

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

background of study

- Any construction works that may influence maritime traffic safety should be **assessed by MSA**(Maritime Safety Audit).

The flowchart consists of four boxes connected by arrows pointing right: 'revision of Sea Traffic Safety Act (Korea)', 'enforcement of MSA (Maritime Safety Audit) System', 'safety assessment based on simulation', and 'simulation design becomes important'.

- For the construction plan to be qualified for MSA, it should fulfill some **quantitative and qualitative criteria**, which can be assessed from shiphandling simulation.

1

background of study

- depending on the degree of the maneuverability of the own ship model used in the simulation, following factors to cope with external disturbances may change
- various maneuvering indices(quantitative)
- the difficulty felt by shiphandler (qualitative)

The diagram features a central illustration of a ship's steering wheel. To its right, two circles represent 'quantitative assessment' and 'qualitative assessment'. The quantitative assessment includes 'rudder index', 'drift angle index', and 'deviation from desired path'. The qualitative assessment includes 'subjective judgment on difficulty'.

3

background of study

- There exist so many factors that may influence simulation results, among which the **maneuverability of own ship** is one of the most important factors.

The diagram shows a central circle labeled 'simulation results may vary'. Four boxes point towards it: 'channel / harbor layout', 'environmental conditions (wind, current, wave)', 'ship maneuverability', and 'competence of shiphandler'.

2

objective of this work

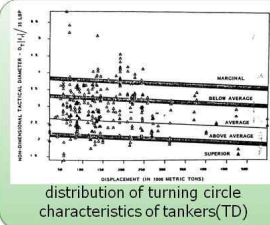
- to estimate **the influence of the maneuverability of own ship model** on the quantitative and qualitative **assessment results** for some basic situations
- series of experimental simulations by changing
 - ship maneuverability : I (insufficient) ~ S (superior)
 - the layout of approach channel : straight , double-bended
 - environmental conditions : calm ~ severe

The diagram shows a balance scale. On the left pan, there are boxes for 'simulation conditions', 'own ship maneuverability', 'channel layout', and 'environmental conditions'. On the right pan, there are boxes for 'safety assessment results', 'qualitative results', and 'quantitative results'.

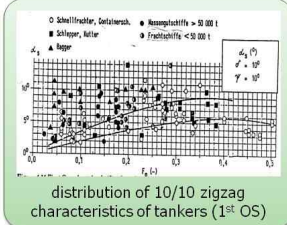
4

† 교신저자 중신회원 iyong@moeri.re.kr

ship maneuverability



distribution of turning circle characteristics of tankers(TD)



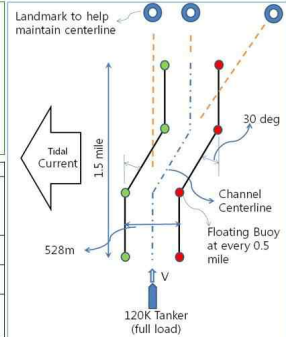
distribution of 10/10 zigzag characteristics of tankers (1st OS)

- 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

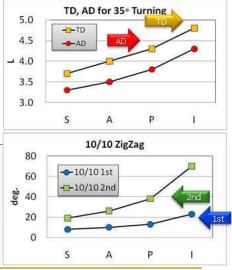


Item	Variables
Ship (120K tanker – full load)	- (I) Insufficient - (P) Poor - (A) Average - (S) Superior
Channel	- Straight - Double-bended
Initial Ship Speed	- 10 kts (full ahead)
Tidal Current	- 0 (no current, calm) - 1 kts (moderate) - 2 kts (severe)

8

ship maneuverability

- own ship : 120,000 dwt tanker
 - full load condition
 - $L \times B \times d = 255.0m \times 42.5m \times 15.7m$
- 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		20/20 ZigZag	IMO standard
			OS1	OS2	OS1	
I	4.8	4.3	20	13	21	
P	4.3	3.8	13	38	16	○
A	4.0	3.5	10	26	13	○
S	3.7	3.3	8	19	12	○
IMO criteria	< 5.0	< 4.5	< 20	< 40	< 25	-

6

measured indices

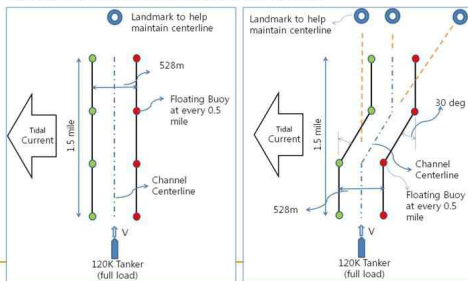
- track plots
- mean rudder angle used
- mean drift angle incurred
- mean deviation from centerline(desired path)
- subjective judgment after each simulation
 - 3 ~ +3 depending on the difficulty shiphandler felt during simulation
 - 3 : very difficult
 - +3 : very easy



9

exercise area of narrow channel

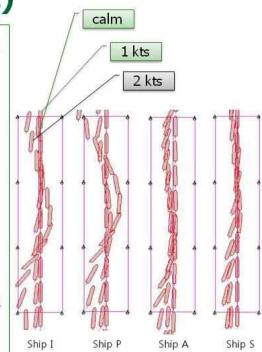
- straight and double-bended channel (bend angle of 30 deg.)
- 1.5 mile long / 528m wide(about 2 L)
- floating buoy to denote channel boundary (every 0.5 mile)
- landmark to denote centerline of the channel



7

track plots (straight)

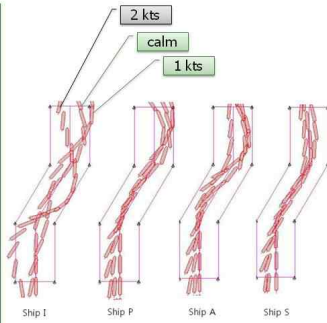
- Depending on the maneuvering characteristics of model ship, wide variation of track plots exists, even under same external conditions.
- Under moderate (under 1 kts) conditions, a little difference in trajectories exists.
- As external condition becomes severe (2 kts), ship I and P have difficulty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



10

track plots (double-bended)

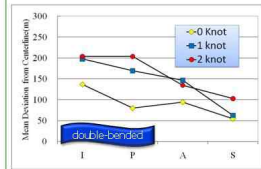
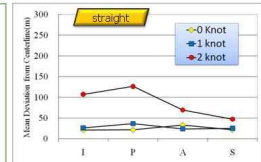
- Depending on the maneuvering characteristics of model ship, wide variation of track plots exists, even under same external conditions.
- All 4 ships have difficulty in maintaining its course and position even in case of calm conditions.
 - Double-bend channel itself is a severe environmental condition.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



11

deviation from centerline

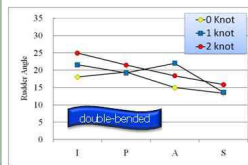
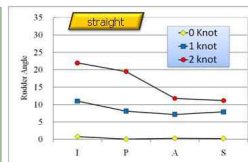
- straight channel**
 - Under moderate external condition, there exists a little difference among centerline deviation of each ship.
 - As external conditions become severe, the mean deviation of ship increases and this magnitude increases as maneuverability of ship becomes poor.
- double-bended channel**
 - 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

rudder angle index

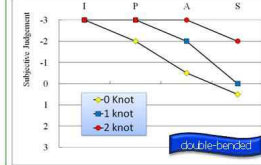
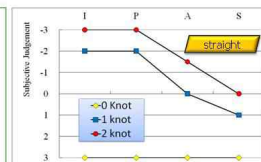
- straight channel**
 - under moderate external condition, there exists a little difference among mean rudder angle of each ship.
 - As external conditions become severe, the mean rudder angles of ship I and P increase significantly.
- double bended channel**
 - all 4 ships use relatively large rudder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



12

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.

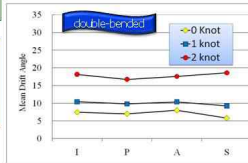
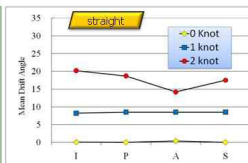


15

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

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