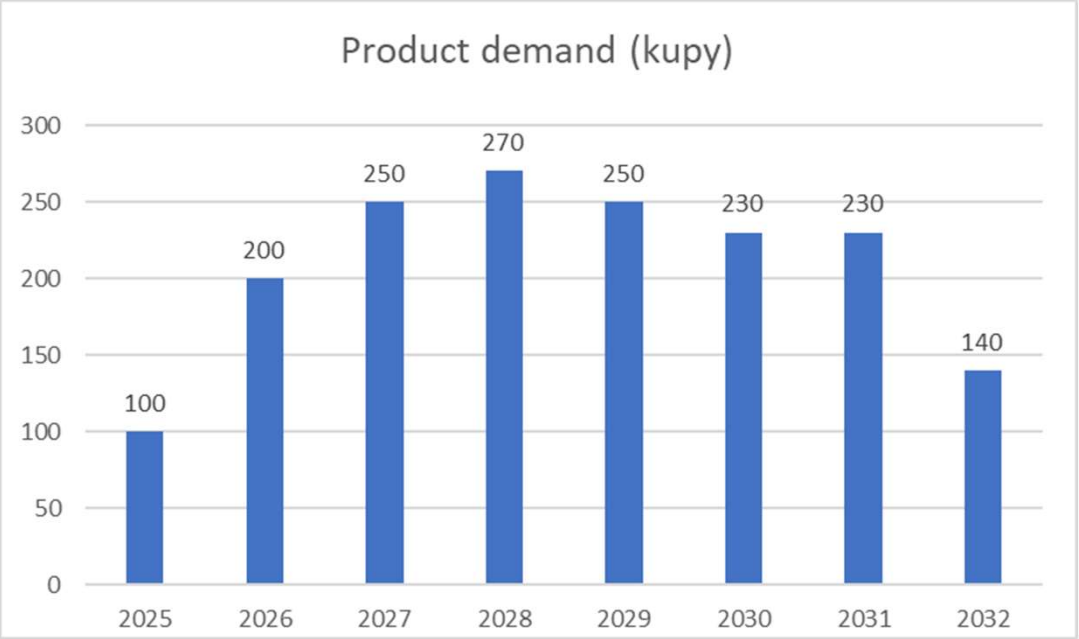
# Exercise session #2

# BC for a double scenario engine assembly line

- Let’s assume to have a demand as attached
- WACC=10%
- Scenario 1: Manual line 5 M€, per unit cost=94€
- Scenario 2: Automatic line 20M€, puc= 46€
- Investment: 40% in 2024, 60% in 2025
- Evaluate the profitability (reference is always the major investment)



# Solution

Insert new data of cost

Investment with yearly distribution

| | | Formulas | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **INPUT** | | | | | | | | | | | | |
| Volumes | kupy | | 0 | 100 | 200 | 270 | 280 | 250 | 230 | 230 | 140 | 1700 |
| Automatic investment | M€ | | 8,00 | 12,00 | | | | | | | | 20,00 |
| Automatic cost (€) | 54 | | | | | | | | | | | |
| Manual investment | M€ | | 2,00 | 3,00 | | | | | | | | 5,00 |
| Manual cost | 94 | | | | | | | | | | | |
| WACC | 10% | | | | | | | | | | | |
| **OUTPUT** | | | | | | | | | | | | |
| Actualization at 2024 | | =(1-WACC)**(n-1) | 1,11 | 1,00 | 0,90 | 0,81 | 0,73 | 0,66 | 0,59 | 0,53 | 0,48 | 6,81 |
| Actualized investment | | =ACT*Make Inv | 8,89 | 12,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 20,89 |
| Actualized total costs | | =Cost*Vol*ACT | 0,00 | 5,40 | 9,72 | 11,81 | 11,02 | 8,86 | 7,33 | 6,60 | 3,62 | 64,36 |
| Actualized VT | | =ACT*VT | 2,22 | 3,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 5,22 |
| Actualized prices | | =Price*Vol*ACT | 0,00 | 9,40 | 16,92 | 20,56 | 19,19 | 15,42 | 12,77 | 11,49 | 6,29 | 112,03 |
| Delta Discounted cash flow | | =ACT(Vt+Price-Inv-Cost) | -6,67 | -5,00 | 7,20 | 8,75 | 8,16 | 6,56 | 5,43 | 4,89 | 2,68 | 32,01 |
| NPV | | =Cumulated DCF | -6,67 | -11,67 | -4,47 | 4,28 | 12,45 | 19,01 | 24,44 | 29,33 | 32,01 | |
| Total actualized investment | | =Cumulated INV | 6,67 | 15,67 | 15,67 | 15,67 | 15,67 | 15,67 | 15,67 | 15,67 | 15,67 | |
| **Profitability** | **204%** | =Cum DCF/Cum Inv | | | | | | | | | | |

Good profitability of automation

# Exercise 1

- Having in mind the PROs of  a Transfer line vs a Machining center line analyze the following scenario.
- There is a demand of 300 k/y. The alternative solutions are:
    1. a transfer line with #3 unit. The units cost of 250 k€ each and have a technical capacity of 350k/y. Efficiency of every single unit is 95%.
    2. a flexible line with #2 machining centers. Each center has a cost of 400K€, a capacity of 200k/y and efficiency 90%.
- Which are the considerations you can do to support the decision?

# Ex 1 solution

**Scenario transfer:**
Efficiency series 0,95**3=0,85
Resultant capacity= 350*0.85=300K so aligned with the demand
Total cost 750 K€
Ratio K€ cost per kupy= 750/300= 2,5 k€/kupy

**Scenario MCs:**
Efficiency #2 machining center in parallel = (0,9+0,9)/2=0,9
Resultant capacity= 400*0,9*2= 360 kupy
Total cost 800 K€
Ratio K€ cost per kupy= 800/360= 2,2 k€/kupy

**The best solution is the transfer line, with series, that requires a minor investment.**
But to decide we need to explore if the major capacity could be an opportunity.
If yes, the major flexibility and the best ratio €/capacity let us opt for parallel.

# Exercise 2

- Which is the main difference of machine tool for machining?
- Can you define the main technologies for each of these?
- Which are the main steps of a gear machining?

# EX 2 solution

Which is the main difference of machine tool for machining?

- **Prismatic and rotating**

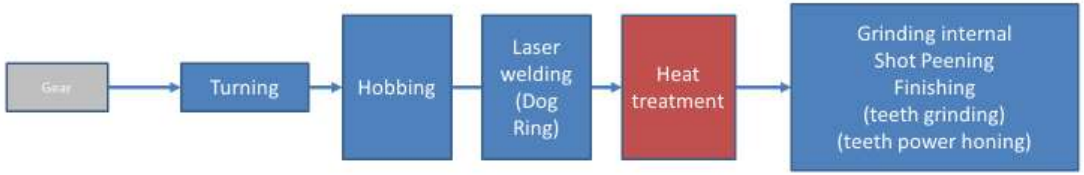
Which are the main steps of a gear machining?

- **Turning**
- **Hobbing**
- **Heat treatment**
- **Griding or finishing**

Can you define the main technologies for each of these?

- **Prismatic: milling, drilling, tapping, boring, bore honing**
- **Rotating: turning, grinding, hobbing, teeth honing**

## Block diagram transmission /gear

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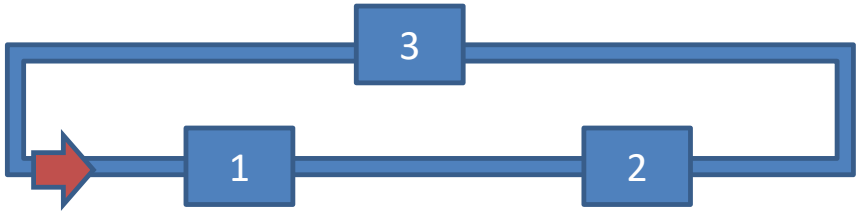
# Exercise 3

- In a ring-shape assembly line




Assumptions:

- Total length 60 m
- Pallet dimension 1 m and number #40
- Speed 3 m/min
- Three automatic assembly station:
  - #1 cycle time 40 s, #2 cycle time 50 s,#3 cycle time 30 s
- In the middle there are synchronous continuous moving manual operation that do not impact the flow

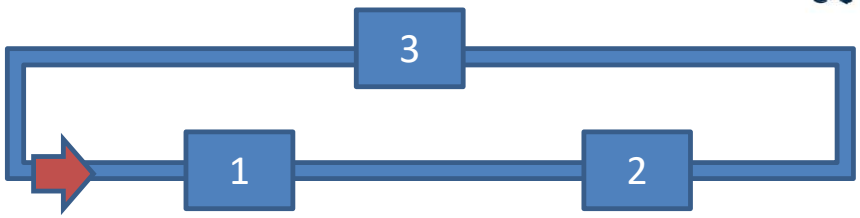
Questions

- Which is the bottleneck? Which is the max throughput?
- Using Queuing theory M/M/1 model which are the time in queue before the other stations?
- Which the queue before the bottleneck?
- Is the pallet number enough?

# Exercise 3 solution

1. **Transform cycle time in rate:**
   - Station #1 1/0,66=1,5 u/min,
   - station #2 1/ 0,84=1,2 u/min,
   - station #3 1/0,5=2 u/min
2. Op #2 is bottleneck, **Pmax=1.2/min= max throughput**
   - Let consider the other two stations as a M/M/1 system with:
   - Lambda=1.2 u/min
   - Mu(1)=1,5 u/min
   - Mu(3)=2 u/min

   Formula:
   - Average time that the customer wait in the queue TQ= $\lambda / \mu (\mu - \lambda)$
   - **TQ1= 1,2/ (1,5*(1,5-1,2))= 2,66 min**
   - **TQ3= 1,2/(2*(2-1,2))= 1,2/1,6=0,75 min**
   - **T(1)=2,66 +0,66=3,33 min**
   - **T(3)=0,75+0,5= 1,25 min**




3. Use Little law to calculate the total cross time:
   - TCT= N.pallet/P= 40/1,2= 33.33 min
4. Calculate T transport= L/speed= 60/3= 20 min since the other station are continuous moving the cross time is inside the transport
5. **TCT= 33.33= 20+ 3,33+1,25+ TQ bottleneck+0,84 hence:**
   - **TQ bottleneck= around 8 min**
6. **Pallet in the que in front of the bottleneck=8*1,2=10**
   - **The number of pallet seems OK**
   - 10 in front of station #2, 1 inside #2, 2 in #1 and 2 #3, the remaining 25 are around the line.