# PROD 1024 Advanced Principles in Lean Manufacturing

## Coursework

**Individually** read the Farm Equipment International data set and:

1. Produce a door-to-door value stream map of the current manufacturing process.

   [25 marks]

2. Outline and answer the eight key questions for the future state design.

   [40 marks]

3. Thereby produce a future state map detailing the processes necessary to operate the factory according to lean manufacturing principles.

   [25 marks]

4. Produce an implementation plan for the company to move from present state to future state.

   [10 marks]

Notes:

1. Submission Date: 28th November 2021

Remember – this is an individual piece of coursework. If you collaborate, you risk losing all your marks!

This coursework is intended to measure the following learning outcomes:

reflect on the significance of lean theory and the application of key lean thinking principles;

critically analyse lean thinking in different engineering sectors;

formulate innovative proposals based on detailed knowledge of the tools and techniques relating to the implementation of lean thinking;

# Farm Equipment International

Farm Equipment International (FEI) produces components and sub-assemblies for agriculture. Here, we are considering one product family, hydraulic control sections. These are produced in several configurations for different tractors and markets. The market for hydraulic control sections covers both original-equipment tractor assemblers and the aftermarket repair and overhaul businesses that support the agricultural industry worldwide.

As the company offers a wide variety of possible configurations, and the fact that the exact configuration each customer requires can vary from order to order, hydraulic control sections are made to order. A hydraulic control lever currently takes 27 days to go through the factory. This production lead time and a large order backlog have resulted in FEI to quote a 60 day lead time to customers. Unfortunately, FEI's original-equipment customers can not predict their exact requirements more than 2 weeks before use. As a result they make frequent changes to the detail of their orders 2 weeks before delivery. These changes lead to frequent expediting of batches at the FEI factory.

Production Control at FEI releases customer orders to the factory approximately in the sequence that they are received, the shop floor supervisors and operators "batch" the orders together by configuration in an attempt to reduce the number of changeovers. This also leads to expediting of orders.

## The product

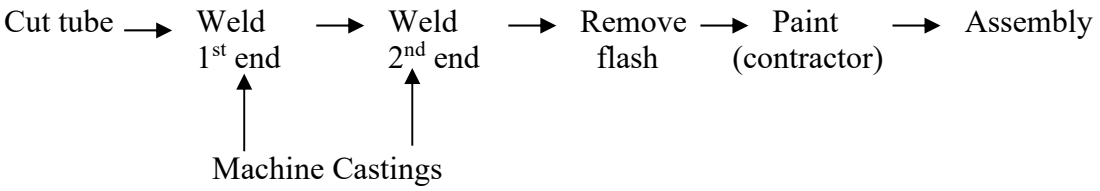
- A hydraulic control section is a metal tube with a cast connector welded to each end.
- Hydraulic control sections are available in 30 different lengths, 3 diameters, and with 2 different types of connectors. Each end of a hydraulic control section can have a different connector. This means that FEI can potentially supply 360 different finished hydraulic control sections. It is not known what the demand for each individual specification is.

## Customer requirements

- 24000 hydraulic control sections per month.
- Order size varies from 20 pieces up to 200 pieces. Average order size is 50 pieces.
- 5 hydraulic control sections per box.
- Several shipments each day by truck to different customers.
- Each order from each customer varies in quantity and configuration.
- FEI requires orders to arrive 60 days before shipping of finished hydraulic control sections.
- Customers may change the mix of configurations up to 2 weeks before the shipping date.

# Production Processes

All the hydraulic control sections follow the same basic factory routing:




- FEI's routing for producing hydraulic control sections is to cut a metal tube to length, weld the connectors in place, deflash (remove the excess weld material), painting (done at an external contractor's premises), and finally assembly of the connectors. The cast connectors are also machined at FEI's factory. Finished hydraulic control sections are shipped to customers daily.
- Switching between tube lengths requires a 15 minute changeover at the cutting, welding and deflash workstations.
- Switching between tube diameters takes a 60 minute changeover at the cutting, welding and deflash operations. This longer changeover is mostly due to a "1st off" quality control inspection after such a changeover.
- Switching between each of the three types of cast connectors takes a 2 hour changeover at the machining operation.
- Tubes are supplied by Kentish Tube Systems Ltd. The lead time for obtaining tubes is 4 months (16 weeks). Kentish Tube Systems Ltd. deliver products every 2 weeks.
- Raw castings for the end connectors are supplied by Essex Castings Ltd. The lead time for obtaining castings is 3 months (12 weeks). Essex Castings Ltd. deliver products every 2 weeks.

## Work Time

- 20 days in a month.
- 2 shifts per day in each department.
- 8 hours per shift, overtime added if necessary.
- Two breaks each shift, 15 minutes per break.
    - Manual processes stop for breaks
    - Lunch is not paid.

## FEI Production Control

- Receives customer orders 60 days from shipment, and enter them to MRP system.
- Generates a "shop order" per customer order. This follows the product through the entire production process.
- Release shop orders to the factory 6 weeks before the shipment date to accelerate MRP's ordering of tubes and castings.
- Issue a daily production list to supervisors in production departments. Supervisors schedule shop orders through their department.
- Receives customer configuration changes 2 weeks before shipment and advises department supervisors to expedite orders as necessary.
- Issues daily shipping schedule to Despatch Department.

**Process Information**

1. **Cutting** (the saw cuts tubes and rods for many FEI product families).
    - Manual process, 1 operator
    - Cycle time = 15 seconds
    - Changeover time = 15 minutes (length), 60 minutes (diameter)
    - Reliability = 100%
    - Inventory
        i. 20 days of uncut tubes
        ii. 5 days of cut tubes.

2. **Welding workstation 1** (dedicated to the hydraulic control sections product family)
    - Welds the first machined casting to the tube
    - Automatic process, with operator load and unload external to the machine cycle
    - Cycle time:
        i. Operator = 10 seconds
        ii. Machine = 30 seconds
    - Changeover time = 15 minutes (length), 60 minutes (diameter)
    - Reliability = 90%
    - Inventory = 3 days of welded sections.

3. **Welding workstation 2** (dedicated to the hydraulic control sections product family)
    - welds the second machined casting to the tube
    - Automatic process, with operator load and unload external to the machine cycle
    - Cycle time:
        i. Operator = 10 seconds
        ii. Machine = 30 seconds
    - Changeover time = 15 minutes (length), 60 minutes (diameter)
    - Reliability = 80%
    - Inventory = 3 days of welded sections.

4. **Deflash workstation** (dedicated to the hydraulic control sections product family)
    - Automatic process, with operator load and unload external to the machine cycle
    - Cycle time:
        i. Operator = 10 seconds
        ii. Machine = 30 seconds
    - Changeover time = 15 minutes (length), 60 minutes (diameter)
    - Reliability = 100%
    - Inventory = 5 days of deflashed sections.

5. **Painting** (hydraulic control sections are shipped to an outside contractor for painting)
    - Painting lead time = 2 days
    - One daily truck pickup of unpainted sections and drop-off of painted sections
    - Observed inventory:
        i. 2 days at the painter
        ii. 6 days of painted sections at FEI.

6. **Connector assembly** (dedicated to the hydraulic control sections product family)
    - Manual process with 6 operators
    - Total Work Time per Piece = 195 seconds
    - Changeover time = 10 minutes fixture swap
    - Reliability = 100%
    - Observed finished goods inventory in warehouse = 4 days of finished hydraulic control sections.

7. **Machining of Castings** (dedicated to the hydraulic control sections product family)
    - Automatic machining process with one machine attendant
    - Cycle time = 30 seconds
    - Changeover time = 2 hours
    - Reliability = 100%
    - Observed inventory:
        i. 20 days of raw castings from the supplier
        ii. 4 days of machined castings.

8. **Despatch department**
    - Removes parts from finished goods warehouse and stages them for truck shipment to customers.