The Road to the 4th Industrial Revolution

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Objectives

- **Review the Achievements of the Textile Industry relevant to the 4th Industrial Revolution**
- **Address the opportunities and challenges that faces the textile industry to advance toward industry 4.0**
  - **Based on the author's educational background, industry experience, direct observations at nine ITMA and other shows, visits to global machine manufacturers' facilities and weaving plants, development of engineered fabric design system and manufacturing software (including expert system)**

Introduction

The First Industrial Revolution (Industry 1.0) 1784-1869

- **Started in Britain with the invention of the steam engine**
- **Converted the limited hand production to mechanized mass production**
- **The textile industry was the most beneficiary**
  - **Textile pioneers invented: Cotton ginning, flying shuttle, power loom, Jacquard shedding motion, spinning jenny (several spindles driven by a single spinning wheel)**
- **Inventions led to establishing textile mills in Brittan, USA, etc.**

Introduction

The Second Industrial Revolution 1870-1917

- **Witnessed the invention of electricity and electrical equipme**
- **Harnessing electrical power for mass production and the adv of assembly line (Automobile Industry led, then others follow such as electronics, textile machine manufacturers, apparel, etc.)**
- **Textile industry benefited from driving each machine by individual motor (as opposed to one steam engine powering numerous machines)**

Introduction

The Third Industrial Revolution Started 1969-1990s

- **Brought automation, electronics and computers**
- **Textile industry introduced automation to their machinery: automation in spinning room (roving, spinning, winding), electronic warp and filling stops, CAD, electronic dobby/Jacquard, and preprograming of pick density, variab speed, automatic pattern change, user interface via buttons and touch screens, etc.**

Introduction

The Fourth Industrial Revolution Started Late 1990s and being continued

Taking advantage of electronics and computers of the Industry 3.0 era to create applications using robotic (automation), internet of things (IoT), artificial intelligent (AI), big data and analytic, and other unknown features to be developed

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Achievements in Automation – Spinning Examples

Combing

R
Au
D

Ring Spinning - Automatic Doffing

Au
W

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Achievements in Automation – Drawing-in

Groz-Bekert

Staubli

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Achievements in Automation – Drawing-in

After setting the drawing-in machine via user interface, autom drawing-in of warp yarns is performed from package or beam

Staubli's SAFIR recognizes yarn color, yarn twist, and double yarn. Ensures yarn color/twist sequence via vision system.

Setting that includes placing heddle wires, drop wires, and ree draw according to weave design is handled by operator.

Robotics and interface with CAD system may reduce/eliminat operator intervention.

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Quick Style Change

Conducted after drawing-in.

Special truck to remove empty warp beam from loom along wit harnesses, drop wires, reed and transfer the full warp beam alo with harnesses, drop wires, and reed from drawing-in room anc them to the loom. Lead to significant reduction of style change

Requires operators and special weaving machine design. Could automated using robotic and vision/guiding systems.

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Achievements in Automation - Warping

Warping is automated in sample and sectional warping with minimum labor intervention

Beaming after warping requires operator intervention. It is not hard to fully automate the process including beaming using robots

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Achievements in Automation -Weaving

Weft Breaks Detection and Repair

Automatic Pattern Change in Electronic Jacquard

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Achievements in Automation -Weaving

Currently, this is limited to stop weaving if a wrap yarn breaks. Operator intervention is required for repair

While there are several inventions, studies and trials, they are not commercially viable due to high cost

Warp Stop Motion

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Achievements in Automation -Weaving

Variable Weaving Speed

Electronically allows preprogramming weaving speed for each weft yarn

Operator has to find optimum speed for each filling yarn

Self-Learning Machine (AI)

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Achievements in Automation -Weaving

Self-Learning Machines

Picanol built OptiMax-I machine equipped with (ITMA 2019):

- **Programmable tension display (TED) with digital setting of the brake to control filling yarn tension during insertion and store the ideal tension for reproducibili**
- **Electronic Right Gripper Opener (ERGO) - electronically controlled to digitally set the gripper opening to minimize the length of the filling waste at the right selvage**
- **QuickStep filling presenter - allows digital programming different timings for filling presentation, insertion and rest**
- **These features along with already established digitized weaving efficiency and s data acquisition, self-learning machine is possible if big data analysis and artific intelligent can be harnessed (industry 4.0)**

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Achievements in Automation -Weaving

Adaptive Control (AI) Systems (Air Jet Weaving)

Sensing weft yarn arrival time (Ta), compare it to expected time (Te) to pre early/late arrival and avoid weaving defects. The adaptive control system m change:

(1) Timing of opening the main nozzle valve,

(2) Change air flow, or

(3) Change weaving speed

Targets increase in weaving efficiency, fabric quality and reduction in air consumption/unit fabric length – pursued by major air jet weaving machin manufacturers (Dornier, Picanol, Toyota, etc.)

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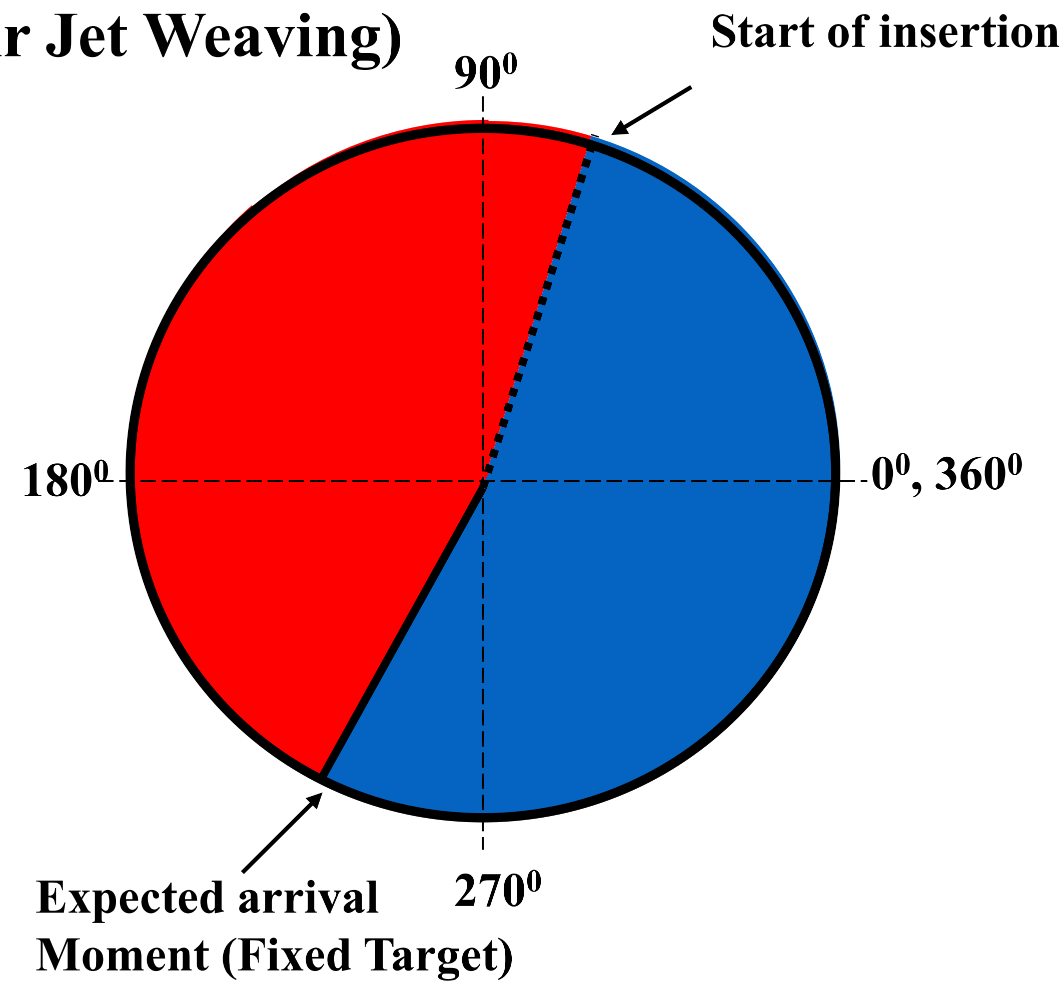
Achievements in Automation -Weaving

Adaptive Control Systems (Air Jet Weaving)

Concept of delaying the time of opening nozzle valve



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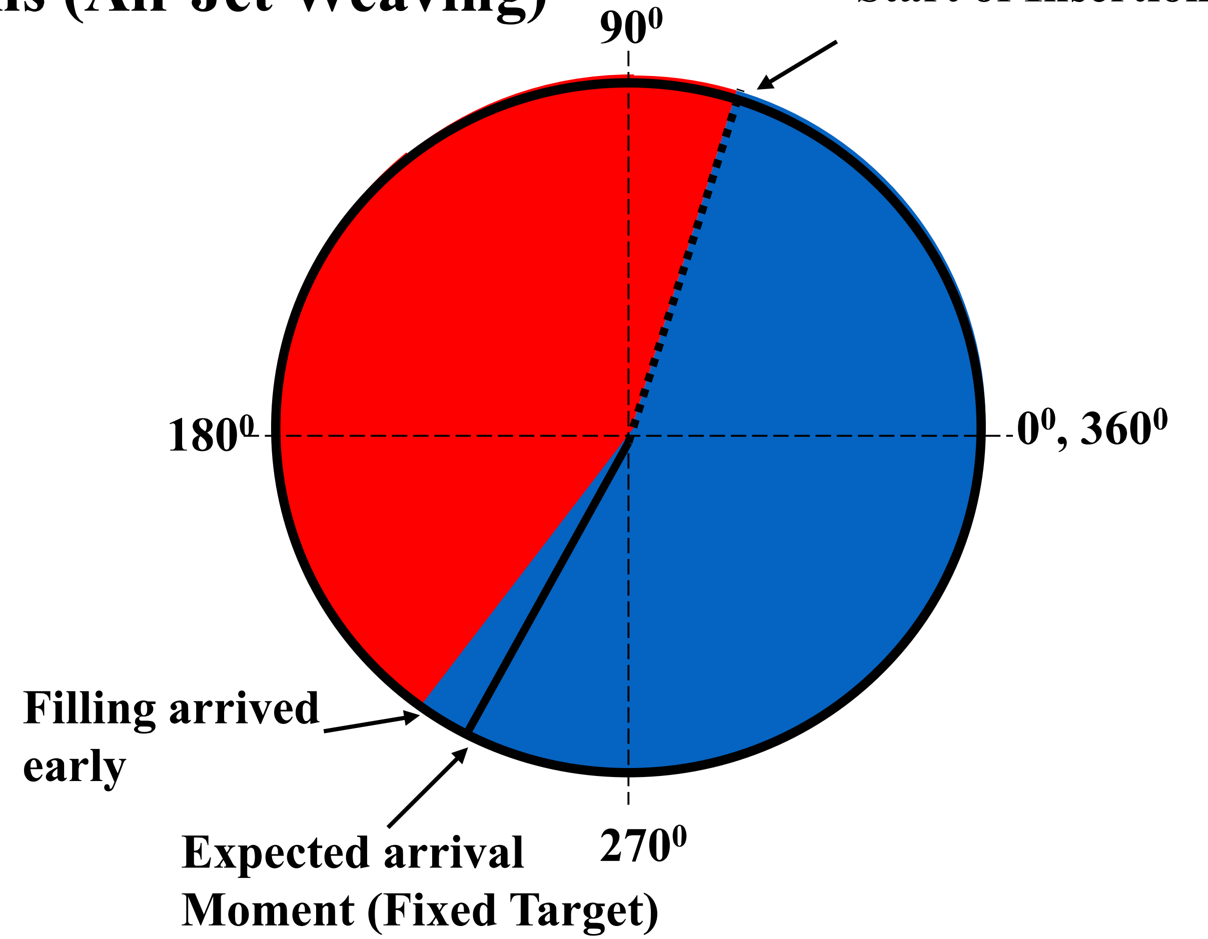
Achievements in Automation -Weaving

Adaptive Control Systems (Air Jet Weaving)



Concept of delaying the time of opening nozzle valve

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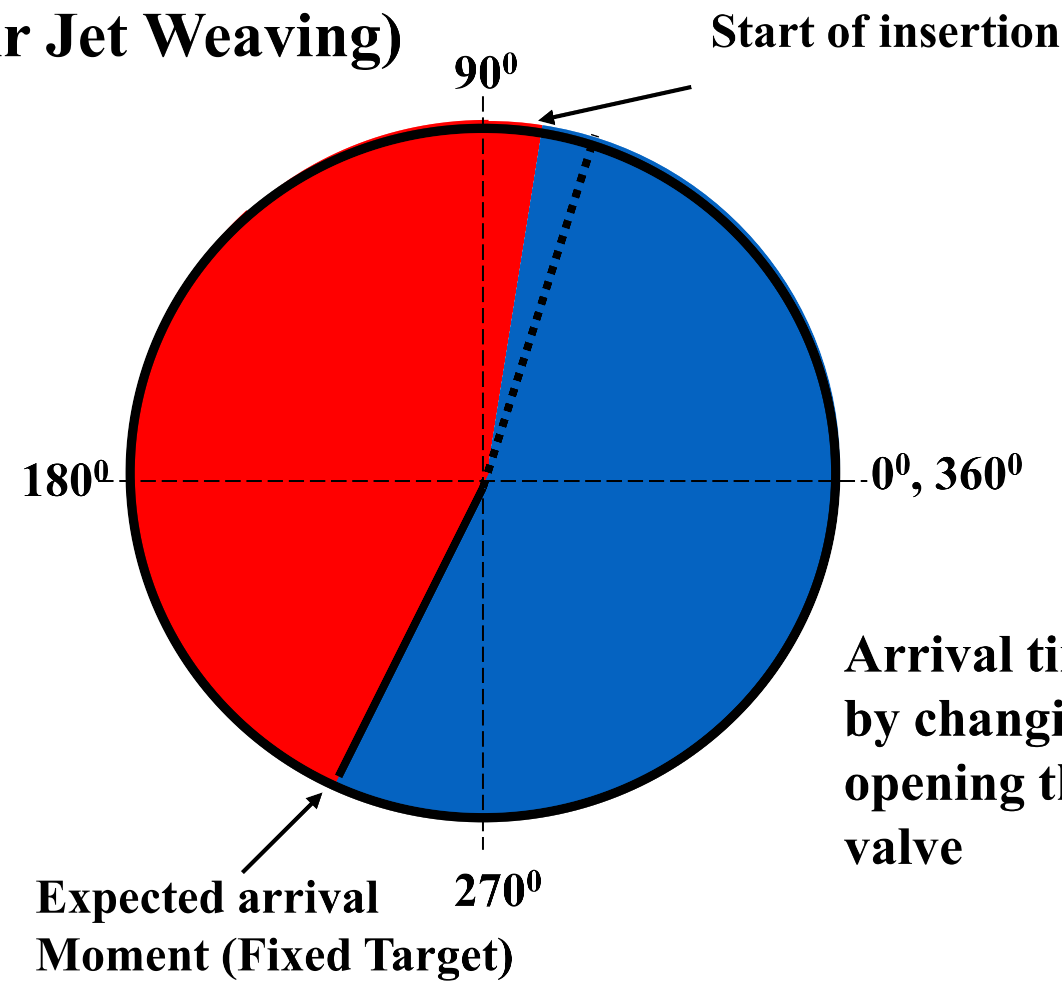
Achievements in Automation -Weaving

Adaptive Control Systems (Air Jet Weaving)



Concept of delaying the time of opening nozzle valve

Arrival time is cont
by changing the tin
opening the main n
valve

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Monitoring Weaving Stops and Efficiency

Weaving machines are interfaced to computerized data collection to monitor warp stops (from warp stop sensor), filling stops (from filling stop sensor) an other stops. Individual machine and weaving room performance can be monitored remotely (Mega Data Collection)

Full advantages of the data are not utilized.

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Smart Communications – within Machine and Inside a Plant Examples

- **Smart Tying-in Machine by Knotex – Romote control to monitor status and calls operator for intervention when needed (ITMA 2003)**
- **Smart Communication for Separate Drive in Dobby by Dornier, Smit (joined Itematech), Staubli, Toyota, Mageba, etc.**
- **Smart Communication for Separate Derive in Jacquard Weaving by Staubli (ITMA 2003)**
- **Smart Beam by Karl Mayer (ITMA 2007)**

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- **Today's digital textile machines can communicate locally and globally (via IoT) and they are ready for Industry 4.0**
- **The road to industry 4.0 requires:**
  - **Development of robotics to complete automation**
  - **Key data from fiber, yarn, fabric, finishing, shipping, marketing (supply chain) should be integrated**
  - **Systems to collect/store big digital data**
  - **Use of IoT to allow machine manufacturers (companies, consultants, etc.?) access and process big data using AI and analytics to diagnose and predict disruptive issues**
  - **Resources: Investment in R&D, human resources, education, etc.**

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A major issue that manufacturers are concerned about is the compromise of their data and intellectual property (IP), which is an impediment to the road to industry 4.0. The textile is a global and diversified industry and there is a need for global laws to protect manufacturers' data and IP from hackers