

- a) To implement an energy and targetting program, there must be certain aspects in place.

It is key to be recording energy data by measuring energy consumption. Energy data loggers can be used on a ~~var~~ variety of assets to determine the efficiency of the asset.

Analysing the data can show at what times the assets are typically used to create trends. This data can set a baseline for comparison. The data can be cross referenced against the energy cost times as the price of energy varies across the day, where late afternoons and evenings are peak times, ~~as~~ where as night times and early morning are at a lower cost in £/kwh.

This can ~~to~~ control the energy consumption by operating Shift patterns around the cost of energy, to reduce the overall cost of the manufacture process and increase profitability.

This data recorded should be monitored regularly to ensure the data is within the company standard. ~~to~~ This will also show if new peaks arise which can be investigated promptly to avoid additional costs.

It is important to report any variations to management which can also cross reference the data to the energy supplier.

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b) Energy auditing is a feasibility study to establish and quantify the cost of various energy inputs to, and flow within a organisation over a given period. This will identify viable and cost effective energy measures which will reduce operating costs.

This includes ~~data~~ data gathering from invoices and meters and undertaking surveys of plant. The audits should identify areas of ~~to~~ ^{to} enhance operating efficiency's.

This includes identify areas of immediate action. It should produce data for use of justification in capital expenditure investment and raise organisational awareness.

In many situations this can be achieved through ~~the~~ the implementation of 'no cost' or low cost measures.

These measures include:

- Changing energy tariff
- ~~Reschedule~~ Reschedule production activities
- Implementing good house keeping.

~~This is not~~ These audits are required due to heat energy waste. This comes from:

- Poorly designed buildings and installations
- Building maybe poorly insulated.
- Mechanical ventilation ducts may be undersized.
- Heating systems may be installed without any optimum start control.
- Time clock controllers may be incorrectly set.

a) • Uneven velocity profiles - ~~Exposure~~ fouling increases at lower velocities due to the reduced stress of the fluid, preventing removal of deposits.

• Fluid temperature - Using water as an example, this fluid can produce scaling from minerals such as calcium carbonate. These salts remain at lower temperatures

• The regurgitation generated on the shellside results in shorter runtimes, production inefficiencies (reduced cooling rate) and reduces service life which increases energy costs. These effects will result in downtime meaning the organisation ~~cannot~~ can not make money from this asset during this period.

b) 1) Crystallisation

2) Chemical reaction

3) Corrosion processes

4) Biological mass accumulation.

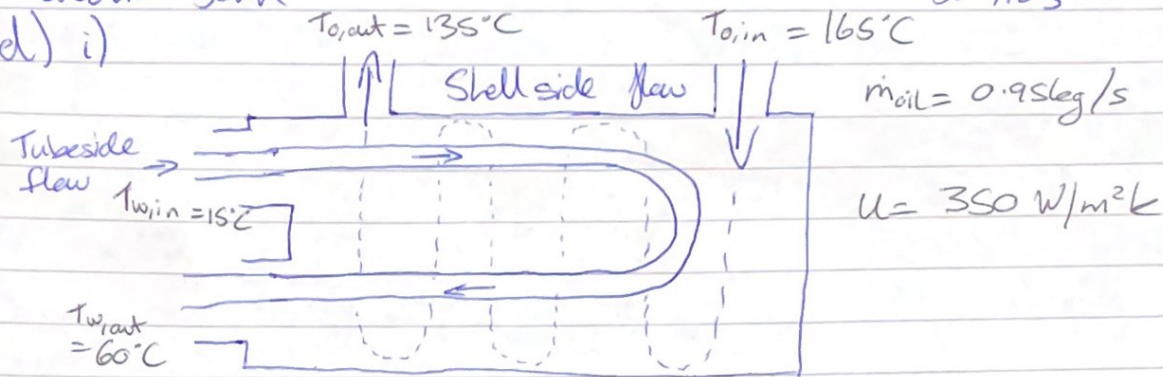
c) The first improvement the helical baffles is that uniform flow velocities are apparent through the tube bundle offering ~~then~~ uniform temperature distribution.

This allows for ~~the~~ for the elimination of regurgitation and eddies as this type of heat exchanger by ~~increasing~~ achieving higher flow velocities. This also allows the shellside to have more turbulent flow conditions which improve the temperature driving force.

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d) i)



ii) $\dot{Q} = \dot{m} c_p \Delta T$ where; $c_p = 2350 \text{ J/kgK}$

$\dot{Q} = \dot{m}_o c_{p_o} \Delta T_o$

$\dot{Q} = 0.95 \times 2350 \times (165 - 135)$

$\dot{Q} = 66,975 \text{ J/s}$

$\therefore \text{J/s} = \text{W}$

$\therefore \dot{Q} = 66,975 \text{ W}$

$\therefore \dot{Q} = 66.975 \text{ kW}$

$\frac{\text{kg}}{\text{s}} \times \frac{\text{J}}{\text{kgK}} \times \text{K}$

iii) ~~$\dot{m}_w$~~ $\dot{m}_w = ?$

$\dot{Q} = \dot{m}_w c_{p_w} \Delta T_w$

where; $c_{p_w} = 4180 \text{ J/kgK}$

$\dot{m}_w = \frac{\dot{Q}}{c_{p_w} \Delta T_w}$

$\dot{m}_w = \frac{66,975}{4180 \times (60 - 15)}$

$\dot{m}_w = 0.356 \text{ kg/s}$

~~$\dot{m}_w = \frac{\dot{Q}}{c_{p_w} \Delta T_w}$~~

iv) $\dot{Q} = U A f \Delta T_{lm}$

where; $f = 1$ for counter flow configurations

$\Delta T_{lm} = \frac{\Delta T_o - \Delta T_i}{\ln\left(\frac{\Delta T_o}{\Delta T_i}\right)}$

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for counter flow configuration;

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Where; $\Delta T_i = T_{h,in} - T_{c,out}$ $\Delta T_o = T_{h,out} - T_{c,in}$

$$\Delta T_i = 165 - 60$$

$$\Delta T_o = 135 - 15$$

$$\Delta T_i = 105^\circ\text{C (or K)}$$

$$\Delta T_o = 120^\circ\text{C (or K)}$$

$$\therefore \Delta T_{lm} = \frac{\Delta T_o - \Delta T_i}{\ln\left(\frac{\Delta T_o}{\Delta T_i}\right)}$$

$$\Delta T_{lm} = \frac{120 - 105}{\ln\left(\frac{120}{105}\right)}$$

$$\Delta T_{lm} = 112.33^\circ\text{C (K)} \quad (2dp) \quad \rightarrow \text{Stored in calculator 'A'}$$

Now; $\dot{Q} = UA\Delta T_{lm}$

$$\therefore A = \frac{\dot{Q}}{U\Delta T_{lm}}$$

$$A = \frac{66,975}{350 \times 1 \times 112.33}$$

$$A = 1.703 \text{ m}^2 \quad (3dp)$$

- a) • Similarity - Both rely on electromagnetic fields.
• 3 Phase AC motors are self starting where as single phase AC motors are not, which require auxiliary means/equipment.
- b) AC drives are based on the way ~~the~~ power is converted, which converts AC supply to a DC supply and change DC back to ~~the~~ a variable AC output for control purposes, mainly using inverters.

By changing the fixed incoming line voltage and frequency, to a variable voltage and frequency output, the output frequency will determine how fast the motor rotates.

The prime advantage of AC motors is the ability to operate an AC motor in bypass mode. This reduces the amount of downtime as the motor can operate on main line power if the drive is not functioning.

- flexibility (elasticity)
c) ~~friction~~ is the mechanical property relied upon when using belts and pulleys, as ~~they~~ they need to absorb shock loads and aid in damping unwanted vibration.
↳ Wear of the belts and pulleys is an issue they suffer from.

Other power ~~the~~ transmissions;

1) Chain & sprocket drives

~~2) Drive systems~~ 2) Gear drive systems
~~2) Shafts & couplings~~

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d) In spur gears, the teeth are parallel to the axis of the gear, where as helical gear's teeth are inclined at an angle (helix angle) with the gear axis.

Spur gears imposes only radial load on bearings, where helical gear imposes radial load and axial thrust on bearings.

Spur gear can be used for ~~parallel~~ parallel shafts only, where, helical gears can use parallel or crossed shafts.

The advantages of spur gears include;

- Efficient and easy to assemble.
- Straight teeth for easy alignment.
- Minimal ~~power~~ ^{power} lost to slippage.

The disadvantages of spur gears are;

- Load at high speed.
- Must be used in parallel
- Not as strong as other gears.

The advantages of ~~spur~~ helical gears include;

- Quiet & smooth.
- Can be mounted in parallel or crossed.

The disadvantages of helical gears;

- Less efficient than spur gears
- Power loss due to slippage.

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Applications;

Spar gear :

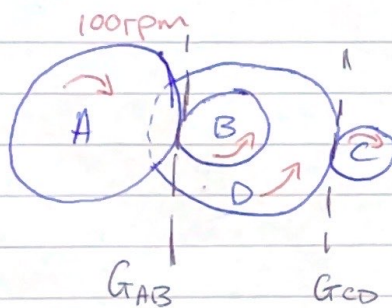
- Clocks
- Electric screwdrivers
- Pumps
- Power plant machinery

Helical gear:

- Automotive drive trains
- Construction equipment
- Helicopter transmissions
- Locomotives

- When meshing two gears the gear teeth must be the same size. Hence, the number of teeth on any gear is directly proportional to its pitch circle diameter.

e) i)



$$t_A = 80 \quad t_B = 20 \quad t_C = 20 \quad t_D = 60$$

$$\omega_B = \omega_D$$

$$G = \frac{t_B}{t_A} \times \frac{t_D}{t_C} = \frac{20}{80} \times \frac{20}{60} = \frac{1}{12} : 1$$

$$\omega_C = ?$$

$$\therefore G = \frac{\omega_A}{\omega_C} \times \frac{\omega_D}{\omega_B} = \frac{\omega_A}{\omega_C}$$

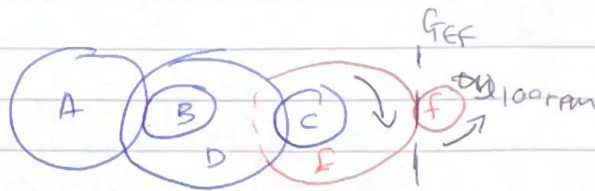
$$\therefore \omega_C = \frac{\omega_A}{G} = \frac{100}{1/12} = 1200 \text{ RPM}$$

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$$\text{ii) } G = \frac{t_s}{t_d} \times \frac{t_c}{t_d} = \frac{1}{12} \cdot \frac{20}{80} \times \frac{20}{60} = \frac{1}{12} : 1$$

iii)



$$t_s = 40 \quad t_f = ? \quad \omega_c = \omega_f$$

$$\frac{G}{t_s} = \frac{\omega_c}{\omega_f} = \frac{1200}{100} = 12 \text{ RPM}$$

$$G_{ef} = \frac{t_f}{t_s} \quad \therefore t_f = G_{ef} \times t_s$$

$$t_f = 12 \times 40$$

$$t_f = 480$$