A MATERIAL DISTRIBUTION SCHEDULING FOR RIGGING
SHIP-HULL BLOCKS WITH PIPES

K Noda, S Shindo, H Kimura

Kyushu University, Japan
1. Background and Purpose

2. Expression of the Pipes

3. Pipe Assembly Order

4. Simulation

5. Discussion

6. Conclusion and Future Works
• In the precedence rigging of shipbuilding, most of the man-hour of rigging consists of piping work.

• About 1,000 pipes only in an engine room

• The assembly order is decided by skilled workers.

• The period of assembly: about six days

When all pipes are set in the same place...

- Wide space needed
- Taking long time to find objective pipes
Related Works

• An assembly simulation system  
  (Y Okumoto, 2009)  
  – Very standard method  
  – Confirming procedure of installation with animation

• Automatic scheduling system of outfitting process planning  
  (Y Wei and U Nienhuis, 2009)  
  – Automatic scheduling system of outfitting process planning  
  – Components’ position, material, weight, … is considered.  
  – Deciding pipe assembly order automatically

Our System: dividing the pipes into several groups automatically
• Dividing the pipes into several groups automatically assembly order depends on the period of the piping works

• Distributing pipes which assembly in one or two days at temporary space placed pipes

To reduce the burden of workers
To reduce temporary space which placed pipes
Pipe Data

- We used piping data extracted from CAD data of shipbuilding design system "MATES" used in Oshima Shipbuilding Co..

PipeN = 48

YD027 2 40 5.5 2 11950.00 -5800.00 9141.17 バカ穴貫通着目点

KeiroN = 1, TenQt = 3

11568.60 -5800.00 9154.30 40
11799.90 -5800.00 9154.30
12550.60 -5800.00 9088.63 40

KeiroN = 2, TenQt = 3

11679.90 -5800.00 9154.30
11679.90 -5800.00 9277.41
11480.24 -5800.00 9289.02 40

KeiroN = 3

... ...

- The pipes are illustrated by a “main pipe” and “branch pipes”.
- Coordinates of the start point, the end point, the point(s) of bend(s)
- Outer diameters of both ends of main pipe and end points of branch pipes
- When the pipes penetrate deck, the coordinates of the penetration points and the types of the penetration
Pipe Data

- We used piping data extracted from CAD data of shipbuilding design system "MATES" used in Oshima Shipbuilding Co..

PipeN = 48

YD027 2 40 5.5 2 11950.00 -5800.00 9141.17 バカ穴貫通着目点

KeiroN = 1, TenQt = 3
11568.60  -5800.00  9154.30  40
11799.90  -5800.00  9154.30
12550.60  -5800.00  9088.63  40

KeiroN = 2, TenQt = 3
11679.90  -5800.00  9154.30
11679.90  -5800.00  9277.41
11480.24  -5800.00  9289.02  40

KeiroN = 3

- The pipes are illustrated by a “main pipe” and “branch pipes”.
- Coordinates of the start point, the end point, the point(s) of bend(s)
- Outer diameters of both ends of main pipe and end points of branch pipes
- When the pipes penetrate deck, the coordinates of the penetration points and the types of the penetration
Pipe Data

- We used piping data extracted from CAD data of shipbuilding design system "MATES" used in Oshima Shipbuilding Co..

PipeN = 48

YD027 2  40  5.5  2  11950.00  -5800.00  9141.17 パカ穴貫通着目点

KeiroN = 1, TenQt = 3

11568.60  -5800.00  9154.30
11799.90  -5800.00  9154.30
12550.60  -5800.00  9088.63

KeiroN = 2, TenQt = 3

11679.90  -5800.00  9154.30
11679.90  -5800.00  9277.41
11480.24  -5800.00  9289.02

KeiroN = 3

:

- The pipes are illustrated by a “main pipe” and “branch pipes”.
- Coordinates of the start point, the end point, the point(s) of bend(s)
- Outer diameters of both ends of main pipe and end points of branch pipes
- When the pipes penetrate deck, the coordinates of the penetration points and the types of the penetration
Pipe Data

- We used piping data extracted from CAD data of shipbuilding design system "MATES" used in Oshima Shipbuilding Co..

PipeN = 48

YD027  2  40  5.5  2  11950.00  -5800.00  9141.17

KeiroN = 1, TenQt = 3

- 11568.60  -5800.00  9154.30  40
- 11799.90  -5800.00  9154.30
- 12550.60  -5800.00  9088.63  40

KeiroN = 2, TenQt = 3

- 11679.90  -5800.00  9154.30
- 11679.90  -5800.00  9277.41
- 11480.24  -5800.00  9289.02  40

KeiroN = 3

- 

- The pipes are illustrated by a "main pipe" and "branch pipes".
- Coordinates of the start point, the end point, the point(s) of bend(s)
- Outer diameters of both ends of main pipe and end points of branch pipes
- When the pipes penetrate deck, the coordinates of the penetration points and the types of the penetration
The type of penetration

- **Tight hole penetration** or **loose hole penetration**

- penetrating sleeves
- pass through sleeves
- socket with inside screw
- scuppers
- side deep deck pieces
- doubling plates
- high pressure pipe penetration pieces
- focus points of tight hole penetration
- focus points of loose hole penetration
3D-Expression of the Pipes

- To understand pipes’ information visually
- Data converter that loads pipes’ data and generates X3D file
- X3D files are available with X3D viewer for free (e.g. Flux Player).

The normal position
3D-Expression of the Pipes

Function: Displaying the data of the pipe on which is clicked on the screen

Upside-down position (assembling period)
it is difficult to decide detailed assembly order…

Priority
1. Pipes penetrating/fixed on deck
2. Pipes located lower
   If pipes have the same value of Z…
3. Pipes with 80-200mm in outer diameter
4. Pipes with 65mm or less in outer diameter
250 mm and over pipes (red ones)

Positioned high place, the pipes are assembled last. These pipes distributed different space from other pipes.
Model ship A
The number of pipes by diameter

- 250mm and over pipes: 22 (2.7% of the whole pipes)
- 80-200mm pipes: 218 (26.9% of the whole pipes)
- 65mm and less pipes: 569 (70.3% of the whole pipes)
- Total of penetration pipes: 225 (27.8% of the whole pipes)
Distribution Plan (Model Ship A)

- Distribution: 1/4

Red pipes: Pipes which attached at the current step
Transparent pipes: The pipe which attached at the subsequent steps
Green spheres: Points of penetration

1. Pipes penetrating on the deck
2. Pipes located lower (Pipes have higher value of Z)
   (If pipes have same value of Z…)
3. Pipes with 80-200mm in outer diameter
4. Pipes with 65mm or less in outer diameter
Distribution Plan (Model Ship A)

- Distribution: 2/4

Red pipes: Pipes which attached at the current step
Blue pipes: Installed pipes
Transparent pipes: The pipe which attached at the subsequent steps
Green spheres: Points of penetration

1. Pipes penetrating on the deck
2. Pipes located lower (Pipes have higher value of Z)
   (If pipes have same value of Z…)
3. Pipes with 80-200mm in outer diameter
4. Pipes with 65mm or less in outer diameter
• Distribution: 3/4

Red pipes: Pipes which attached at the current step
Blue pipes: Installed pipes
Transparent pipes: The pipe which attached at the subsequent steps
Green spheres: Points of penetration

1. Pipes penetrating on the deck
2. Pipes located lower (Pipes have higher value of Z)
   (If pipes have same value of Z… )
3. Pipes with 80-200mm in outer diameter
4. Pipes with 65mm or less in outer diameter
**Distribution Plan (Model Ship A)**

- **Distribution: 4/4**

  Red pipes: Pipes which attached at the current step
  Blue pipes: Installed pipes
  Transparent pipes: The pipe which attached at the subsequent steps
  Green spheres: Points of penetration

1. Pipes penetrating on the deck
2. Pipes located lower (Pipes have higher value of Z)
   (If pipes have same value of Z…)
3. Pipes with 80-200mm in outer diameter
4. Pipes with 65mm or less in outer diameter
Enlarged View of Model Ship A

Distribution: 2/4
• Distribution: 1/4

Red pipes: Pipes which attached at the current step
Transparent pipes: The pipe which attached at the subsequent steps
Green spheres: Points of penetration

1. Pipes penetrating on the deck
2. Pipes located lower (Pipes have higher value of Z)
   (If pipes have same value of Z…)
3. Pipes with 80-200mm in outer diameter
4. Pipes with 65mm or less in outer diameter
Distribution plan (Model ship B)

• Distribution: 2/4

Red pipes: Pipes which attached at the current step
Blue pipes: Installed pipes
Transparent pipes: The pipe which attached at the subsequent steps
Green spheres: Points of penetration

1. Pipes penetrating on the deck
2. Pipes located lower (Pipes have higher value of Z)
   (If pipes have same value of Z… )
3. Pipes with 80-200mm in outer diameter
4. Pipes with 65mm or less in outer diameter
Distribution plan (Model ship B)

- Distribution: 3/4

Red pipes: Pipes which attached at the current step
Blue pipes: Installed pipes
Transparent pipes: The pipe which attached at the subsequent steps
Green spheres: Points of penetration

1. Pipes penetrating on the deck
2. Pipes located lower (Pipes have higher value of Z)
   (If pipes have same value of Z…)
3. Pipes with 80-200mm in outer diameter
4. Pipes with 65mm or less in outer diameter
Distribution plan (Model ship B)

- Distribution: 4/4

Red pipes: Pipes which attached at the current step
Blue pipes: Installed pipes
Transparent pipes: The pipe which attached at the subsequent steps
Green spheres: Points of penetration

1. Pipes penetrating on the deck
2. Pipes located lower (Pipes have higher value of Z) (If pipes have same value of Z… )
3. Pipes with 80-200mm in outer diameter
4. Pipes with 65mm or less in outer diameter
• The pipes with over 250 mm in diameter

Red pipes: Pipes which attached at the current step
Blue pipes: Installed pipes
Transparent pipes: The pipe which attached at the subsequent steps
Green spheres: Points of penetration

1. Pipes penetrating on the deck
2. Pipes located lower (Pipes have higher value of Z)
   (If pipes have same value of Z…)
3. Pipes with 80-200mm in outer diameter
4. Pipes with 65mm or less in outer diameter
This study’s features and the evaluation

- Loading pipes’ data
- Distribution according to the priority
- Generating X3D file

Only 1 second

◆ The on-site supervisors in this shipyard comment...
  - Almost practical level
  - Preferable to use it for free
  - Trying it in practice and confirming usefulness
Interference of pipes and handling of it

Assembly order
①→②→③→④

when pipe ② is assembled earlier, pipe ③ cannot be assembled with cranes
Interference of pipes and handling of it

Assembly order
①→②→③→④

when pipe ② is assembled earlier, pipe ③ cannot be assembled with cranes

It is desirable to be possible to change order of pipe ② with that of pipe ③
Interference of pipes and handling of it

- The pipe which it is hard to attach later have to be grouped with interfered pipes.

**Diagram:**

- Distribution 1/4
  - Distribution 2/4
  - Distribution 1/4
  - Distribution 2/4

  - impossible to exchange 2 and 3 order
  - possible to exchange 2 and 3 order
Pipes interference check function

the assumption that pipes are installed by cranes

projecting pipes on the X-Y plane

- 3-D interference problem into 2-D problem
- Cylinders into rectangles

simplify
• Model ship A

• Red pipes are interfered

• These pipes belong to different groups…

The same group is preferable
Test of this function

Before

After

The same group

Distribution 1/4

Distribution 1/4
An Issue of this function

Pipes are floating in the air

Fixed pipe group as the same group too

Pipe support information is needed
• Pipes are approximated as aggregate of rectangles

Not accurate near connecting point
Precision of approximation

- Pipes are approximated as aggregate of rectangles

But...

On-site workers deal with pipes are a little interfered
Discussion 1. Problem of assembly order

Figure of Distribution 2/4

Blue pipes: pipes assembled at distribution 1/4
Red pipes: pipes assembled at distribution 2/4
Transparent pipes: pipes assembled at distribution 3/4

- Only this pipe belongs to distribution ¾
- This pipe should be in same group as the right and left pipes
- We need the system that last pipe is grouped as the other pipes
Discussion 2. Area division

- Dividing an engine room to some parts (4-6)
- Assign one worker to one area
- Work in parallel
Discussion 2. Area division

- Positions of division borders are depend on positions of bulkheads
  It varies according to ships
- It is favorable to be able to decide the number of partitions and position of theirs manually
Conclusion & future works

Conclusion

- A new system that divides the pipes into several groups considering the assembling order that skilled workers adopt
- Pipes interference check function
- 3-D display of distributed pipes

the burden of workers is reduced

Future works

- Blushing up pipes interference check function
- Study of further rules of grouping
- Area division
- Discovering further problems in practice