**The Core Problem in Simple Terms**

Imagine you have a big, expensive sewing machine, but instead of sewing cloth, it's weaving wires to make the inside of a mattress (the spring part).

Right now, the people running the factory have a big blind spot:

* **They don't know how much wire is being used** while the machine is running.
* **They don't know how efficiently the machine is working.** Is it running at 100% speed or is it often stopped for adjustments?

This means managers might only find out at the end of the day or week that they used too much wire or didn't produce enough mattresses, which is too late to fix the problem.

**The Proposed Solution**

They want to create a **live TV dashboard**, like a sports scoreboard, but for the mattress-wiring machine. This dashboard will show crucial information in real-time to everyone on the factory floor.

**Step-by-Step Breakdown of the Requirements**

**1. Collect Data from the Machine**

This is the foundation. The system needs to automatically pull information from the "FIDES-81" machine. The key piece of data is **Wire Usage**.

* **How?** This likely involves connecting to the machine's computer (its PLC - Programmable Logic Controller) using a specific communication protocol (e.g., OPC UA, Modbus).
* **What Data?** It needs to know:
  + **Meters of wire consumed** for each mattress or per hour.
  + **Machine Status:** Is it running, idle, or stopped due to an error?
  + **Production Count:** How many mattress units have been completed?

**2. Calculate Machine Efficiency**

This is the "brain" of the system. It takes the raw data and turns it into meaningful performance metrics.

* **Actual Wire Used:** This comes directly from the machine sensors.
* **Expected Wire Target:** The system needs to know the ideal amount of wire for one mattress (this is a pre-set value entered by engineers).
* **Efficiency Calculation:** A common formula in manufacturing is **Overall Equipment Effectiveness (OEE)**, which is a combination of:
  + **Availability:** (Planned Running Time - Downtime) / Planned Running Time
    - \*Example: If the machine was stopped for 1 hour in an 8-hour shift, Availability = (8-1)/8 = 87.5%.\*
  + **Performance:** (Actual Units Made / Ideal Units Possible)
    - \*Example: If the machine can ideally make 10 units/hour but only made 75 units in 8 hours, Performance = 75 / (10\*8) = 93.75%.\*
  + **Quality:** (Good Units / Total Units Made)
    - \*Example: If 72 of the 75 units were good, Quality = 72/75 = 96%.\*
  + **OEE = Availability × Performance × Quality**
    - \*Example: 0.875 \* 0.9375 \* 0.96 = 78.75% OEE\*

The system will perform these calculations automatically and in real-time.

**3. Display the Data on a TV Screen**

This is the "face" of the system. The information must be presented clearly and simply so that an operator or manager can understand the situation at a glance from across the room.

* **Format:** A large, dynamic web page or a dedicated app designed for a TV.
* **User-Friendly Design:**
  + **Large Numbers and Fonts**
  + **Visual Graphs:** A live bar chart showing Actual vs. Expected wire usage.
  + **Traffic Light Colors:**
    - **Green:** Efficiency is above target.
    - **Yellow:** Efficiency is slightly below target.
    - **Red:** Efficiency is critically low, requiring immediate attention.
  + **Key Metrics Displayed:**
    - **Live OEE %** (e.g., **78.75%**)
    - **Wire Used Today:** (e.g., **5,250 meters / Target: 5,000 meters**)
    - **Units Produced:** (e.g., **75 / Target: 80**)
    - **Machine Status:** (e.g., **RUNNING** in green)

**The Final Outcome (The "Why")**

By implementing this system, the factory achieves:

* **Transparency:** Everyone sees the same data, instantly.
* **Timely Interventions:** If the wire usage is too high or efficiency drops, the team can stop and fix the issue *immediately*, instead of wasting a whole day of production.
* **Better Productivity:** By identifying and eliminating small stops and inefficiencies, the machine produces more mattresses with less waste.
* **Data-Driven Decisions:** Managers can make decisions based on real data, not guesses, leading to better planning and cost savings.

In essence, they are putting a "health monitor" on their expensive machine, giving the team the information they need to keep it running at peak performance.

**The Critical Parameters for the Fides FT-81**

Think of these parameters as the "recipe" for your spring unit. You must input these for every new spring type.

**1. Spring Wire Diameter (Gauge):**

* **What it is:** The thickness of the steel wire, usually given in mm or AWG (American Wire Gauge).
* **How it's set:** You physically change the wire spool and adjust the feed rollers and guides to accommodate the new thickness. The machine's control system needs to know the gauge to calculate feed length accurately.
* **Typical Range:** 1.8mm to 2.8mm (approx. 13-11 AWG) for mattress springs.

**2. Spring Height (Uncompressed):**

* **What it is:** The height of the individual spring before it's compressed into the unit.
* **How it's set:** This is determined by the **distance between the coiling point and the transfer mechanism**. It is a critical mechanical setting, often adjusted using handwheels or servos with a digital readout.
* **Typical Range:** 100mm to 200mm (4" to 8"), depending on mattress design.

**3. Spring Outer Diameter (O.D.):**

* **What it is:** The width of the individual coil.
* **How it's set:** This is determined by the **size and profile of the coiling mandrel (the arbor)**. You must physically change the mandrel to change the spring diameter.
* **Typical Range:** 60mm to 100mm is common.

**4. Number of Active Coils:**

* **What it is:** The number of coils in the spring that are designed to compress under load.
* **How it's set:** This is programmed into the machine's PLC (Programmable Logic Controller). It tells the coiling head how many rotations to make before cutting the wire.

**5. Number of Knots (Springs) per Row:**

* **What it is:** The number of springs across the width of the mattress.
* **How it's set:** Programmed into the PLC. The machine's indexing mechanism will space the springs accordingly. For an FT-81, this is a fixed number for a given production run (e.g., 72 springs for a Queen size).
* **Example:** A Queen mattress (60" x 80") might have 72 springs wide and 108 springs long.

**6. Number of Rows:**

* **What it is:** The total number of rows for the mattress length.
* **How it's set:** Programmed into the PLC. The machine will count the rows and stop when the preset number is reached.

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| --- | --- | --- | --- | --- | --- |
| Mattress Size | Dimensions (Inches) | Dimensions (cm) | **Typical Columns (Springs per Row)** | **Typical Rows** | **Total Spring Count (Approx.)** |
| **Twin / Single** | 38" x 75" | 96.5 x 190.5 cm | **48 - 52** | **90 - 100** | 432 - 520 |
| **Twin XL** | 38" x 80" | 96.5 x 203 cm | **48 - 52** | **96 - 106** | 460 - 550 |
| **Full / Double** | 53" x 75" | 134.5 x 190.5 cm | **66 - 72** | **90 - 100** | 594 - 720 |
| **Full XL** | 53" x 80" | 134.5 x 203 cm | **66 - 72** | **96 - 106** | 633 - 763 |
| **Queen** | 60" x 80" | 152.5 x 203 cm | **72 - 80** | **96 - 106** | 691 - 848 |
| **King** | 76" x 80" | 193 x 203 cm | **90 - 102** | **96 - 106** | 864 - 1081 |
| **California King** | 72" x 84" | 183 x 213 cm | **86 - 96** |  |  |

**7. Helix (Knot) Pitch:**

* **What it is:** The distance between the centers of two adjacent springs. This determines how tightly packed the springs are.
* **How it's set:** This is a function of the **indexing mechanism** that moves the transfer chain. It is programmed into the PLC and is crucial for ensuring the springs mesh correctly when knotted.
* **Calculation:** It is roughly equal to the Spring O.D. plus a small gap.

**8. Wire Feed Speed:**

* **What it is:** The speed at which the wire is pulled from the spool and fed into the coiling head.
* **How it's set:** Adjusted via a variable speed drive on the main motor. This is a primary control for the **cycle time** of the machine.

**9. Lacing Wire Parameters:**

* **What it is:** The settings for the wire that connects (laces) the springs together at the top and bottom.
* **How it's set:** This involves its own feed system, including wire gauge, the pattern of the lacing hooks, and the tension. It must be synchronized with the main spring coiling cycle.

**How Production Varies Depending on These Parameters**

The production output of the Fides FT-81 is measured in **spring units per hour**. Here’s how the parameters affect it:

**1. Parameters that MAJORLY Affect Speed (Cycle Time):**

* **Wire Feed Speed (Parameter #8):** This is the most direct control. **Higher feed speed = faster coiling = higher production.** However, there is a limit. Running too fast can cause wire whip, mis-feeds, poor coil shape, and increased wear on the machine.
* **Number of Active Coils (Parameter #4):** A spring with 5 coils takes less time to coil than a spring with 7 coils because the coiling head has to rotate fewer times. **Fewer coils = faster cycle time.**
* **Spring Height (Parameter #2):** While the coiling time is the same, a taller spring requires the machine to move the wire a greater vertical distance. This can add a tiny amount of time per cycle, but it's less significant than the coiling time itself.

**2. Parameters that Affect "Time per Unit" (Not per Spring):**

* **Number of Knots per Row (Parameter #5):** A mattress with 80 springs per row takes longer to produce than one with 60 springs per row because the machine has to index more times to complete a single row. **More springs per row = longer time to complete one full unit.**
* **Number of Rows (Parameter #6):** Similarly, a longer mattress (more rows) takes longer to produce than a shorter one.

**Production Calculation Example:**

* Let's say your machine's cycle time (time to make one spring and index to the next position) is **0.5 seconds**.
* You are making a Queen unit with **72 springs per row** and **108 rows**.
* Total springs = 72 \* 108 = 7,776 springs.
* Time to coil all springs = 7,776 springs \* 0.5 sec/spring = 3,888 seconds.
* Convert to hours: 3,888 / 3600 = **~1.08 hours of pure coiling time**.

You must then add time for:

* Loading the initial wire and lacing wire.
* Machine setup and calibration at the start.
* Any jams or misfeeds (downtime).
* Unloading the finished unit.

Therefore, your real-world production might be **one Queen unit every 1.5 hours or so.**

|  |  |
| --- | --- |
| Parameter | Specification |
| **Spring Wire Gauge** | 1.9 - 2.4 mm (varies with jaw type) |
| **Spring End Ring Diameter (Dfi)** | 61 - 88 mm |
| **Spring Height (by number of turns)** | 4 turns: 55-120 mm, 5 turns: 120-150 mm, 6 turns: 140-160 mm, 7 turns: 160-190 mm |
| **Performance** | Up to 81 springs per minute |

The **Fides FT-81 is a Bonnell spring *lacing* or *knot-tying* machine**. It does not coil the springs. It takes **pre-made, individual helical springs** and automatically wires them together into a grid structure (the Bonnell unit).

Therefore, the "wire usage" calculation is exclusively for the **lacing wire** that connects the springs. The efficiency is about how effectively it uses this lacing wire.

**Equation for Lacing Wire Usage on the Fides FT-81**

The total lacing wire used for one mattress unit is the sum of the wire used on the top and the bottom.

**Total Lacing Wire Length = (Top Grid Wire Length) + (Bottom Grid Wire Length)**

Since the top and bottom are usually identical, we can calculate for one side and double it.

**1. Wire Length for One Side (e.g., Top)**

The lacing wire forms a zig-zag pattern. For a grid of R rows and C columns (springs per row), the pattern is:

* **Longitudinal Wires:** There are L\_r longitudinal wires running the entire **length** of the mattress.
* **Transverse Wires:** There are T\_r transverse wires running the entire **width** of the mattress.

Wire\_Length\_Per\_Side = (L\_r \* Mattress\_Length) + (T\_r \* Mattress\_Width)

**2. Determining Mattress Length and Width from Spring Parameters**

* Mattress\_Width = (C - 1) \* Helix\_Pitch
* Mattress\_Length = (R - 1) \* Helix\_Pitch

**3. The Complete Formula**

Combining the above, the total lacing wire for the entire unit is:

Total\_Lacing\_Wire\_Length = 2 \* [ L\_r \* ((R - 1) \* P) + T\_r \* ((C - 1) \* P) ]

**Where:**

* R = Total Number of Rows
* C = Number of Springs per Row (Columns)
* P = Helix (Knot) Pitch (distance between spring centers in mm)
* L\_r = Number of Longitudinal Lacing Wires (running the length)
* T\_r = Number of Transverse Lacing Wires (running the width)

**Efficiency and "Actual vs. Theoretical" Usage**

On the Fides FT-81, the "theoretical" usage is the pure geometric length of the zig-zag pattern, as calculated above.

The **"actual" usage will be higher** due to machine process waste:

Actual\_Lacing\_Wire = Total\_Lacing\_Wire\_Length + Waste

**Sources of Waste (Overhead) on the Fides FT-81:**

1. **Knot Overhead:** Each time the lacing wire wraps around a spring, it uses extra length to form the knot itself. This is a small, fixed amount per connection.
2. **Start/End Clipping:** The machine must leave a tail at the beginning and end of each lacing wire run, which is wasted.
3. **Inter-Wire Connections:** When a spool of lacing wire runs out and a new one is started, there is a waste from the connection process.

**Practical Calculation Example**

Let's calculate for a **Queen-size** unit on the Fides FT-81.

* **Grid Size (**C**x**R**):** 76 springs per row x 102 rows
* **Helix Pitch (**P**):** 80 mm
* **Lacing Pattern:** A common "2x2" pattern, meaning:
  + L\_r = 2 longitudinal wires
  + T\_r = 2 transverse wires

**Step 1: Calculate Mattress Dimensions**

* Mattress Width = (76 - 1) \* 80 mm = 6,000 mm
* Mattress Length = (102 - 1) \* 80 mm = 8,080 mm

**Step 2: Calculate Theoretical Lacing Wire per Side**

* Wire Per Side = (2 \* 8,080 mm) + (2 \* 6,000 mm)
* Wire Per Side = 16,160 mm + 12,000 mm = 28,160 mm

**Step 3: Calculate Total Theoretical Lacing Wire**

* Total Theoretical = 2 \* 28,160 mm = **56,320 mm (56.32 meters)**

**Step 4: Estimate Actual Lacing Wire**  
To get the actual usage, we add waste. A common industry estimate for waste is **~5-10%** for an efficient machine.

* Actual Lacing Wire (with 7% waste) = 56.32 m \* 1.07 ≈ **60.26 meters**

**Estimated Lacing Wire for Different Mattress Sizes**

Using the same "2x2" lacing pattern and an 80 mm Helix Pitch, here are the estimates:

|  |  |  |  |
| --- | --- | --- | --- |
| Mattress Size | Spring Grid (C x R) | **Theoretical Lacing Wire** | **Actual Lacing Wire (Est. with 7% Waste)** |
| **Twin** | 48 x 100 | 53.12 m | ~56.84 m |
| **Twin XL** | 48 x 106 | 55.52 m | ~59.41 m |
| **Full / Double** | 66 x 100 | 55.52 m | ~59.41 m |
| **Full XL** | 66 x 106 | 57.92 m | ~61.97 m |
| **Queen** | 76 x 102 | 56.32 m | ~60.26 m |
| **King** | 92 x 102 | 58.72 m | ~62.83 m |
| **Cal King** | 88 x 112 | 62.72 m | ~67.11 m |

**Key Takeaways for Fides FT-81 Efficiency**

1. **Fixed Overhead:** The waste from knotting and clipping is a *fixed overhead per spring unit*. A larger mattress has more knots, so the absolute waste is higher, but it might be a smaller percentage of the total.
2. **Efficiency Levers:**
   * **Minimize Stoppages:** Every time the machine stops and starts for a jam or spool change, waste is generated.
   * **Optimize Knotting Mechanism:** A well-maintained knotter head will use a consistent and minimal amount of wire per knot.
   * **Accurate Setup:** Correct tension and alignment prevent jams and broken wires, which are major sources of waste.