
5	VRLA	2419	813	3632	4400	424	1660	3659	4156	2552	1959	1342	1447	**28463**
	Total	**14712**	**2338**	**7108**	**6757**	**6823**	**6654**	**5888**	**7276**	**4675**	**4875**	**4739**	**4830**	**76675**

A1.3: Battery Production for Year 2003

Item	Battery Type	Production Per Month												Total
		Jan	Feb	March	April	May	Jun	July	Aug	Sept	Oct	Nov	Dec	
1	IB-Local	60	157	160	186	295	524	495	192	215	425	156	434	3299
2	IB-IPS	141	40	459	999	1327	1032	885	696	621	286	60	184	6730
3	IB-Solar	1155	1707	829	2654	1213	1581	3696	2113	2534	2610	2152	2597	24841
4	IB-EXPORT	9555	1535	943	13210	1900	2615	2477	1675	0	4088	685	36	38719
5	VRLA	1547	353	2604	4875	5340	2186	341	1673	4383	1256	531	236	25325
	Total	**12458**	**3792**	**4995**	**21924**	**10075**	**7938**	**7894**	**6349**	**7753**	**8665**	**3584**	**3487**	**98914**

A1.4: Battery Production for Year 2004

Item	Battery Type	Production Per Month												Total
		Jan	Feb	March	April	May	Jun	July	Aug	Sept	Oct	Nov	Dec	
1	IB-Local	297	48	191	197	569	1741	138	156	411	224	289	156	4417
2	IB-IPS	270	307	686	912	1424	1069	254	500	429	489	369	11	6720
3	IB-Solar	2061	2129	2172	1873	2493	2684	2710	3005	2014	2193	1860	3143	28337
4	IB-EXPORT	2595	2470	975	7441	11000	350	2650	2192	1594	1725	2726	10380	46098
5	VRLA	693	844	5157	329	141	3650	1924	1521	992	3	1	0	15255
	Total	**5916**	**5798**	**9181**	**10752**	**15627**	**9494**	**7676**	**7374**	**5440**	**4634**	**5245**	**13690**	**100827**

A1.5: Battery Production for Year 2005

Item	Battery Type	Production Per Month												Total
		Jan	Feb	March	April	May	Jun	July	Aug	Sept	Oct	Nov	Dec	
1	IB-Local	306	144	328	133	294	333	366	289	24	38	238	24	**2517**
2	IB-IPS	303	537	1484	1194	734	1743	419	626	996	647	983	252	**9918**
3	IB-Solar	2117	2869	2516	2582	3236	4357	2836	3973	5026	4793	4205	3125	**41635**
4	IB-EXPORT	100	0	1475	1075	1111	0		584	720	0	0	1806	**6871**
5	VRLA	3	1	3530	586	403	442		396	373	348	1635	104	**7821**
	Total	**2829**	**3551**	**9333**	**5570**	**5778**	**6875**	**3621**	**5868**	**7139**	**5826**	**7061**	**5311**	**68762**

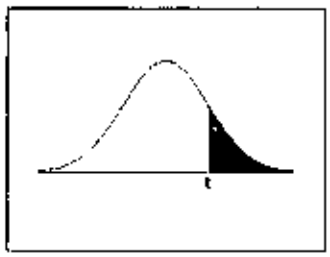
A1.6: Battery Production for Year 2006

Item	Battery Type	Production Per Month												Total
		Jan	Feb	March	April	May	Jun	July	Aug	Sept	Oct	Nov	Dec	
1	IB-Local	12	255	742	74	220	180	247	182	325	72	40	178	**2527**
2	IB-IPS	19	978	2775	2931	2515	2077	2494	1693	2453	3100	2270	1118	**24423**
3	IB-Solar	28821	3016	2951	5880	3525	3471	3360	3434	3732	3701	6282	5246	**73419**
4	IB-EXPORT	600	6748	0	1292	206	955	2306	100	874	2050	1325	2892	**19348**
5	VRLA	56	1646	1	7583	3310	2890	3177	2039	1030	1560	1579	1809	**26680**
	Total	**29508**	**12643**	**6469**	**17760**	**9776**	**9573**	**11584**	**7448**	**8414**	**10483**	**11496**	**11243**	**146397**

APPENDIX 2

t-DISTRIBUTION TABLE

A2: t-Distribution Table



The shaded area is equal to α for $t = t_\alpha$.

df	$t_{.100}$	$t_{.050}$	$t_{.025}$	$t_{.010}$	$t_{.005}$
1	3.078	6.314	12.706	31.821	63.657
2	1.886	2.920	4.303	6.965	9.925
3	1.638	2.353	3.182	4.541	5.841
4	1.533	2.132	2.776	3.747	4.604
5	1.476	2.015	2.571	3.365	4.032
6	1.440	1.943	2.447	3.143	3.707
7	1.415	1.895	2.365	2.998	3.499
8	1.397	1.860	2.306	2.896	3.355
9	1.383	1.833	2.262	2.821	3.250
10	1.372	1.812	2.228	2.764	3.169
11	1.363	1.796	2.201	2.718	3.106
12	1.356	1.782	2.179	2.681	3.055
13	1.350	1.771	2.160	2.650	3.012
14	1.345	1.761	2.145	2.624	2.977
15	1.341	1.753	2.131	2.602	2.947
16	1.337	1.746	2.120	2.583	2.921
17	1.333	1.740	2.110	2.567	2.898
18	1.330	1.734	2.101	2.552	2.878
19	1.328	1.729	2.093	2.539	2.861
20	1.325	1.725	2.086	2.528	2.845
21	1.323	1.721	2.080	2.518	2.831
22	1.321	1.717	2.074	2.508	2.819
23	1.319	1.714	2.069	2.500	2.807
24	1.318	1.711	2.064	2.492	2.797
25	1.316	1.708	2.060	2.485	2.787
26	1.315	1.706	2.056	2.479	2.779
27	1.314	1.703	2.052	2.473	2.771
28	1.313	1.701	2.048	2.467	2.763
29	1.311	1.699	2.045	2.462	2.756
30	1.310	1.697	2.042	2.457	2.750
32	1.309	1.694	2.037	2.449	2.738
34	1.307	1.691	2.032	2.441	2.728
36	1.306	1.688	2.028	2.434	2.719
38	1.304	1.686	2.024	2.429	2.712
∞	1.282	1.645	1.960	2.326	2.576