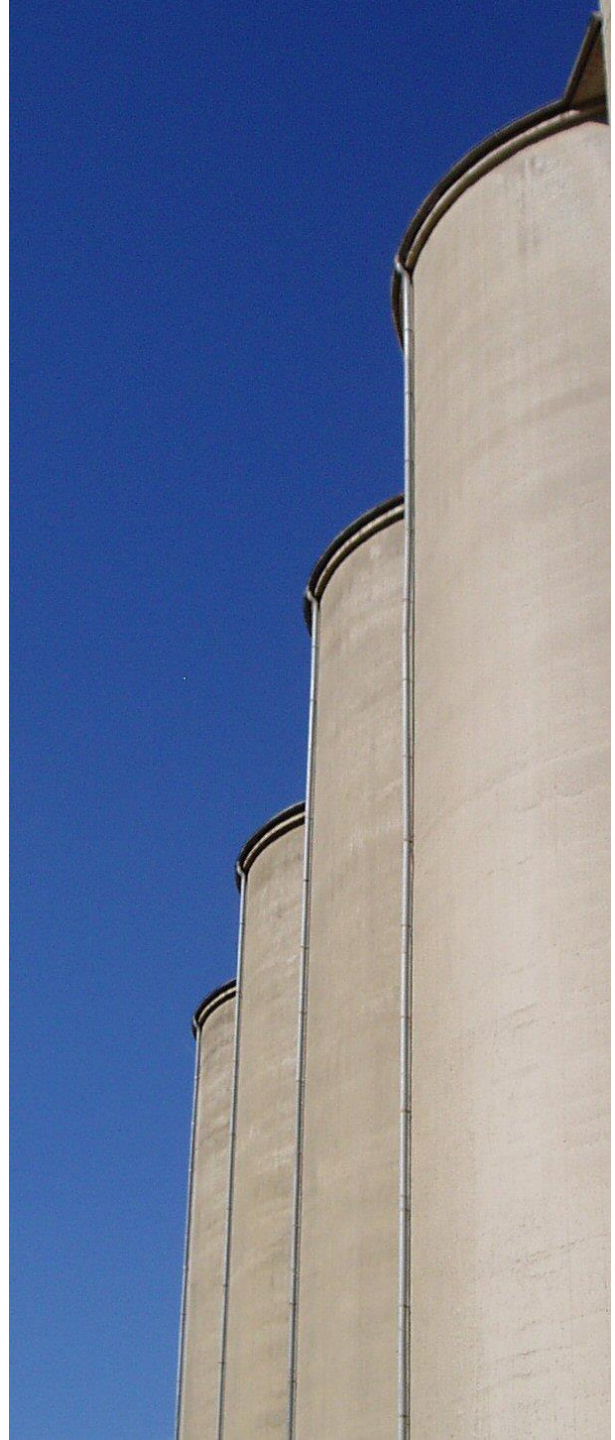
UNIVERSITY of GREENWICH

The Wolfson Centre
for Bulk Solids Handling Technology

Between Ship and Quay: Ship Unloading technologies

Choice of Equipment



Continuous Ship Unloader versus Crane, Grab and Hopper

CSU

- Limited range of bulk solids
- Specific to bulk density and flow properties
- Higher rates
  - At top end
  - For given machine size
- Less dependent on operator skill

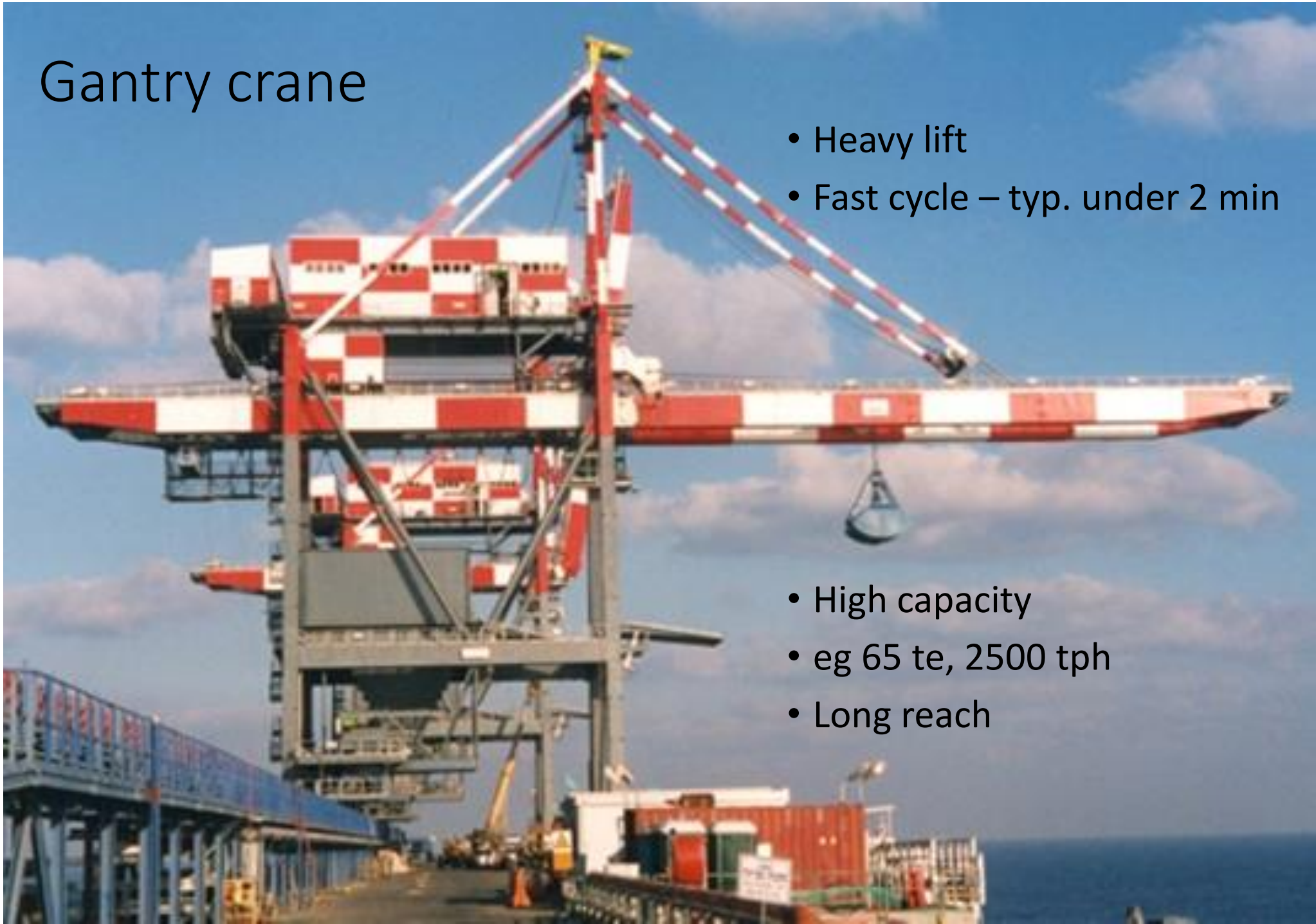
Grab Crane and hopper

- Use for both bulk and unit load
- Range of bulk solids
- More spillage
- Lowest product degradation
- Easy to cope with wide range of bulk densities

Grab Cranes

- All should be “level luffing”!
- Crane type and size
- Grab size
- Cycle time
- Control systems (semi-automation)
- Hoppers
- Dust control

Gantry crane



- Heavy lift
- Fast cycle – typ. under 2 min

- High capacity
- eg 65 te, 2500 tph
- Long reach


PORT OF KOPER

Gantry cranes

- Fast cycle, heavy lift
- Even 2 trolleys
- High rate
- Few parts move during cycle – trolley and grab
- Low wear, low maintenance cost per tonne
- Hopper integrated
- Reach – for largest ships (Valemax 380,000DWT 65m beam)
- Lends itself well to semi-automation (common for container handling)

- Bigger investment
- More space and weight
- No slewing function
  - Must travel to move along hold
  - Not convenient in small holds, esp. during clean-up
- Less flexible - hopper normally integrated
  - Cannot be easily converted for unit loads

Level luffing cranes

- “Horse head”

  versus

- Single boom (“Toplis” rig)

Single-Jib Level-Luffing Crane ("Toplis" gear)

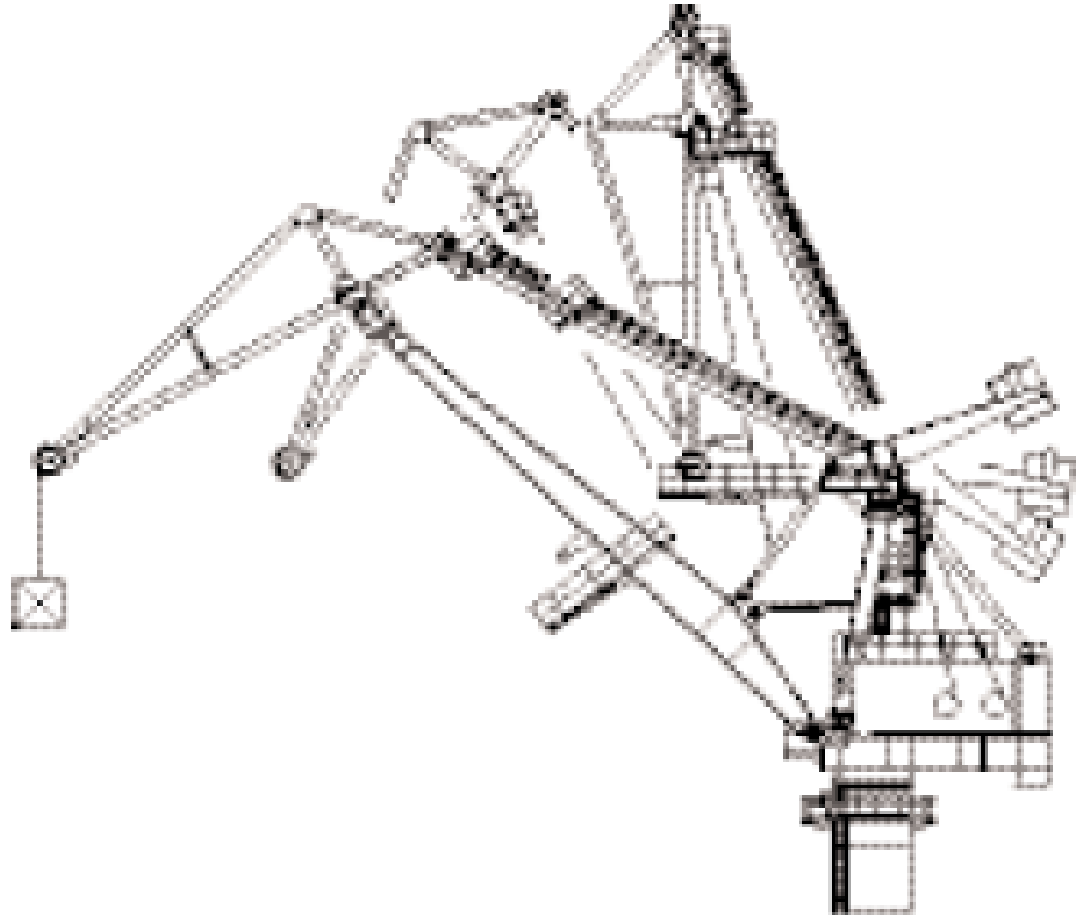
- Invented 1914 by Claude Toplis at Stothert & Pitt
- Level luffing by rope arrangement
- Luffing by rope or crank
- Less costly
- Lower weight
- More maintenance
- Not so well balanced
  - More power required due to lifting of boom
- Long free-swinging length

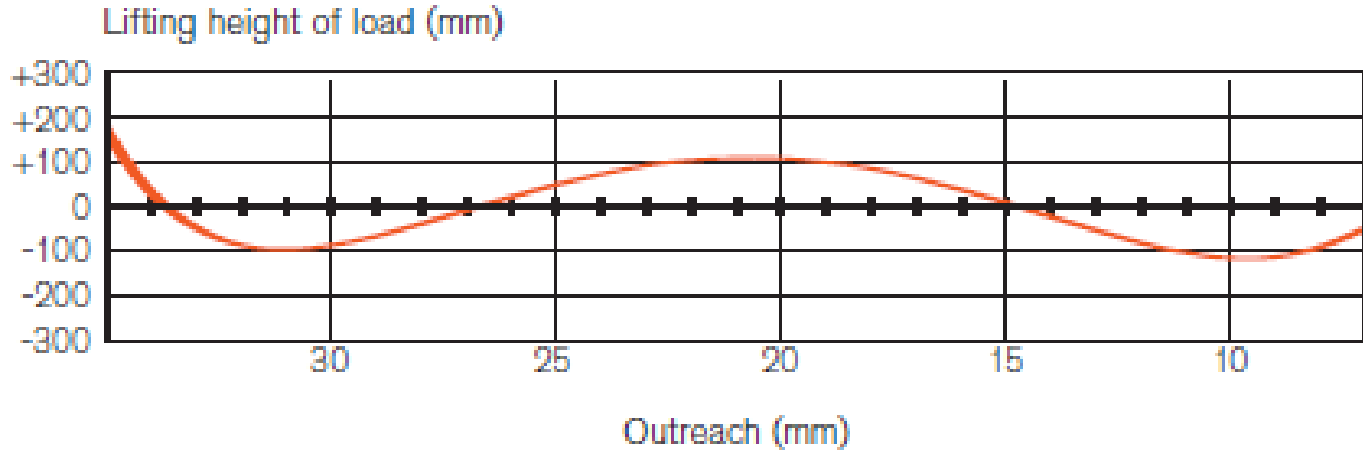

CSBC
LLC II
HAI


Articulated Jib
(“Horse-head”)
level luffing
crane

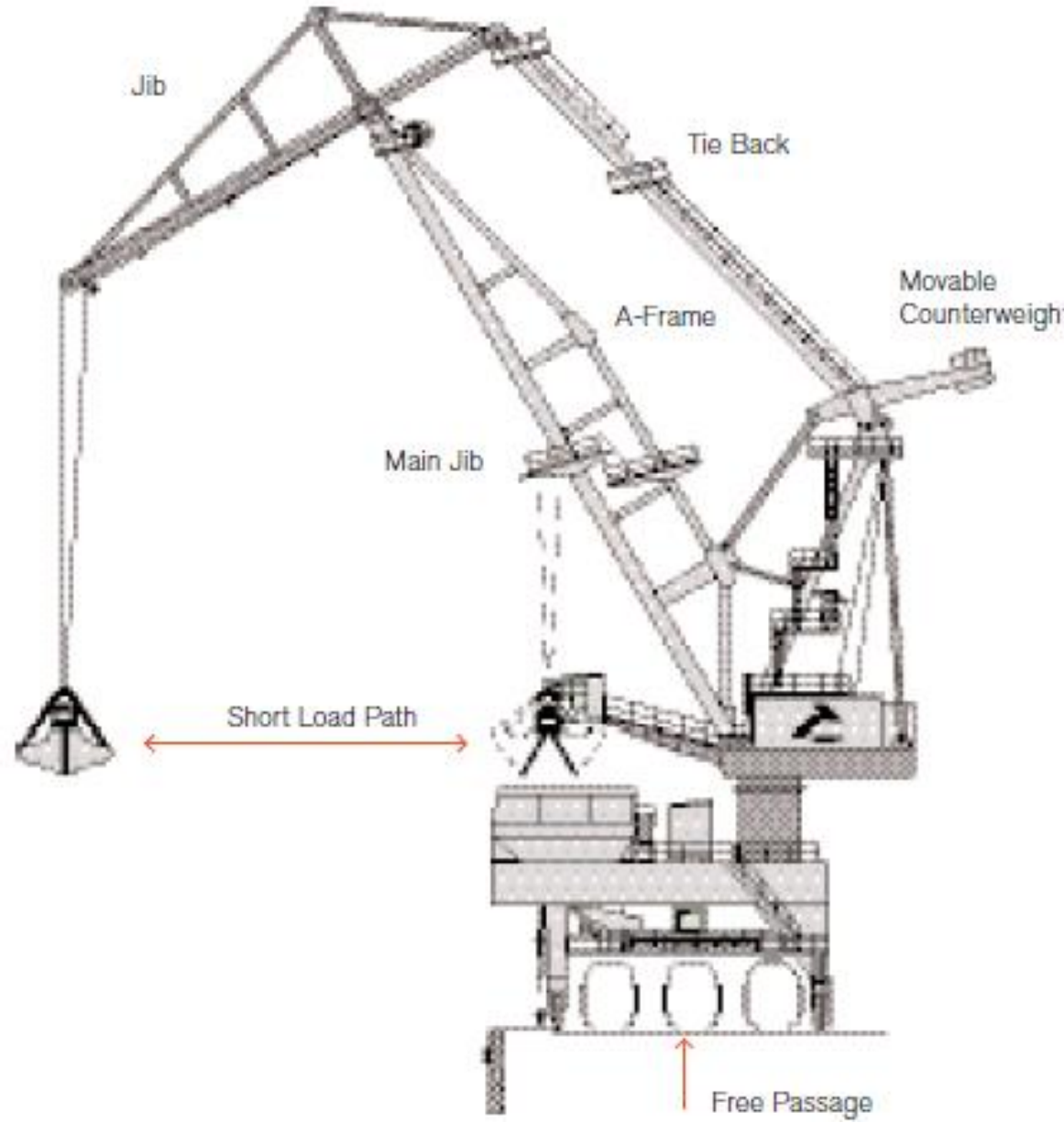
Articulated Jib level luffing crane

Originated by Babcock and Wilcox in 1930's





- Short free-swinging length – less affected by wind and sway
- Accurate and fast operation, reduced spillage
- Low power usage (moving components balanced and load not lifted during luffing)
- Mechanical luffing drive (minimal maintenance)
- Minimum wear on cables (only move during lifting and lowering)
- Lends itself to automation



Level Luffing Cranes

- Popular up to 500-600 tph with grab
- Larger are used
- Hopper required
  - Free standing?
  - “Kangaroo”?
- Flexibility

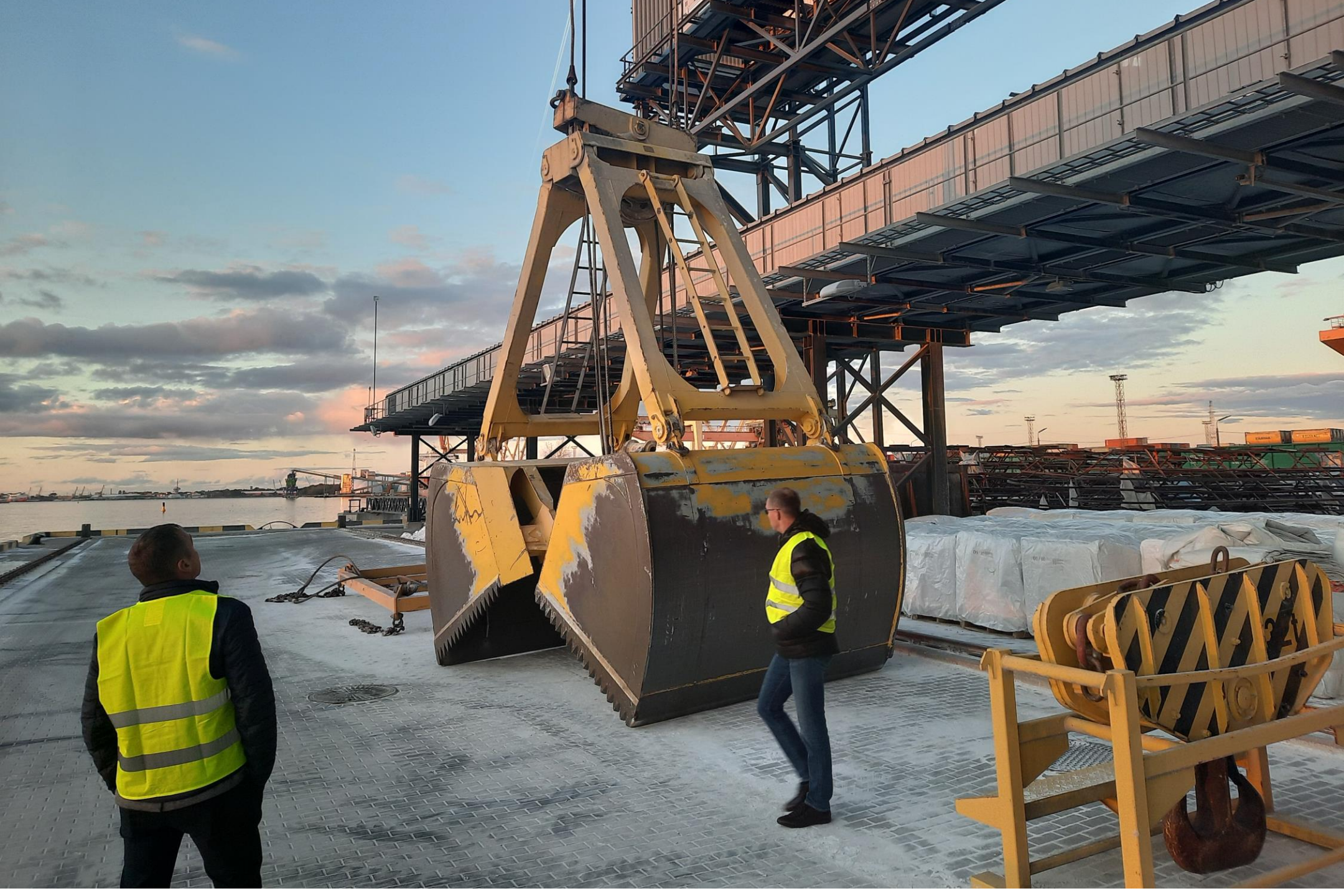
Hydraulic grab cranes

- Useful for small cargo flows
- 100-200 tph +/-
- Mobile or fixed
- Low cost
- Limited reach
- Readily tradeable
- Uses electro-hydraulic grab

Clam-Shell Grabs

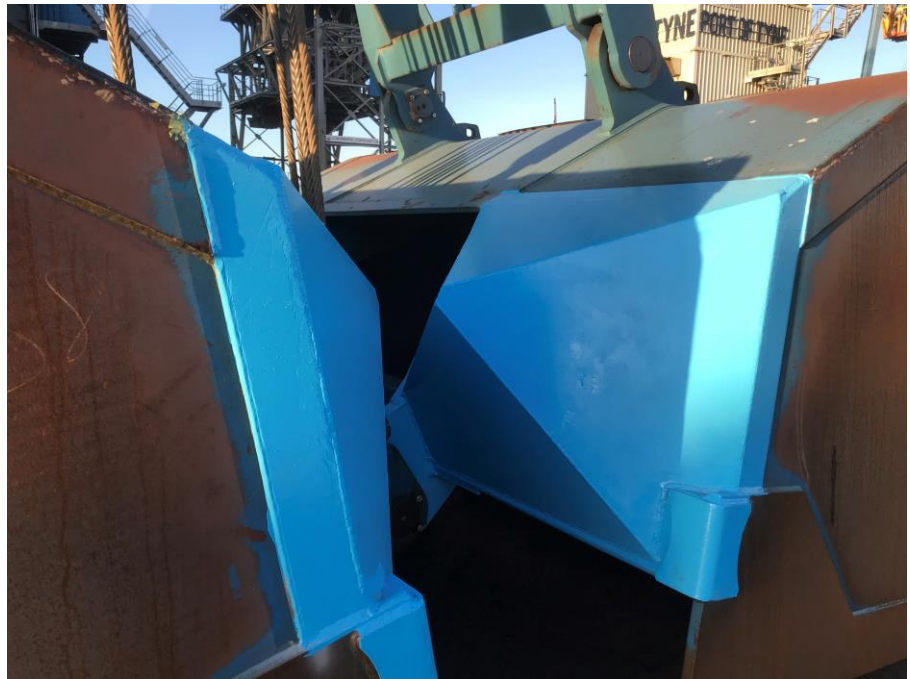
For “Class 1” and Class 2” commodities

- Two-Rope or Electro-Hydraulic
- Volume – to match crane capacity to bulk solids density
- **Different grab size for different commodities!**
  - **Bulk density change**
- Sealing efficiency – dribbling
- Cannot dig into “Class 3” commodities



Reducing dust emission from grabs

- Pyramidal covers over open tops
  - Reduce roll-off of excess bulk solid
  - Reduce wind lift-off of dust



Orange-Peel Grabs

- Two-Rope or Electro-Hydraulic
- Can dig into materials that a clam-shell grab cannot enter
- Especially good for “Class 3” (extreme shape) commodities
- Scrap metal, biomass, wastes
- No good for “Class 1” (free flowing) commodities – will dribble excessively

Grab weight considerations

- Crane lift limit = weight of grab + weight of grab contents
- If the grab weighs less, then its contents can be greater within a given crane lift capacity;
- BUT: this is only achieved IF the grab volume is increased in the right proportion
- More important to match the grab volume and crane weight limit to the commodity bulk density

But also beware:

- Too light a grab cannot dig into a caked or poorly flowing commodity
- Especially class 3 materials (scrap metal, raw biomass, reclaimed wood, other waste materials . . .)

Free-standing crane discharge hopper

- Size
- Space
- Weight
- Dust
- Grab positioning
  - Use of free-standing hopper requires slewing in each crane cycle
  - Increases cycle time

Controlling dust at grab discharge

- Containment and shielding against wind
- Grab lowered inside hopper before opening
  - The deeper, the better the containment (less extraction needed)
- Smallest workable size around grab
- Extraction and filtering of displaced air

“Kangaroo” crane

- In-built hopper attached to portal
- Moves with crane
- Eliminates need for slewing each cycle
- More efficient when traversing
- Universal with gantry crane, optional for level-luffing

Crane Semi-Automation Systems

- Much R&D on full positioning systems for gantry container cranes
  - Not usually on grabs
  - Bulk is small beer by comparison with boxes!
- Part automation available for gantry grab cranes
  - Unknown (?) on other crane types
- Operator controls grab digging operation
- Computer takes over for “return to base” to empty grab
- Many limitations due to unpredictable factors
  - Flex in crane structure
  - Wind

Grab Cranes summary

- Flexible
  - Different bulk cargoes
  - Unit loads
- Gentle to cargo
- Cycle time and unloading rate varies
  - With reach and depth through unloading operation
  - With operator skill and fatigue
- Spillage and dust are issues
- Large size and weight relative to throughput compared to CSU

Fixed
(inc. rail mounted)
versus mobile
harbour
cranes

Mobile versus fixed cranes

Fixed / rail mounted

- Heavier
- Balance more optimised
- Faster cycle
- Lower maintenance & “cost of ownership”

Mobile harbour crane (not construction-type crane)

- Flexibility for redeployment elsewhere
- Lighter weight
- Many efficiency and safety features compromised to achieve mobility!

Compromises with mobile cranes

- Invariably single boom
  - Should feature Toplis reeving (for level luffing)
  - Long free-swinging length, much sway and wind effect
  - Normally no moving counter-weight (to save weight)
    - Not so well balanced – more load cycling on quayside
    - Inherently more susceptible to overturning
- Time-consuming to travel between holds
- Does not incorporate a kangaroo hopper
- More hydraulic and/or rope drives
  - Higher wear and tear
  - Increased cost of ownership
- Often cabin is less well positioned (poorer view)

Mobile versus rail mounted cranes cont.

- To be cost effective, the mobile crane must use its mobility to benefit the business
- A mobile crane used in one place for a long period (years) is unlikely to be an economical alternative to a rail mounted portal crane!

Continuous Ship Unloaders

- Screw
- Bucket Elevator
- Bucket Wheel
- Blanket Belt
- Pneumatic

Screw CSU

Screw CSU

- Good for dusty cargos – containment
- Throughput medium to moderately high – 800 to 2400tph depending on density
- Low to moderate product degradation
- Free flowing cargos ok
- Moderate energy consumption (~60kW per 100tph)

- Not good with tramp material
- Loses effectiveness with highly cohesive cargoes

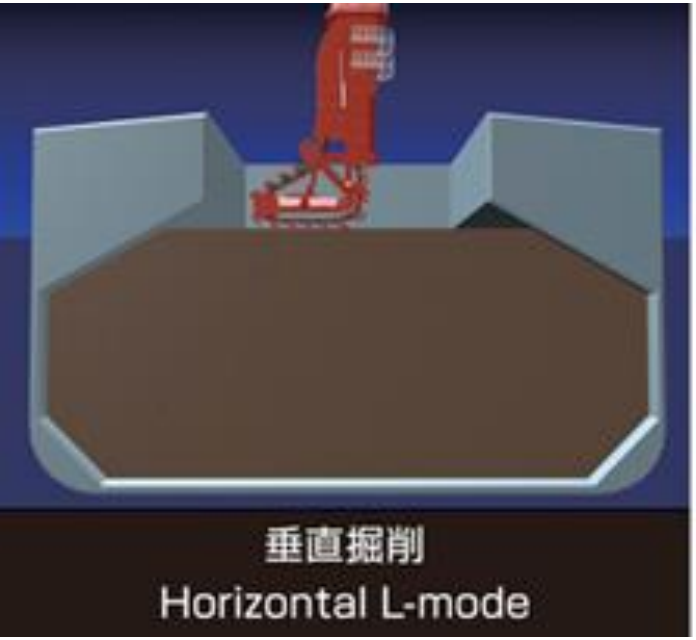

Bucket wheel
CSUs

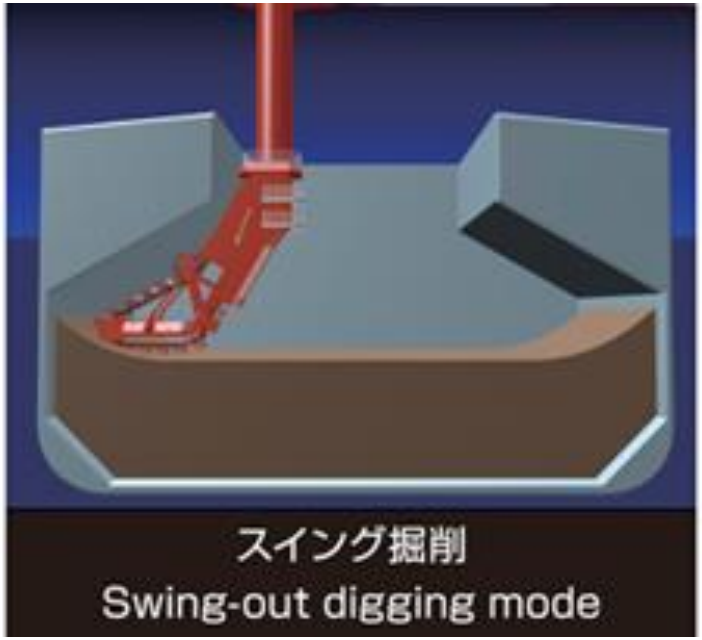
Bucket wheel CSU

- High rates – 2500 tph and more
- Good for cohesive cargoes
- Low to moderate product degradation
- Large and heavy
- Dust containment not so good

Bucket elevator CSUs

Adjustable “foot” on bucket elevator CSU



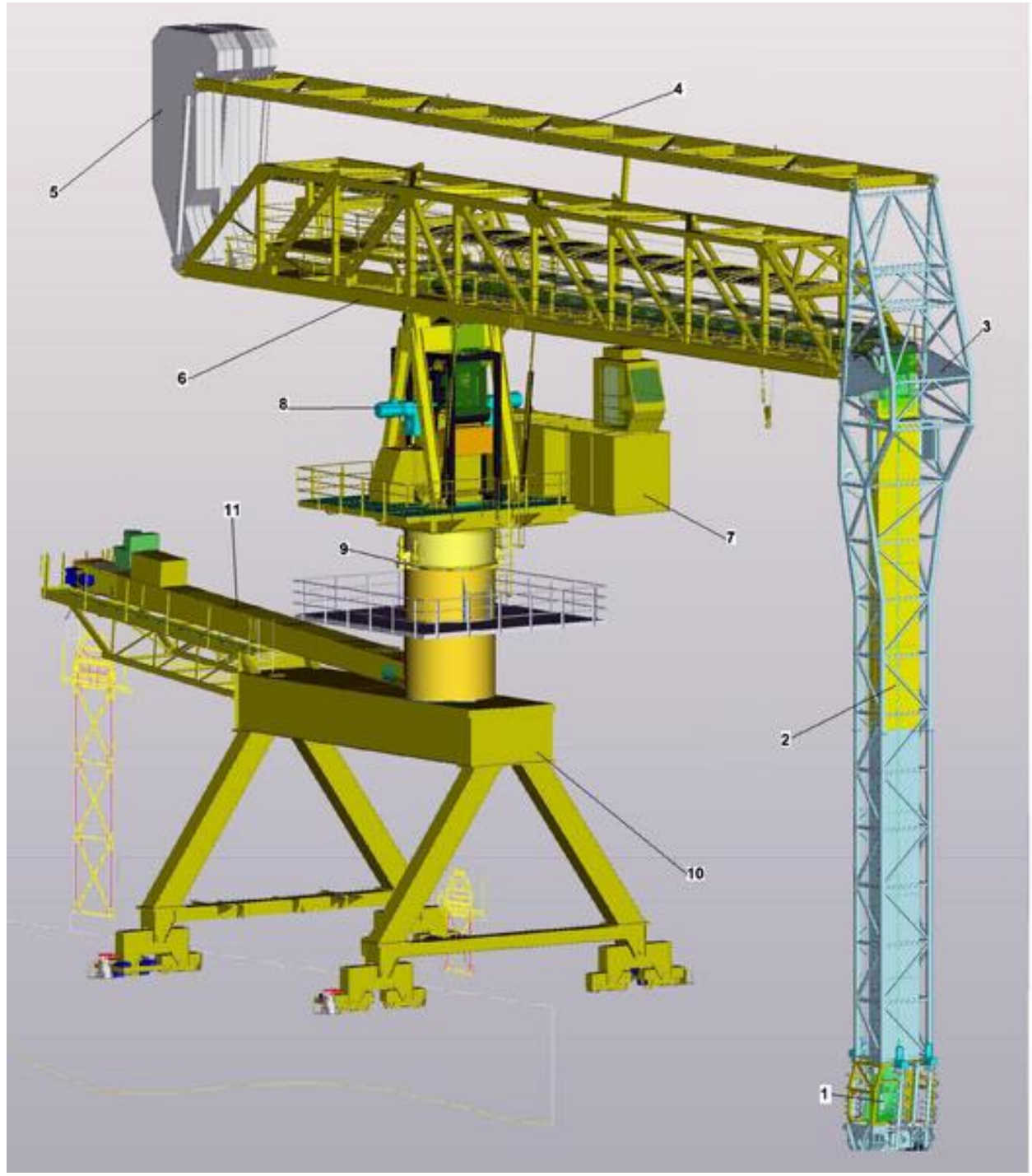


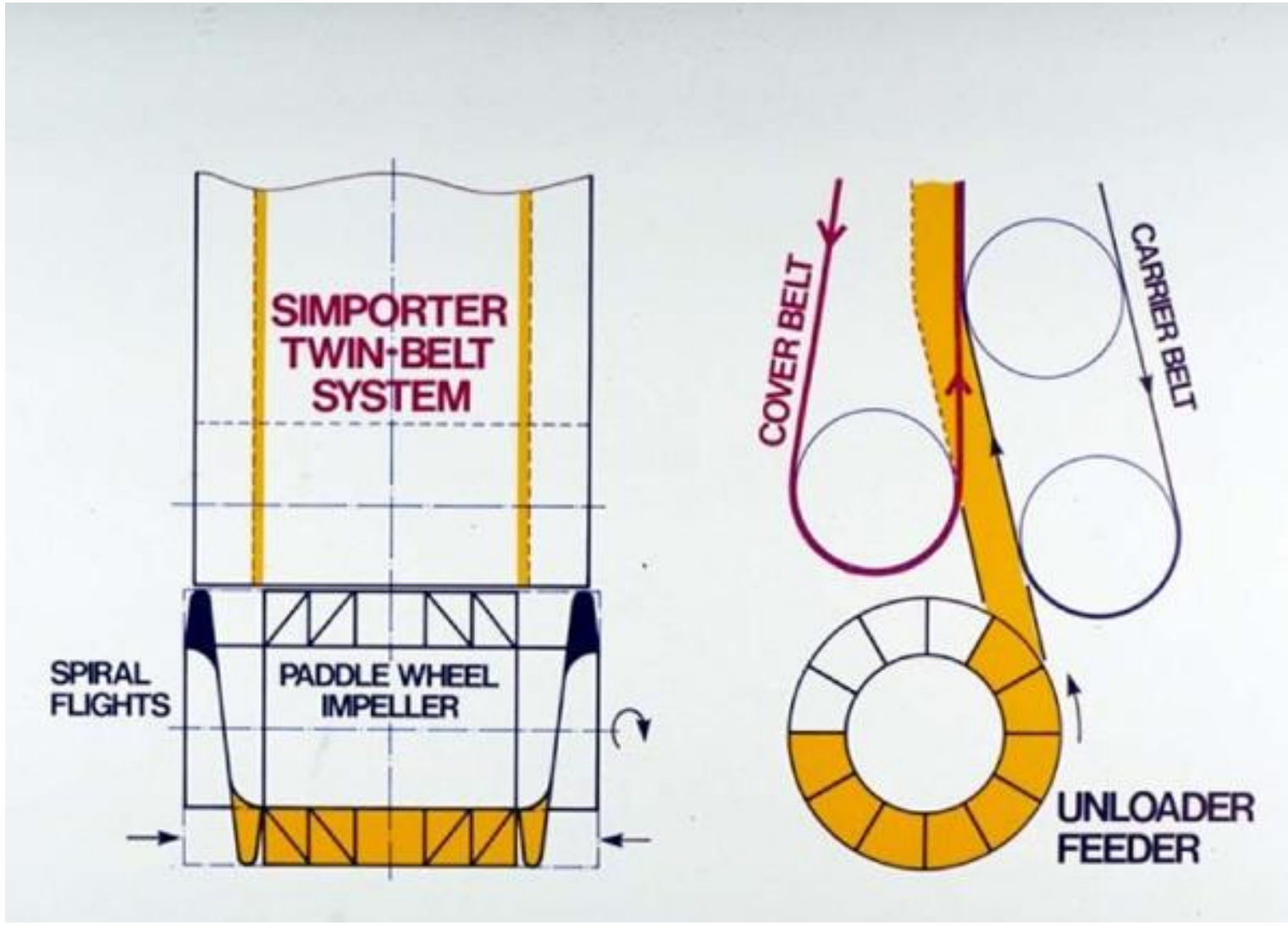
Bucket elevator CSU

- Medium to high capacities – to 6000 tph or more
- Wide range of rates
- Good for cohesive cargoes
- Low to moderate product degradation
- High weight
- Dust containment not so good
- Damage from tramp material

Blanket-belt CSU
("Simporter")

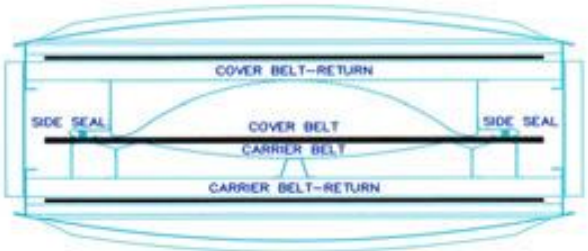
“Simporter” developed by Simon-Carves, sold to Vigan in 2007



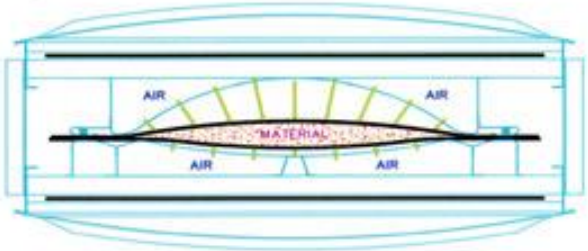

SIMPORTER
TWIN-BELT
SYSTEM
SPIRAL
FLIGHTS
PADDLE WHEEL
IMPELLER
COVER BELT
CARRIER BELT
UNLOADER
FEEDER

SIMPORTER TWIN–BELT SYSTEM

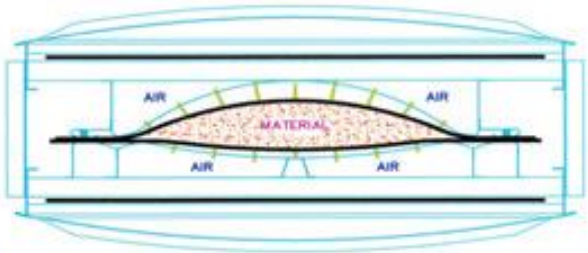
SECTIONS THROUGH AIRBOXES IN ELEVATOR LEG



SIMPORTER EMPTY



SIMPORTER RUNNING AT INTERMEDIATE CAPACITY



SIMPORTER RUNNING AT FULL CAPACITY

Blanket-belt (sandwich belt) CSU

- Medium rates – 500-1500 tph
- Theoretically, low maintenance
- Low degradation to cargo
- Low energy consumption (~40kW per 100tph)
- Depends on flow properties of cargo
  - Not good for extremely free flowing commodities
- Not popular

Pneumatic CSU


VIGAN

Feeder for cohesive cargoes


Mobile
pneumatic CSU

Pneumatic CSU

- Low weight on quayside
- Few moving parts – low maintenance
- Excellent for dust containment
- Good for free flowing cargos – not for cohesive
  - Feeder can be added for slightly cohesive ones
- Small mobile units available
- Size limited – mostly ~200 tph (rarely to 800 tph for favourable cargoes)
- Rate varies with luff and hoist position (reach and depth)
- Damage to coarse particles
  - More dust in material after unloading
  - Particularly during “clean up”
  - Increases dust emission further downstream
- High energy consumption, ~80 to 100kW per 100 tph

Continuous Ship Unloader versus Crane, Grab and Hopper

CSU

- Limited range of bulk solids
- Specific to bulk density and flow properties
- Higher rates
  - At top end
  - For given machine size
- Less dependent on operator skill
- Lends itself to wireless control from ship-board
- Lead time often longer

Grab Crane and hopper

- Use for both bulk and unit load
- Range of bulk solids
- Less damage from tramp material
- More spillage
- Lowest product degradation
- Easy to cope with wide range of bulk densities
- Dependent on operator skill and fatigue

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Ship Unloading:
Choice of Equipment