Manufacturing Excellence and Innovation to Deliver Business Growth

Future of Manufacturing Technologies

SMART manufacturing
Contents

- Smart Manufacturing
- Current Challenges
- Future organization
- Road map for smart Manufacturing Plants
- Examples
TVS Motor, the Journey...

TVS Motor – Sales Trend 2.0 Million Vehicles with turn over of closely 1.3 Billion US$

1979 – Hosur plant

1997 - Mysore plant

2006 – Himachal Plant

2006 - 3 Wheeler Plant

2007 – Indonesia plant

TVS Motor, the Journey...
Drive towards TVS Mfg systems for growth.....
TVS MOTOR Products...

Each product group has value to customer

- **Mopeds**
- **Scooters**
- **Motorcycles Executive & Economy**
- **3 Wheeler**
- **Motorcycles Premium**
Present scenario of Automobile sector In India
Quick Look at Indian Economy

• India is the 10th largest economy in the world

• In last fifteen years consuming class (middle class and aspirant house holds) have grown from 52 million to 116 million.

• India is the second largest manufacturer of small passenger vehicles, buses and two wheelers in the world.

Source:- IMF, Dr. Rajesh Shukla and SIAM
<table>
<thead>
<tr>
<th><strong>Indian Auto Industry: Today</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Market Size</strong></td>
</tr>
<tr>
<td>• 18mn domestic units in FY15</td>
</tr>
<tr>
<td>• Production Capacity increased from 11mn in FY05 to 25mn in FY15</td>
</tr>
<tr>
<td><strong>Potential</strong></td>
</tr>
<tr>
<td>• Only 35 cars and 90 two wheelers per 1000 population</td>
</tr>
<tr>
<td><strong>Global Footprint</strong></td>
</tr>
<tr>
<td>• In the last five years number of players increased from 18 to 44 and exports from 1.4mn to 3.1mn</td>
</tr>
<tr>
<td><strong>Employment Generation</strong></td>
</tr>
<tr>
<td>• One commercial vehicle generates jobs for roughly 21 people.</td>
</tr>
<tr>
<td>• In the last ten years more than 19mn additional jobs</td>
</tr>
<tr>
<td><strong>GDP Contribution</strong></td>
</tr>
<tr>
<td>• Automobile sector contributes to 7.1% of GDP with a turnover of nearly USD110bn</td>
</tr>
</tbody>
</table>
….And Industry at the growth threshold…

Two Wheeler Penetration and GDP Per Capita

SOURCE: Credit Suisse Aug 2012
Supported by Increasing Affordability…
...And Widening Choices

Number of New Two wheeler Product launches per year
**Trends.**

- “Customer Base is ever expanding and ever demanding – Product Variety, Quality, Cost, Reliability, Lead times

- Green shoots of economic revival?

- Improving but fragile consumer sentiments

- Increasing competitiveness.

- Technology lead innovation to define future growth
Buzz Words in Manufacturing

Modern Manufacturing System

6 Sigma
JIT
Pull System
SOP
Lean Manufacturing
Mizusumashi
SMED
TPM
Kanban
TQM
Kobetsu Kaizen
Andon
Pokayoke
5S
Andon
QC Circle
Jishu Hozen

All are interlinked ....... Towards......improvements
Key Elements to Establish Modern Manufacturing System

- Two Steps Training
- Standardized Operations
- Flow Manufacturing
- Quality Assurance in Process
- Low Cost Automation
- Fool Proof System
- Operators’ Involvement in Improvement
- Operators’ Daily Checking of Machines
- Good Housekeeping
- Visual Control
- Visual Information System
- Simple Production Planning
- Quick Changeover
- Parts Supply System
- Modern Manufacturing System

Business Oriented Manufacturing
Aim is to establish connection between and within all critical 4M of manufacturing (Man, Machine, Material and Methods) and use this data effectively to produce Zero defect products.

In second phase this data was utilized for efficient performance of other business processes.
Indian GDP is expected to raise steadily

- 2000: $47 b
- 2010: $1708 b
- 2013: $1870 b
- 2019: $3096 b

Source: IMF, GDP USD current prices
India and China:

2000

2010

2020
What should be our Winning or next practices....

It is not the strongest species that survive, nor the most intelligent, but the ones most responsive to change.

Charles Darwin
The Challenge of Change: within and across
Business Challenges: The going gets tough...

- Competition, Global Players Muscle
- Financial Health, Strong system support.
- Supply Chain woes
- Rising Aspirations, IR Issues
- Squeezing Margins
- Customer Preferences, Dynamic Customer Profiles
- Rising Fuel Prices
- Regulatory Norms, Alternate Fuels (Diesel)
VUCA World – Major disruption by 2020

- Market is Volatile, Customer demands are Uncertain and Complex, Action to be taken in Ambiguity

- 50 billion – connected devices like Internet of things (IoTs)... Smart and Artificial Intelligence (AIs)

- More than 5 devices / person and 10 devices / connected individual

- Q Brain
New Role for Supply chain in flat world

• Continue to focus on Value stream mapping but extend to Product development, Customer service and Logistics
• Integration of Traditional concepts and process improvement – Lean, Six Sigma, TOC (theory of constraints)
• Collaborative working
• Involve Suppliers in Technology growth
• Back bone of industry
Actions in VUCA world KRI & KAI

• VUCA World

• Requires Change in Key Result Indicator (KRI) - SPEED, Agility, Flexibility

• Change in Key Activity Indicator (KAI)
  • Anticipate Change
  • Generate Confidence
  • Initiate action
  • Liberate Thinking
  • Evaluate Results

Supply Chain  
End to End Supply system 4.0
Challenges of Manufacturing

- Lead time to market
- Productivity
- Flexibility
- Process Quality
- Uptime
- Energy consumption
- Cost of ownership
- Environment
Plan for future-End to End Connected Organisation

Supplier → Factory → Dealer → Customer

IOT (internet of things) → Information Flow
Data lifecycle in IoT

- Integration
- Data mining
- Alerts
- Storage
- Dash boarding
IOT value framework

- Business Strategic & Innovation
  - Connected vehicles
  - Bigdata
  - Integrated intelligence
  - Process parameter control
  - Smart manufacturing
  - Energy management

- Operational excellence
  - Connected supply chain
  - TPM
  - Building management system

- Hygiene and aesthetics
  - Genealogy of vehicle
  - Traceability
  - Security & control
  - Visitor management

SMART MFG
Internet of things

- Connected people
- Connected devices
- Smart manufacturing
- Connected supply chain
- Connected products
- Connected enterprise
Connected assets – benefit areas

- Operational monitoring and alerting
- Remote service and repair
- Performance history
- Predictive maintenance
- Performance benchmarking
- Intelligence and analytics
- Total productive maintenance (TPM)
Trends in SMART manufacturing

- Rapid Prototyping
- Light Weight material
- New Geometries & Form Functions
- High Strength to weight Ratio

- Digital Supply Chain
- Real Time tracking of material and Deliveries
- Optimized Pricing and sourcing
- Predictive maintenance

- Additive Manufacturing

- Demand Driven Supply Chain using Big Data

- Distributed Manufacturing

- Strategic Outsourcing
- faster New Product Intro (NPI)
- Optimized Logistic
- Virtually Connected factories

- Focus on Customer and Market
- Product Customization
- Inventory Optimization
- Improved Capital ratio
Smart manufacturing objectives

- Automation
- Process control
- Traceability
- Analytics
- Improve predictability
- Zero defect
Connected manufacturing – benefit areas

- Unified real time visibility
- Automation
- Process parameter control
- Traceability
- Condition based maintenance
- Six sigma and lean

Visibility into manufacturing drives Cost optimization and reduce wastages
Connected manufacturing – benefit areas

- Green enterprise
  - Pollution monitoring
  - Water measurement
  - Power meter

Visibility into manufacturing drives Cost optimization and reduce wastages
Application areas for IoT in manufacturing supply chain

- Energy efficiency
- Operational efficiency
- Maintenance efficiency
- Service efficiency
- Supply chain efficiency
- Assets efficiency
Next Practices

Speed of Action and according to opportunity

Focus on New Opportunities:
Create new opportunities

Focus on Customer Value +
Combination of Systems and Tools
+ SPEED of Action
Product Innovation

Key Elements

Business Excellence  Manufacturing Excellence

Society

Supply Chain (Design to Delivery)

Process

Product

Societal factors (Culture, People, Environment)

Economic Factors (Political, Global trends, GDP)

Business

Customers
Process Innovation

Drivers

Manufacturing Excellence

- Time
- Cost
- Quality

Business Excellence

- Product Development (Market In Approach)
- People & Leadership (Noble Mind, Contributing to society)
- Sustainable Growth (Break Thru)

Internally driven

Externally driven
System Innovation through IOT

Drivers

Manufacturing Excellence

SMART MFG

Instrumented – Real time Visibility

Intelligent
Advanced Optimisation

Interconnected
System to System Integration

Time

Cost

quality

Internally driven

Externally driven
IOT Industry 4.0 drivers

Drivers

SMART MFG

Collect

Instrumented – Real time Visibility

Intelligent
Advanced Optimisation

Interconnected
System to System Integration

Control
Configure

Internally driven

Externally driven
Smart Manufacturing

Zero Defect Assembly

Smart Manufacturing Plant

- Traceability
- Supplier connectivity
- Zero defect Machine/Measuring and Gauging
- Machine data Capturing
- Dealer connectivity
- Environment
  - Water consumption
  - Waste management
Sensors available in the market

- Temperature
- Speed
- Motion
- Rotation
- Presence
- Absence
- Level
- Volume
- Leak
- Weight
- Humidity
- Lumens
- Decibels
- Length
- Distance
- Voltage
- Pressure
- Torque
- Angle..
EXAMPLES
Currently Implemented: Zero Defect Cell in Engine Assembly Line

<table>
<thead>
<tr>
<th>Station No/ Name</th>
<th>Sl No.</th>
<th>Zero Defect Measure</th>
<th>Sensor Used</th>
<th>Working Y/N</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>STATION-AUX1</td>
<td>1</td>
<td>Scan the barcode of Cylinder head &amp; Cover</td>
<td>2-D Cognex Scanner</td>
<td>N</td>
<td>Require 2D barcode</td>
</tr>
<tr>
<td>SAI NOZZLE</td>
<td>2</td>
<td>Vision verification of Oil Hole clearance in Cylinder head through Checker</td>
<td>Cognex Checker</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>PRESSING</td>
<td>3</td>
<td>If it is OK, suction Air will get on, load the Nozzle &amp; press start</td>
<td>Nozzle Presence Sensor</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>STATION-AUX2</td>
<td>1</td>
<td>Avoid Wrong picking</td>
<td>Door with proximity sensor</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>KITTING</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>STATION-1</td>
<td>1</td>
<td>Press start for vision inspection of presence &amp; absence of kitting parts. Captured image will be displayed on the Monitor</td>
<td>Cognex Camera</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>PRECHECK AND</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DAMPER PRESSING</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Scan the barcode of Cylinder head &amp; Cover</td>
<td>2-D Cognex Scanner</td>
<td>N</td>
<td>Require 2D barcode</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Cylinder Head clamps using Gear &amp; Worm Mechanism</td>
<td>Torque Feed Back-Servo</td>
<td>Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Damper presence</td>
<td>Sensor</td>
<td>Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Zero Defect Machine

Idea:- Integrate smart sensors for checking & correcting accuracy to ensure zero defect to next customer

<table>
<thead>
<tr>
<th>AUTO COMPENSATION</th>
<th>AUTO CORRECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROBING</td>
<td>PROBING</td>
</tr>
<tr>
<td>TOOL BREAKAGE SENSOR</td>
<td>TOOL BREAKAGE SENSOR</td>
</tr>
<tr>
<td>BURR FREE FIXTURE</td>
<td>BURR FREE FIXTURE</td>
</tr>
<tr>
<td>PRE OPN CHECK</td>
<td>PRE OPN CHECK</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PART SENSOR</th>
<th>PART SENSOR</th>
<th>PART SENSOR</th>
<th>PART SENSOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRESSURE SWITCH</td>
<td>PRESSURE SWITCH</td>
<td>PRESSURE SWITCH</td>
<td>PRESSURE SWITCH</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Level -1</th>
<th>Level -2</th>
<th>Level -3</th>
<th>Level -4</th>
</tr>
</thead>
</table>

SMART MACHINE

**MECHANICAL ASPECTS**

- Design optimisation (Material selection, Heat treatments etc)
- Flexible machines (with minimal change should be able to use for other models)
- Maintainability (MTTR, MTBF)
- Accessibility inside the machine for maintenance
- Ergonomics friendly
- Provision for auto loading/unloading front by floor and gantry
- Provision for top gantry implementation
- Fixture to be free from burrs and contamination
- No burr accumulation inside the machine
- Hydraulics less machine or minimal hydraulic/compact hydraulic

**ELECTRICAL ASPECTS**

- Latest version PLC and CNC to be used
- Field bus control (Ethernet based) 100Mbps CAT 6.0 Standard
- CNC/PLC should be same to automation plc’s
- ASI Interface on ethernet for all field sensors
- Wireless communication b/w master and slave
- Drives on ethernet based Protocol
- 10" HMI display
- 15% spare space with 24/24 spare DI/DO
- Led lights for cabinet and machine
- SSR relays

**Checks for a Smart Machine**

2015-16
Traceability system

- Traceability system for processing lines.
- Accumulate process and inspection history of work (engine).
- Send information on each process every time work passes by.

- **Time**
- **Serial number**
- **Equipment number**
- **Tool condition**
- **Processing environment**
- **Inspection result**

- **Approx. 200 words**

- **CF card buffer**
  - temp
  - back-up

- **Backup server**
  - *Daily data backup (Function of SQL Server)*

- **Traceability server**
  - *History search, display function*
  - *Redundant HDD (RAID)*

- **Ethernet**
  - **SQL**
    - MES interface module Q71MES96
    - ID tag
    - Robot
    - Processing machine

  - **Cleaning**

  - **Inspecting**

- **Smart MFG**
360 degree view of Vehicle

Customer
- Demographic
- Insurance
- Loan
- Mera Fnd (Loyalty)
- NPS, Voice

Vehicle information

Process parameters
- Engine mainline
- Engine sub-assembly
- Vehicle mainline
- Vehicle sub-assembly
- Tightening torques and angle
- Parts pairing
- Error proofing

Service
- Service history
- Parts changed
- Warranty
- CSI, Voice

Test results
- End of line
- ABS
- Roller test bench
- Gauging
- CMM
- Leak testing

Genealogy
In house parts
Bought-out
On-line OEE

Business Objectives
- On-line measurement of OEE
- PDCA to be improved from week to shift to hours
- Analysis should help the shop floor managers to take corrective action

Background
- OEE is important for
  - Measuring efficiency
  - Capacity calculation
  - Continuous improvement in productivity
- Loss of capacity to be analyzed
- Faster PDCA will help in faster action to reduce waste

Actions Implemented
- Two critical operations in a cell are provided with DAQ
- 400 DAQ are connected on-line to centralized server for OEE calculation
- Data entry touch boards to 400 machines
- WiFi in shop floor
- Patented DAQ

Benefits
- On-line production, scrap and OEE report
- Hourly PDCA enabled

Future Improvement
- To extend DAQ for Welding, painting process

Future plan
- Predictive maintenance
Integrated EHS systems

**Background**
- 14 Wells collect water
- Collection of water based on ground water level
- Ground water level should be monitored before drawn
- Water drawn should be measured and reported
- Cost effective automated system

**Actions Implemented**
- Remote measurement of water drawal

**Benefits**
- Manpower saving
- Prevention of pump breakdown

**Future plan**
- Standardization in other plants

**Results achieved**
- Automated system and no manual intervention
- Automated reports to PCB

**Further Improvement**
- Sensors for ground water level monitoring and drawal
Truck locator

- **On-line monitoring of truck movement from Hosur, Mysore and HP**
- **Vehicle availability to promise**
- **Predictability improvement**

![Map of South Asia with highlighted trucks]
Digital Inspection and Process controls

Road Map for Smart Machining lines

Manufacturing Operations Management

Manufacturing Execution System

Intelligent Machines
- Automated adjustment in process parameters
- Robot / pick and place setup

SQC/SPC interact with machines
- Measure Product specification and monitor SQC charts
- SQC monitoring

Manufacturing Operations Management

Manufacturing Execution System

Intelligent Machining line
- Automated correction between machine parameter/adjustments
- Machines talks each other

Unmanned Machining line
- Automated part feeding
- Auto Part transfer from line stores

Interaction between cells

(Dark room Industry)

Multiple plants interact

plants Interaction

Independent Machining plants
- Interaction between cells
- Pressing Fabrication
- Painting
- Machining
- Engine assy
- Vehicle assy

Automated material movement, RFID, Barcode, Intelligent Sensors

Automated material handling, Machine monitoring & maintenance (MTBF)

Road Map for Smart Machining lines

SMART MFG
12 Facts You Need to Know About The INTERNET of THINGS

01  2018
96% of senior business leaders plan to use IoT in the next 3 years.
- Wired

02
30% of c-level execs believe IoT will unlock new revenue from existing products/services.
- The Economist

03
94% of businesses have already seen a return on their investments in IoT.
- CMO.com

04
"...IoT will have the biggest impact in customer service and support..."
- The Economist

05
The IoT will lead to a 25% reduction in asset maintenance costs and 35% reduction in downtime.
- U.S. Department of Energy

06
$970 will be saved per year per fleet vehicle
- Cisco

07
38% of businesses believe IoT will have a major impact over the next 3 years.
- The Economist

08
$41 trillion will be spent over the next 20 years for infrastructure upgrades.
- Intel

09
IoT could add $10-15 TRILLION to the global GDP.
- GfK

10
Because of the IoT there will be 22x more data traffic by 2020
- Freescale

11
0.06% of things that could be connected actually were in 2014.
- Baseline Magazine

12
40% of all data generated by 2020 will come from connected sensors.
- Frost & Sullivan
End of Presentation

The Transformation to Smart Manufacturing is happening Faster than one thinks......