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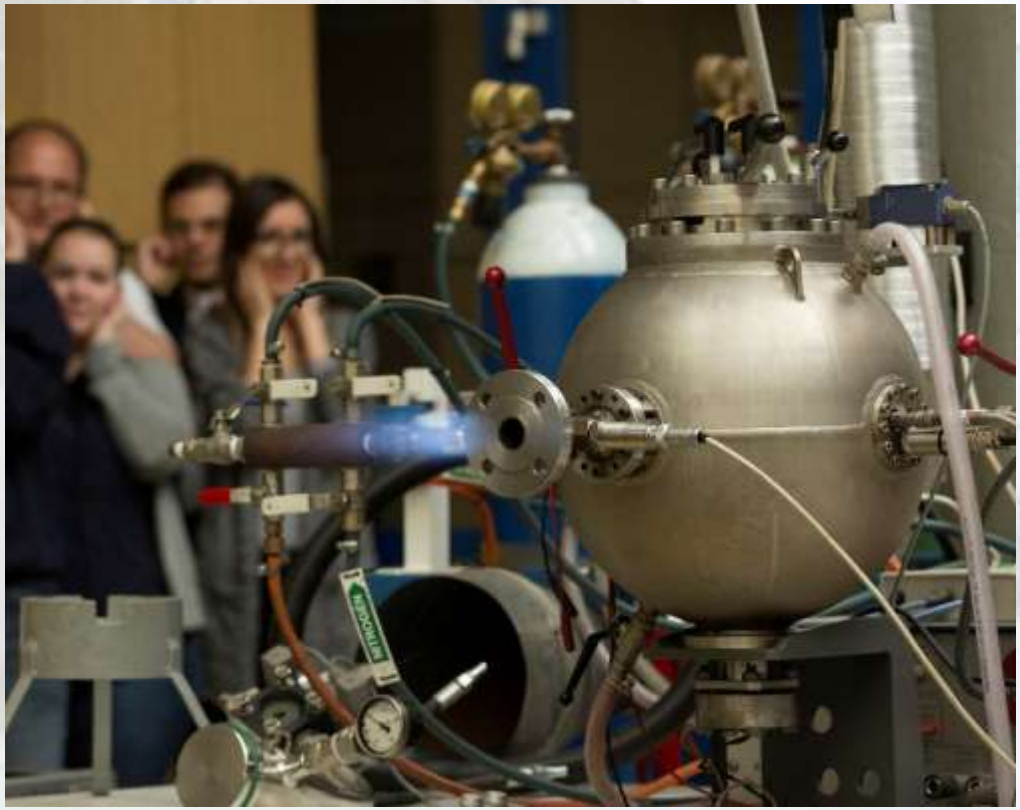

# OPTIMIZING THE PERFORMANCE OF HEAT EXCHANGERS DEPENDING OF THE USED AMOUNT OF MATERIAL TO REDUCE THE CARBON FOOTPRINT

The CCUV4 Workshop in Prague

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# THE ROLE OF HEAT EXCHANGERS

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- Without heat exchangers, our modern standard of living would be virtually unsustainable, as they are present in all aspects of life, often even invisibly.
  - electricity (boilers in power plants)
  - insulations of electric appliances, cushioning, packaging materials (process heat exchangers in chemical plants)
  - heating and cooling equipment in homes (radiators, air conditioners)
  - processed food (dried, concentrated foods, alcoholic beverages)
  - transport (heat exchangers cooling car engines)
- unfortunately, with energy supplies and prices as they are today, the researched topic has perhaps never been as important as it is today

# THE ROLE OF HEAT EXCHANGERS

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- heat exchangers will not cause a problem directly
- indirectly and in long term, they have a fairly significant carbon footprint
- According to our knowledge and experience, the carbon footprint and the optimisabality of the heat exchangers are on three legs:
  - the best solution for the given task → optimizing the heat transfer process (long term)
  - reduce the mass of the equipment → less energy is needed to process the raw material (long term)
  - reduce the dimensions of the equipment → using standardized dimensions and using less welding (significant $CO_2$ emissions at discrete times)

# DIFICULTIES

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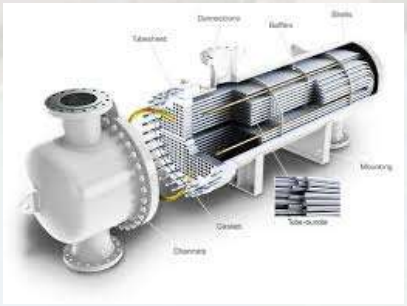
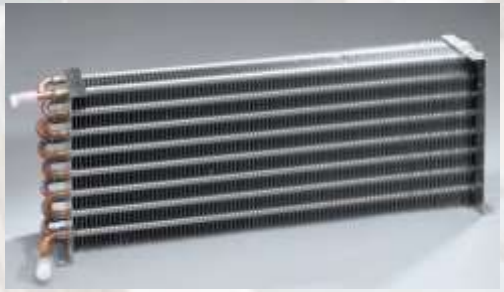
- no strict rules for the choice of heat exchanger equipment for a given task
- practically everything will be influenced by external conditions
- must be think in whole system instead of individuals (does not work standalone)
- moreover, the selection process influenced by
  - temperature of the media
  - material properties of the media
  - type of the heat transfer process



# DEFINITION OF THE OBJECTIVE FUNCTION

- optimisation can be mean
  - optimisation of a single element of the plant,
  - optimisation of the whole structure in same aspect,
    - heat exchanger,
    - pipelines,
    - steel structure,
  - optimisation of the whole plant.

# DOUBLE PIPE HEAT EXCHANGERS

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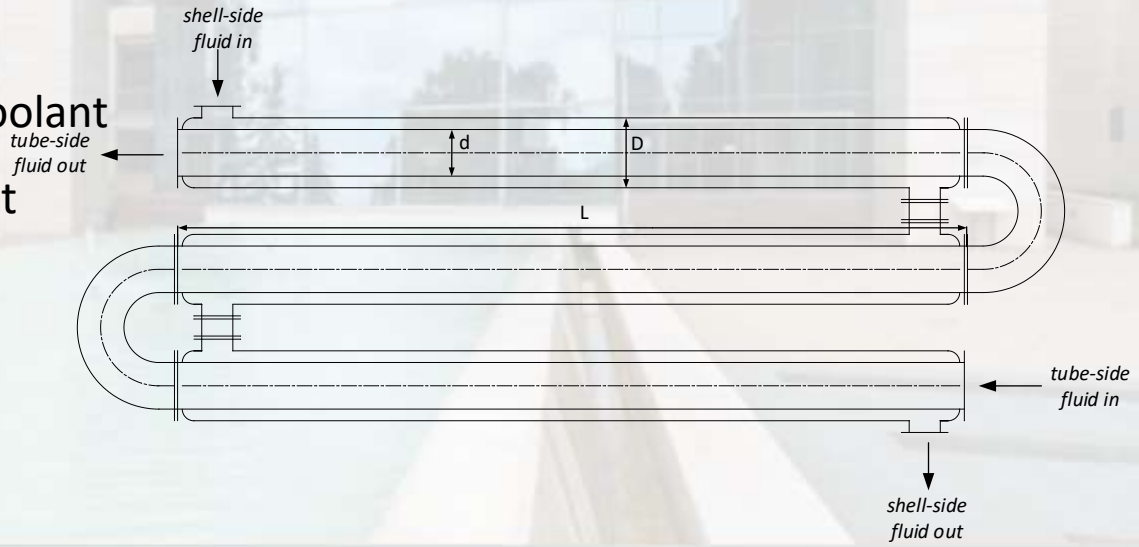
- simplest of the heat exchanger devices
- for heat sensitive fluids
- safest construction
- optimisation: 5 variables
  - length of tube
  - inside diameter of tubes
  - outlet temperature of coolant
  - mass flow rate of coolant



# DOUBLE PIPE HEAT EXCHANGERS

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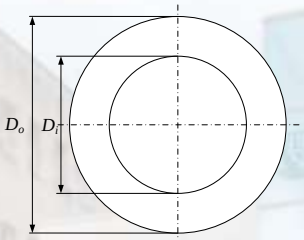
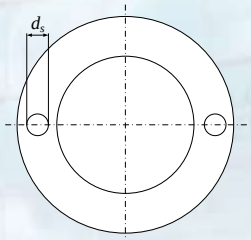
- turbulence enhancing options




λ = 0

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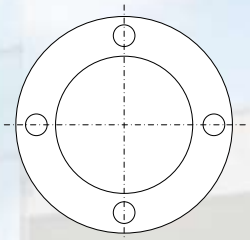

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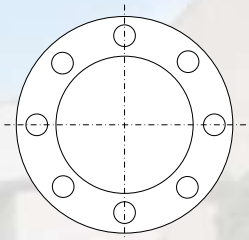

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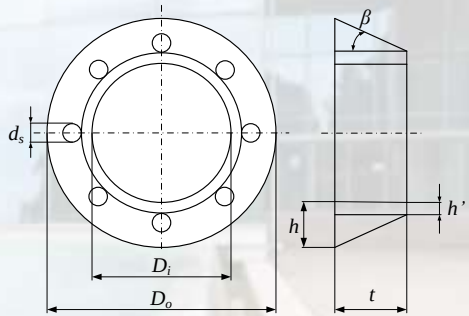

# SHELL AND TUBE HEAT EXCHANGERS

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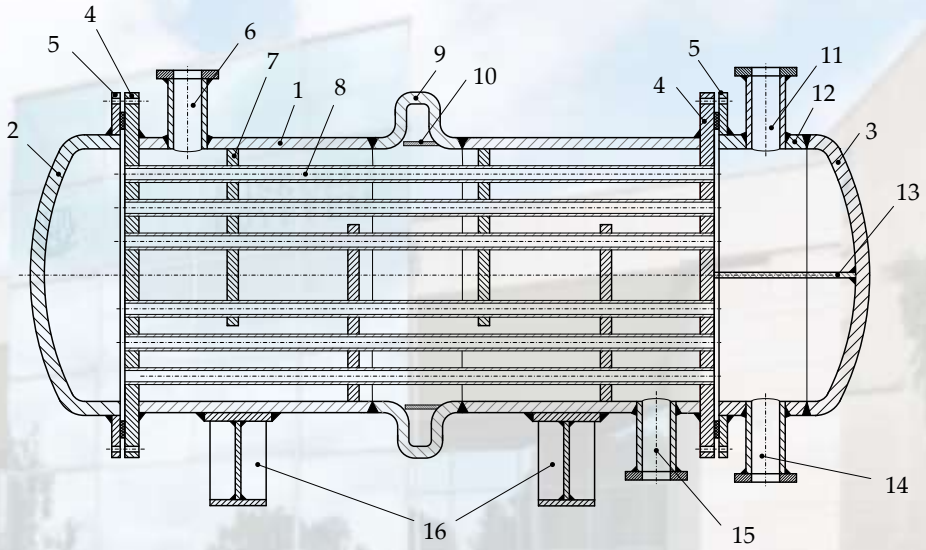
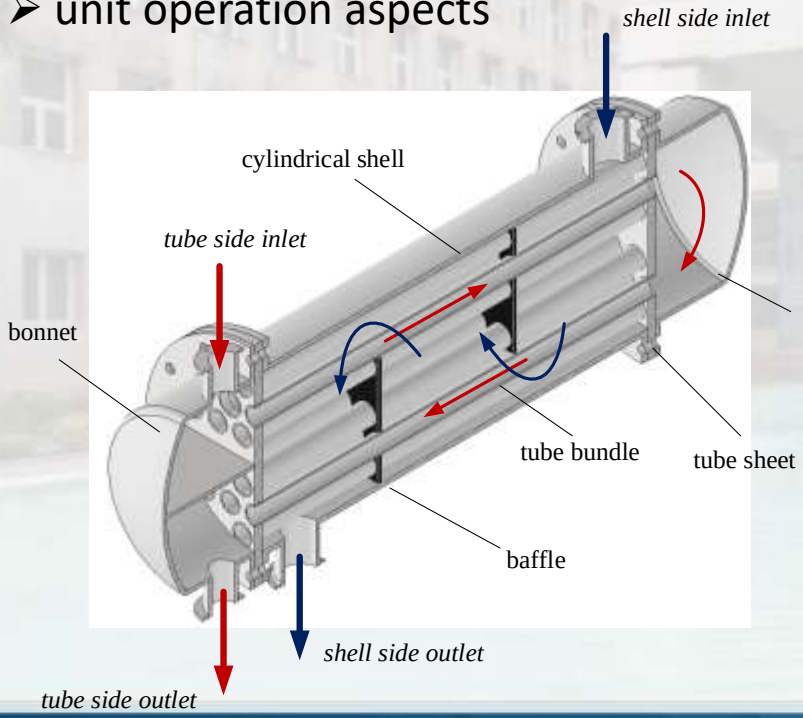
- „working horses” of the industry
- safety aspects
- operational safety aspect
- unit operation aspects



# SHELL-AND-TUBE HEAT EXCHANGERS

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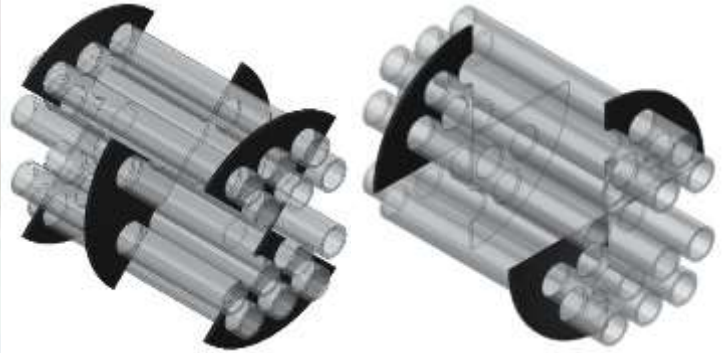
- shell side turbulence enhancing options

*segment type baffles*



*flower type baffles*

*disk-and-donut type baffles*

# SHELL-AND-TUBE HEAT EXCHANGERS

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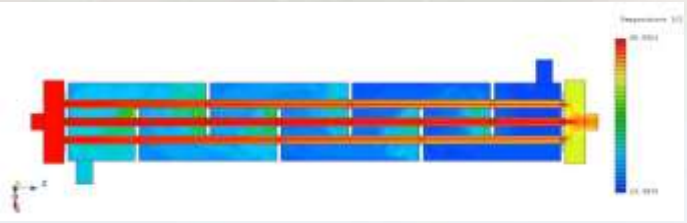
- shell side turbulence enhancing options

*rotated segment baffles*

*ladder type baffles*



*helical baffle*

# FINNED TUBE HEAT EXCHANGERS

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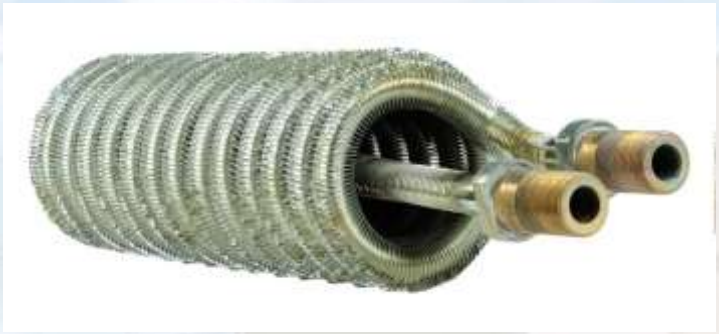
- area of application: one fluid is in gas phase
- low value of heat transfer coefficient
- high value of heat trasfer area
- air coolers, cooling/heating systems,



# FINNED TUBE HEAT EXCHANGERS

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- the finned surface can be produced:
  - cutting
  - welding
  - perforation
  - and combination of these
- whatever they are, they involve significant energy use
- these type is commonly used in vehicles
  - coolant must be cool down to ensure the secure oparation
  - mass should be reduced to decreasing fuel consumption

# FINNED TUBE HEAT EXCHANGERS

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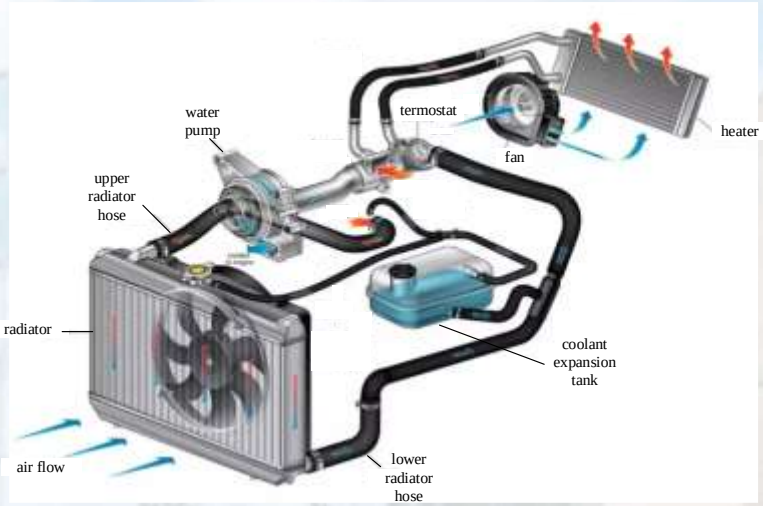
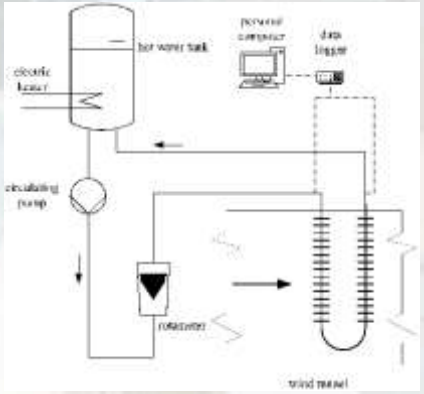
- main part: automotive radiator → heat transferred from cooling liquid to the air
- cooling liquid: circulates between the engine/battery pack and the automotive radiator
- water pump: circulates the cooling liquid
- higher velocity → higher heat transfer coefficient → higher amount of transferred heat
- thermostat: another radiator can be installed to the system, this can heat up the inner volume of the vehicle



# FINNED TUBE HEAT EXCHANGERS

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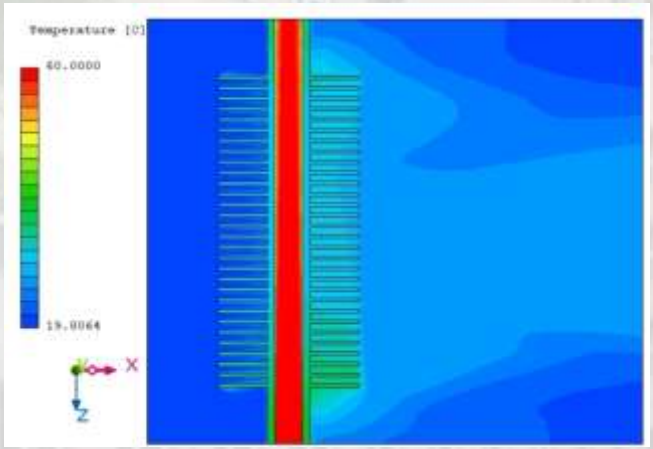
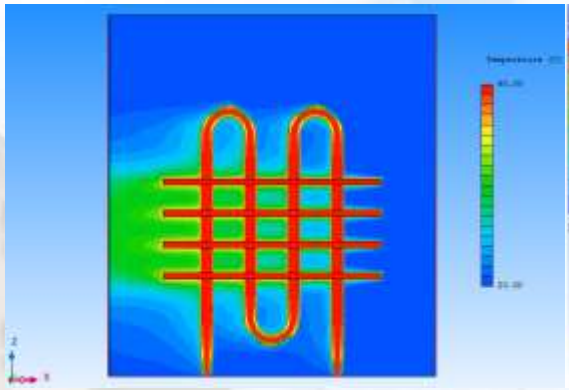
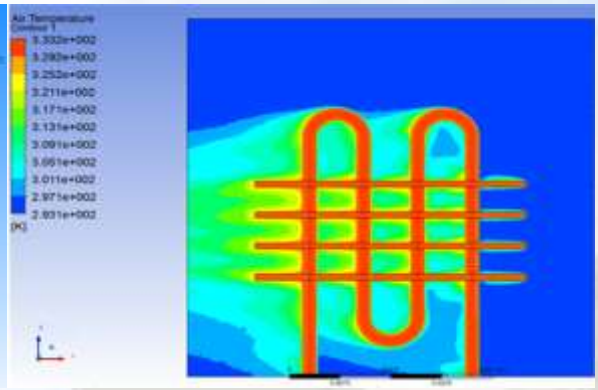
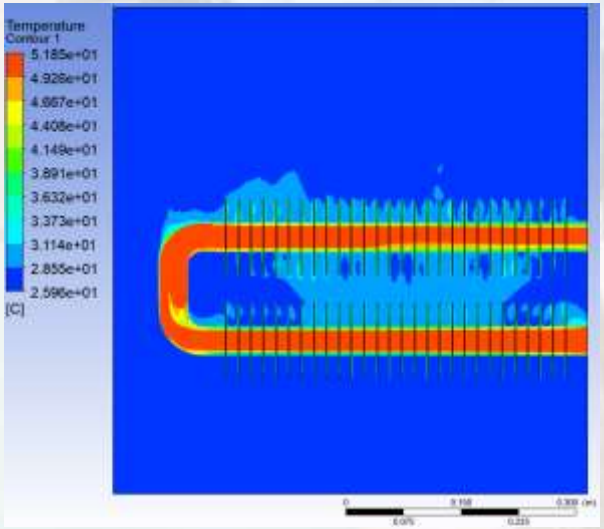



investigation of the effect of the fin geometry





simulation techniques of finned tube heat exchangers




compare the results of measurement, CFD and theoretical method

# MANUFACTORING COSTS

- these costs will directly affect $CO_2$ emission
- material costs:
  - proportional with the mass of the raw material
  - raw material can be:
    - tubes
    - sheets
    - standardized fitting
    - metal blocks (extended surface, tube sheet)
  - this cost can be reduced using standardized dimensions

# MANUFACTORING COSTS

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- manufactoring costs:
  - welding cost:
    - complexity factor
    - number of elements to be welded
    - mass of elements to be welded
    - type of welding
    - edge preparation/surface preparation
  - painting cost
  - non-destructive examinations

# STEEL STRUCTURES

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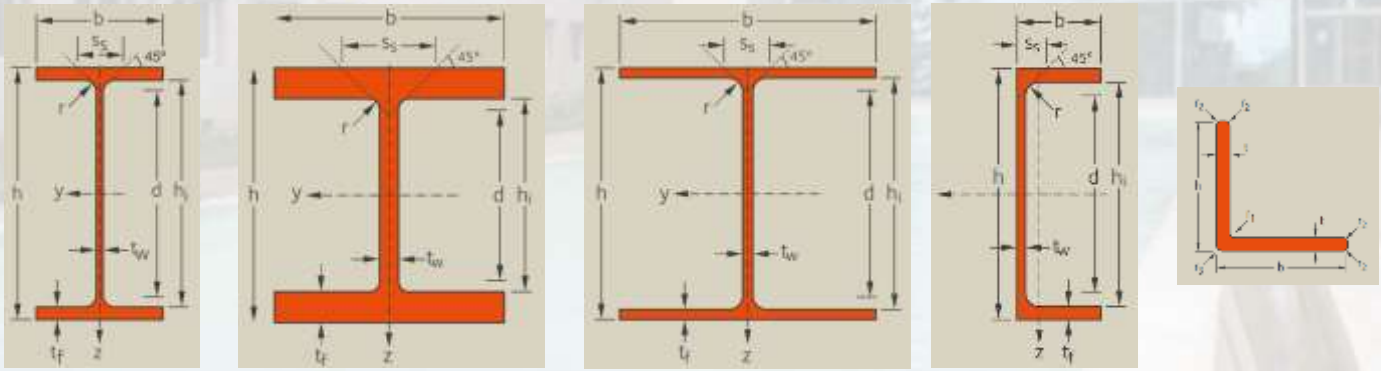
- steel structures are the skeleton of the plants/factories
- integral part of the plant
- represent a significant part of the steel consumption of the plant
  - compressed and/or bended beams
  - tubular members, tubular trusses
  - frame structures
  - pipe bridges
  - silos, storage tanks

*BorsodChem HPM plant (under construction)*

- smaller sizes are more justified, since
  - smaller masses are easier to move (transport, lifting)
  - can be produced with lower power equipment
  - no deflection from own weight
  - connect them to each other is easier
- recommended to work with standardised dimensions



# STEEL STRUCTURES – THE BIGGER THE BETTER?

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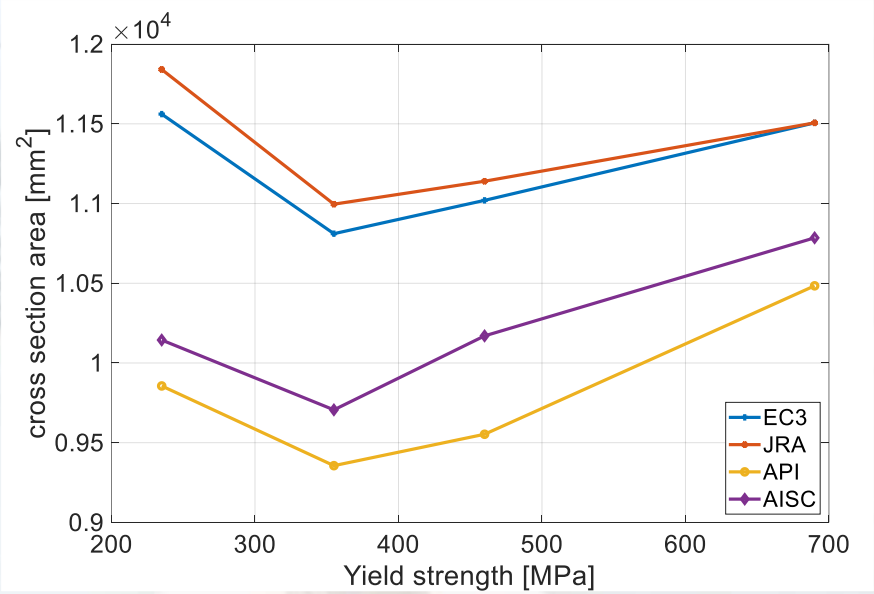
- geometric properties
  - axial load (tension/compresson), shear load: cross section areas
  - bending: section properties (strong axis and weak axis)
  - torsion: torsional section property
- material properties
  - static load
  - dynamic load
  - fire load?
- requirements of codes, standards



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