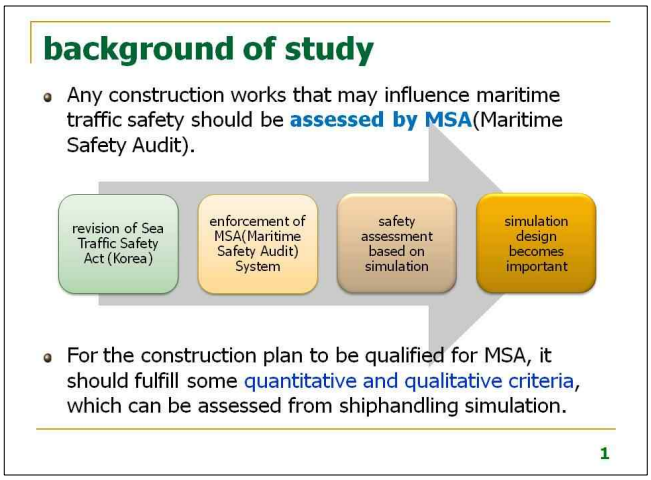
선박의 조종성능 모델링이 선박 통항 시뮬레이션 결과에 미치는 영향에 관한 고찰

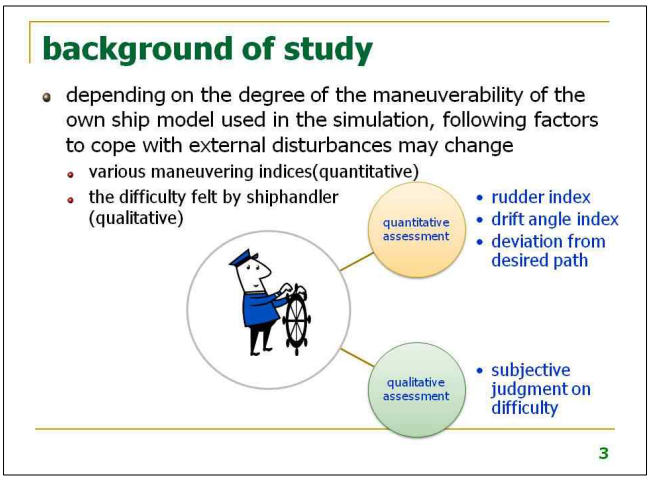
† 공인영 · 양영훈* · 윤근항* · 박세길** · 오재용**

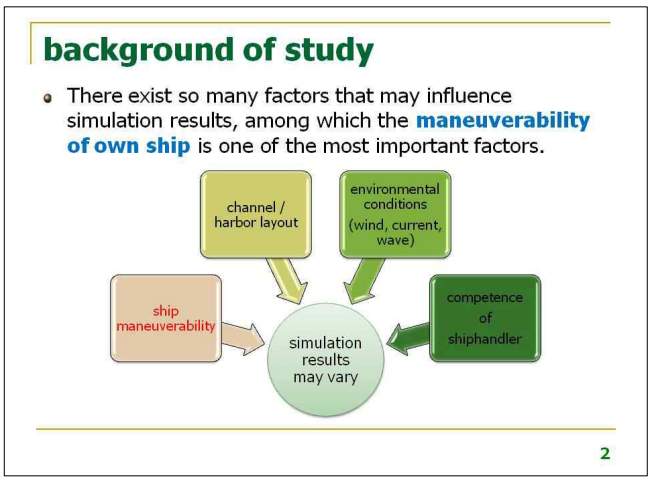
† 한국해양연구원 책임연구원, *한국해양연구원 연구원, *한국해양연구원 선임연구원

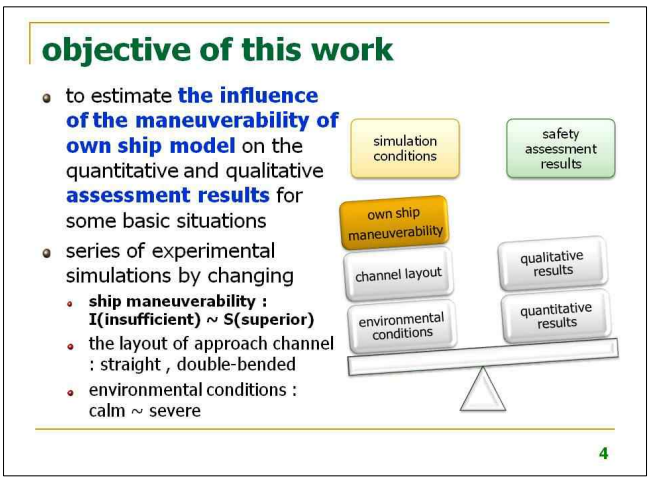
요 약 : 2010년 1월부터 발효된 국토해양부의 해상교통안전진단 시행지침에서 선박운항 시뮬레이션은 매우 중요한 부분이다. 선박운항 시뮬레이션에 사용되는 본선의 조종성능 모델링 결과가, 최종적인 선박통항 안전성 평가 결과에 어떠한 영향을 미치는지를, 동일한 환경조건 하에서 선박의 조종성능을 체계적으로 변화시키면서 검토하였다. 직선수로, 이중 변곡 수로, 그리고 실제 해역에서의 평가결과를 보였으며, 환경외력의 크기에 따라 조종성능의 변화가 최종 안전성 평가 결과에 미치는 영향에 대해서도 검토하였다.

핵심용어 : 해상교통안전진단, 통항 시뮬레이션, 조종성능 모델링, 안전성 평가



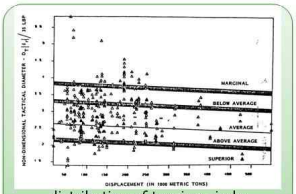




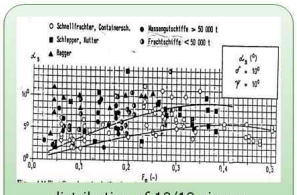


† 교신저자 종신회원) iygong@moeri.re.kr

ship maneuverability



distribution of turning circle characteristics of tankers(TD)



distribution of 10/10 zigzag characteristics of tankers (1st OS)

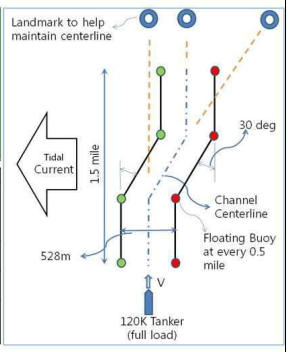
- maneuverability of ships may vary significantly regardless of its size
- IMO maneuvering standards
  - to prevent the appearance of ships with poor maneuverability
  - implies that most ships navigating nowadays have at least minimum maneuvering performance

5

simulations

- simulations are carried out by 1st officer
- asked to keep centerline as close as possible during simulations
- initial ship speed : 10 knots
- initial position : 0.75 mile before the entrance of the channel
- tidal current : 0,1,2 knots

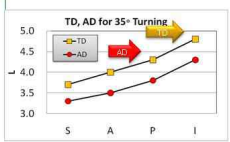
Item	Variables
Ship (120K tanker – full load)	- (I) Insufficient - (P) Poor - (A) Average - (S) Superior
Channel	- Straight - Double-bended
Initial Ship Speed	- 10 kts(full ahead)
Tidal Current	- 0 (no current, calm) - 1 kts (moderate) - 2 kts (severe)



8

ship maneuverability

- own ship : 120,000 dwt tanker
  - full load condition
  - L x B x d = 255.0m x 42.5m x 15.7m
- 4 kinds of maneuvering performance
  - **I(insufficient)** : below IMO standard
  - **P(poor)** : satisfy IMO standard in minimum sense
  - **A(average)** : ships with normal maneuvering performance
  - **S(superior)** : ships with extraordinary good maneuvering performance



Ship	TD/L	Ad/L	10/10 ZigZag OS1	10/10 ZigZag OS2	20/20 ZigZag OS1	IMO standard
I	4.8	4.3	23	70	21	X
P	4.3	3.8	13	38	16	O
A	4.0	3.5	10	26	13	O
S	3.7	3.3	8	19	12	O
IMO criteria	< 5.0	< 4.5	< 20	< 40	< 25	-

6

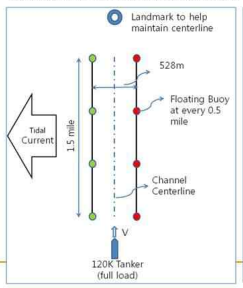
measured indices

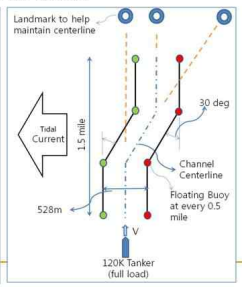
- track plots
- mean rudder angle used
- mean drift angle incurred
- mean deviation from centerline(desired path)
- subjective judgment after each simulation
  - -3 ~ +3 depending on the difficulty shiphandler felt during simulation
    - - 3 : very difficult
    - +3 : very easy

9

exercise area of narrow channel

- straight and double-bended channel (bend angle of 30 deg.)
- 1.5 mile long / 528m wide(about 2 L)
- floating buoy to denote channel boundary (every 0.5 mile)
- landmark to denote centerline of the channel

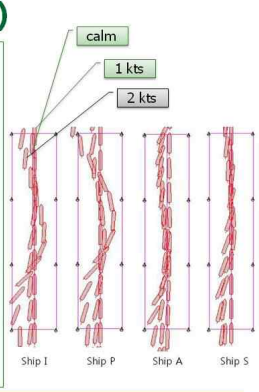




7

track plots (straight)

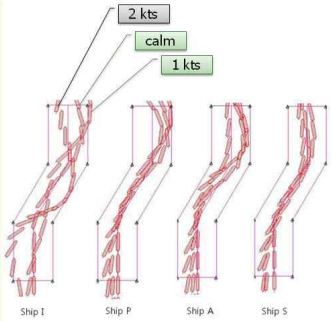
- Depending on the maneuvering characteristics of model ship, wide variation of track plots exists, even under same external conditions.
- Under moderate(under 1 kts) conditions, a little difference in trajectories exists.
- As external condition becomes severe(2 kts), ship I and P have difficulty in maintaining its course and position.



10

track plots (double-bended)

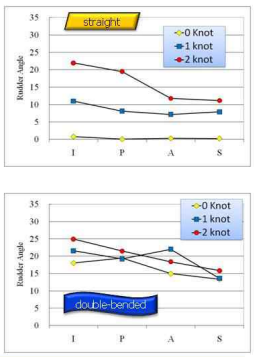
- Depending on the maneuvering characteristics of model ship, wide variation of track plots exists, even under same external conditions.
- All 4 ships have difficulty in maintaining its course and position even in case of calm conditions.
  - Double-bend channel itself is a severe environmental condition.
  - Difficulty increases as maneuverability becomes poor and external disturbances becomes strong.



11

rudder angle index

- straight channel
  - under moderate external condition, there exists a little difference among mean rudder angle of each ship.
  - As external conditions become severe, the mean rudder angles of ship I and P increase significantly.
- double bended channel
  - all 4 ships use relatively large rudder angles to maintain their courses and positions,
  - the magnitude of rudder angle increases as maneuverability of ship becomes poor.

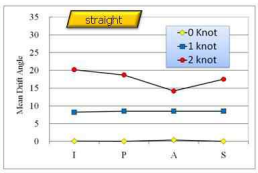


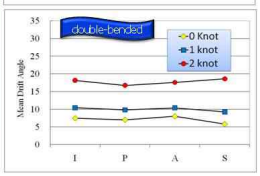
12

drift angle index

- straight & double-bended channel
  - Under moderate external condition, there exists a little difference among drift angle of each ship.
  - As external conditions become severe, the mean drift angles of all ships increase significantly .

The drift angle of 10 degrees is known as practical limit beyond which the shiphandler's difficulty increases rapidly.

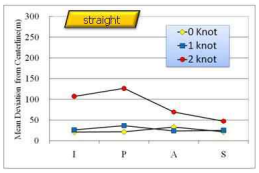


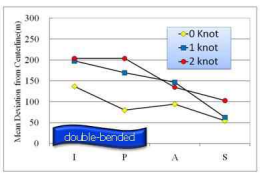


13

deviation from centerline

- straight channel
  - Under moderate external condition, there exists a little difference among centerline deviation of each ship.
  - As external conditions become severe, the mean deviation of ship increases and this magnitude increases as maneuverability of ship becomes poor.
- double-bended channel
  - All 4 ships deviate significantly from centerline of the channel regardless of external disturbances.
  - This implies that double bended channel itself is a severe environmental condition.

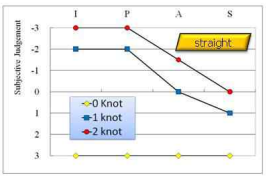


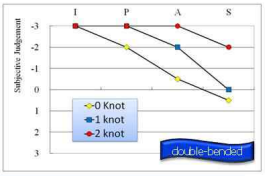


14

subjective judgment

- straight channel
  - With moderate to severe external conditions, the difficulty felt by shiphandler increase significantly.
  - This tendency becomes severe as maneuverability of ship becomes poor.
- double bended channel
  - The shiphandler feel serious difficulty even in case of no-current conditions depending on the maneuverability of ships
  - This implies that double bended channel itself is a severe environmental condition.





15

concluding remarks

- When the strength of external disturbance is not severe,
  - the quantitative maneuvering indices may not vary significantly regardless of the maneuverability of ships,
  - however, the qualitative assessment result such as subjective judgment may change significantly depending on the ship maneuverability.
- This implies that shiphandlers may mitigate the maneuverability difference of ships,
  - which result in reduced difference in quantitative results
  - but relative big difference in qualitative mental burden shiphandlers may feel during navigation.
- In case that external disturbance becomes severe,
  - the quantitative and qualitative assessment results show relatively big difference depending on the maneuverability of ship.
  - This implies that the mathematical ship model used in the simulator may be very important for the safety assessment of severe environmental conditions

16