Trends in the Design of Modern Tugs for Tanker Escort and Terminal Operations

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OUTLINE

- Tug Technology - a Primer
- Recent Design R & D efforts
- Escort Towing
- Offshore Terminal Operations
- State-of-the Art Designs
- The SAFETUG Project
- Q & A
Tugboat Technology

a “Primer”
Tug Functions

- Harbour ship-assist
- Oil or gas terminal support
- Coastal or ocean towing
- Salvage
- Multi-purpose
- Escort
- Offshore support
Tug Technology

- Selecting the Right Propulsion System for the Job
- Selecting the Right Hull Form for Different Towing Functions
- Matching Hull Forms to Propulsion
- Choosing suitable Deck Equipment for role
Propulsion Choices

- Conventional
  - Single-screw
  - Twin-screw
  - Multiple (3 or more) – shallow draft
- Cycloidal Propeller
  - Voith ‘tractor’
- Z-drive
  - ASD configuration
  - Z-Tractor configuration
Propulsion Characteristics

• Thrust per unit power:

  - Twin Screw: 10-15 Kg/Kw (open)
    - 15-20 Kg/Kw (nozzle)

  - Z-drive tugs: 15-20 Kg/Kw
    - Average = 17 Kg/Kw
    - Usually restricted propeller diameter

  - VSP tugs: 12.5-16 Kg/Kw
Hull Form Issues

CLASSICAL TUG FORMS
NOT SUITED TO Z-DRIVES

LARGE AFT SKEG DEFLECTS THRUST

PREFERRED AFT HULL FORM
FOR BEST ASD PERFORMANCE

THrust

D.W.L.

HULL REACTION TO WASH

UNIMPEDED PROP WASH

THrust

D.W.L.

Robert Allan Ltd.
Vancouver, BC
www.ral.bc.ca
Form and Function

• Hull Shape optimized for escort towing
  – Side sponsons
  – High freeboard
  – Large skeg
  – Maximum stability
Form and Function

- Operational Requirements must be defined and understood
  - e.g. side slip vs. indirect operations
- Hull form and Appendage design must then be tailored to the required function
Recent Tug Design R & D

by Robert Allan Ltd.

- Escort Towing
  - advanced hull forms
  - Alternate propulsion systems
- Seakeeping Studies
  - Advanced Hull Forms
- Towline Dynamics
R&D Efforts

Escort Towing:
Analyzing relative performance of alternate drive systems and hull forms
R&D Efforts

Model Test programs and related analysis have proven conclusively that a well-designed ASD tug can deliver equal or better escort performance than a VSP tug.
R&D Efforts

- **Towline Dynamics:** Tug to Ship
- Current on-going R&D test program
- Highlights need for better ship connection devices
Escort Towing Operations
Ship-handling vs. Escorting

- Speed of towing operations critical
  - Harbour towage typically occurs at < 6 knots

- Proposed definition of “escort towing”:
The deployment of a tug in a position from which it can rapidly and safely effect steering or braking control over a ship which has lost propulsion and/or steering control in a confined waterway, and (most critically), at a speed in excess of 6 ÷ 7 knots.
Escort Towing Forces

- Steering (Fs) and Braking (Fb) Forces in Tanker Coordinates
- Critical factors in developing towline forces:
  - Hull Form, plus Appendages
  - Thrust Direction
  - Speed of operation
Indirect Towing Manoeuvres
- At slow speed
Indirect Towing Manoeuvres

- At medium speeds
Indirect Towing @ High Speed

"Z-Tech 6000" class tug, "Indee"
indirect at 9 knots
THE EVOLUTION OF ESCORT TUGS

• CONVENTIONAL VSP ASSIST TUGS

• CHARACTERISED BY
  - LARGE AFT SKEG
  - OPERATIONS OVER THE AFT DECK
  - MODEST POWER
  - EXCELLENT MANOEUVRABILITY
  - GOOD STABILITY
The Evolution of Escort Tugs

M.V. "Lindsay Fossô"
Escort Tugs - The European Experience

- Large ASD Tugs - ’90’s

**M.V. Thorax**
- 90 tonne B.P.
- CPP / ASD

**M.V. Hopetoun**
- 125 tonne B.P.
- CPP / ASD
Escort Tugs - The European Experience

- VSP tugs

- Example of innovative, original thinking
- First application of dedicated skeg-first operation
- Prototype for Crowley’s ‘Protector’ class tugs
The Evolution of Escort Tugs

**m.v. Ó Ajaxô - 2000**

- Dedicated AVT escort tug design by R.A.L.
- Highly efficient, stable hull form
- 41 metres L o.a.
- 10,000 bhp (7650 Kw)
- Voith Propulsion
- 92 tonnes B.P.
- 150 tonnes Fs
Escort Tugs - Latest Generation

- 37 m, 65 tonne BP AVT Escort Tugs for Ostensjo Rederi, Norway
- 2 delivered
- 2 more building

- Advanced hull form
- High lift skeg with “turbo-fin”
- Same indirect performance as larger ‘Ajax’
Latest AVT Technology…

Ostensjo AVT 37/65 - Velox
Latest AVT Technology...

Ostensjo AVT 37/65 - Velox
The Evolution of Escort Tugs

- Effective Escort Tugs with ASD Propulsion:
  - Robert Allan Ltd. extended research program
  - On-going R&D Program with Institute of Marine Dynamics, St. Johns, Nfld.
ASD Escort Tug Concept

- **RAstar** ASD escort tug
  - Length ~ 50 metres
  - 125 + tonnes B.P.
  - Fs > 150 tonnes
  - @ 10 knots
  - Speed > 15 knots

Hull form used as basis for model testing
ASD Escort Tugs

- **ASD 36/80 E** Terminal/Escort Tug

More later...
Offshore Terminal Towing Operations

• Terminal developments in increasingly exposed areas
• Perceived Risks with LNG and Oil tankers
• Sea-States more extreme than in most conventional ports
• Forces between tug and ship heavily influenced by sea-state and wind, and proximity to the ship
Towline Dynamics Studies
Offshore Terminal Operations

• Line Forces
  – magnified up to >10 x BP
  – Deck Fittings and Winches stressed
  – High Potential for Towline failure

• Fender Loads
  – vary up to 5 x BP
  – Wide spread of impact area
  – Potential for ship structural damage

• Tug motions can be difficult on crew

• Rated push or pull performance difficult to sustain
ASD 36/80 E Terminal/Escort Tug for IRSHAD

• A new generation of high performance Terminal tug
• The first true purpose-designed ASD Escort Tug
• Incorporates the results of recent R&D efforts

• Excellent stability and handling characteristics
• Fi-FI and Oil Spill response capability
ASD 36/80 E Terminal/Escort Tug

- **Design Features:**
  - ASD Hull form optimized for maximum escort performance
  - Deck machinery suitable for Escort, Ship-handling and Towing
  - Excellent Sea-keeping and stability
  - All-round visibility
ASD 36/80 E Terminal/Escort Tug - Hull Form Features

• Sponsored Hull Form
• Deep Escort Skeg
• Generous Freeboard
• Aft Lines Optimized for Astern Performance
ASD 36/80 E Terminal/Escort Tug - Model Testing Program

- Calm water resistance
- Self-Propulsion tests
- Indirect Towing Forces
- Towing Staple Position Optimization
- Motions in a seaway
ASD 36/80 E Terminal/Escort Tug - Improved Seakeeping

Comparative seakeeping tests performed between RAL - ASD 36/80 design and current 37m design:

• Roll Amplitude:
  - reduced by 45%
ASD 36/80 E Terminal/Escort Tug
- Improved Seakeeping

Roll Accelerations:
- reduced by 65%
ASD 36/80 E Terminal/Escort Tug

Loa = 35.80 m.
B = 13.50 m.
D = 6.03 m.
ASD 36/80 E  Terminal/Escort Tug

B.P. = 80 tonnes +
Fs  = 120 tonnes
Fb = 150 tonnes

V_k = 14+ knots
ASD 36/80 E  Terminal/Escort Tug

- Fi-Fi 1
- Oil-Rec
- Dispersant
ASD Escort/Terminal Tugs

- 34m version just selected for Costa Azul LNG terminal project in western Mexico
- 4 tugs to be built for 2008 service
- Similar hull form and seakeeping advantages to 36m prototype
Other Recent Tug Developments

New “Fit for Purpose”

High Performance Tug designs:

• **Ramparts** Class Terminal/Ship-Handling tugs

• **Z-Tech** Concept

• **Rampage 5000** Class Offshore Support tugs
R A m p a r t s C l a s s A S D t u g s

- 24, 28, 30, 32, 34 metre lengths
- BP up to 80 tonnes

- Standardized Design Concepts
- Widespread International acceptance
Z-Tech 6000 Class Harbour Tugs

- Winner of 3 Major International Industrial Design Awards
- Combine best features of ASD and Z-drive Tractor configurations
- Concept Introduced formally at ITS 2004
- Tugs delivered or building – 28 to date, including 10 tugs for the Panama Canal
Z-Tech 6000 Class Harbour Tugs

True Omni-directional performance:

• Speed
  – 13 knots ahead
  – 12.8 knots astern

• B.P.
  – 63 tonnes ahead
  – 61 tonnes astern
Lamnalco Blackbird - Z-Tech 6000

Length = 27.6 m.
Beam = 11.5 m.
Depth = 5.0 m.
Power = 5000 bhp
Fi-Fi 1
Z-Tech 6000 Tug Indee

Indirect escort towing at 9 knots
RAmpage 5000-ZM Class Offshore Support Tug

Loa = 49.50 m.
Beam = 15.0 m.
Depth = 6.75 m.

Power = 6000 kW +
BP = 100 tonnes +

- Fi-Fi 1
- Oil-Recovery
RAmpage 5000 Z-M Class
Offshore Terminal Tugs

First of Class:
RAmparts 5000 Z-M
Seabulk Angola

- 2 building in Singapore
- 2 just ordered, 2 pending
SAFETUG Project

• International Joint Industry Project (JIP) proposed by MARIN, Netherlands

• Sponsored by:
  – Oil Companies
  – Most Major International Towing Companies
  – Some Shipyards
  – Some Consultants

• 3 Steering Groups:
  – Research - MARIN team
  – Design - Rob Allan - chair
  – Operations - Jaarko Toivula, Neste Oil - chair
SAFETUG Project

- **Primary Objective:**
  The development of a set of data related to tug design and performance in a seaway that will:
  
  (a) Enable Owners and Users to realistically define their requirements for a specific operating area, and
  
  (b) Provide Naval Architects and Owners with guidance as to the best hull characteristics for better sea-keeping performance
SAFETUG Project:

• Testing performance of a range of typical Tug designs:
  – ASD
  – Voith
  – Z-Drive tractor

• Testing impact on Tug performance of a range of hull design features and appendages

• Develop concepts for more optimized Tug hull forms for offshore performance
SAFETUG Project

- **Tug Design Committee** - Objectives
  - Select suitable test models
  - Agree on “Measures of Merit” for designs
  - Select which hull variables to evaluate further
  - Select, as appropriate, alternative hull designs to evaluate
  - Coordinate with Operational Group on overall design criteria
FUTURE DIRECTIONS:

• **SAFETUG** RESULTS:
  – WILL PROVIDE MEANINGFUL RESULTS AS DESIGN GUIDANCE
  – WILL PROVIDE ABILITY TO PREDICT TUG PERFORMANCE IN A SEAWAY

• **RAL** HIGH PERFORMANCE DESIGNS:
  – OFFER IMPROVED SEA-KEEPING AND TOWING PERFORMANCE
  – RAL Independent Test Results Contributed to the SAFETUG Database
FUTURE DIRECTIONS:

• ON-GOING RESEARCH INTO TUG PERFORMANCE
• BETTER UNDERSTANDING OF TUG DESIGN REQUIREMENTS
• BETTER SEA-KEEPING
• BETTER WINCHES AND DECK EQUIPMENT
• SAFER TUGS
• MORE RELIABLE PERFORMANCE
Questions???