Revision 4, 2015-04-16

SHIPFLOW DESIGN Tutorials

ADVANCED



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Introduction to SHIPFLOW-FRIENDSHIP DESIGN environment

• First start of the SHIPFLOW Design application (Windows OS)

START > All Programs > FLOWTECH > SHIPFLOW x.x.xx > Shipflow Design

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Customized workspace



Tutorial 1 part 1 – Self propulsion simulations

This exercise is a practical introduction to self propulsion simulations with SHIPFLOW. It requires knowledge about XPAN, XBOUND and XCHAP. It also requires basic knowledge about propeller modelling with SHIPFLOW, for example the tutorial in ho_propellers.

The examples are set up using the zonal approach with very coarse grids to reduce computational times during the exercise. Real cases must be performed with a much finer grid resolution.

There are three simulations required to evaluate the propulsive factors, a towing (resistance), an open water (POW), and self propulsion simulation. All three simulations will be set up during the exercise.

There are two ways to perform the self propulsion simulations, the first is fully automatic where the program executes resistance, pow and selfpropulsion in a series and the second way is to run the three parts separately. The manual variant is described in handout ho-selfpropulsion.pdf that can be found on the course DVD.

1. Start with importing the configuration "ex1" from **DVD:\AdvancedTraining\Tutorial_Advanced_1\source**

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2. Save the project in your working directory

3. Now check the configuration, see that there is already a propeller geometry input but no propeller model defined.



4. Since the propeller adds a non symmetrical flow in the domain it has to cover both sides, therefore one should add symm (nosym) command in the xflow section as below

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5. The next step is to add the propeller lifting line model in the xchap section, make sure that the id matches the propeller id. The cf parameter sets the frictional coefficient for the propeller blades at its local Reynolds number.

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6. Add the POW command and select JV=[0.2,0.9] (recommended is to cover the whole working range of the propeller with intervals not larger than 0.1). Set START to start. Limit the number of iterations to 50 with the keyword MAXIT in the POW command (recommended is 500). Set the name of the POW output file with the keyword OUTPUT to POW.dat

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7. Add the SELFPROPULSION command and set it to ON. The CTOW value will not have to be set since it will be automatically calculated by the ITTC78 command that we will set further down.



- 8. Add the ITTC78 command and set it to ON. In order to extrapolate data to full scale some data has to be set here:
 - 1. LWL in model scale LM=5.5
 - 2. LWL in full scale LS=63.0
 - 3. Ship propeller diameter DS=3.0
 - 4. Maximum transverse area above the waterline A_T=55
 - 5. Model propeller open water RPS NPOW=18



9. In order to run the self propulsion automatically add spauto(all, simrun) in xflow section.

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10. Optionally a new, faster solver can be used in SHIPFLOW versions 6.0 and newer. In xchapl control add solver (krylov) like in the picture below.

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- 11. Now the configuration is ready to run, check that the number of iterations is set to 200, save the project and start the computations. (The computations should take approximately 15 minutes on a 2.0Ghz laptop with 2 processes.)
- 12. After the computations are finalized all the results are written to id_OUTPUT file and also a report is prepared which can be visualised in the GUI under Documentation Browser tab or in any web browser as it is an html file.

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Tutorial 2 part 1 – Forebody optimization – bulb – Delta Shift

For this tutorial you need to use Friendship FRAMEWORK together with SHIPFLOW.

- 1. Import roro_medium SHIPFLOW configuration from **DVD:\AdvancedTraining\Tutorial_Advanced_2\source**
- 2. Save the project as roro_opt.fdb and run calculations without any changes to the configuration.
- 3. Go to the Table Viewer and double click on results for V, CWTWC and Sref to create parametres for evaluation.



- 4. Go to 3DView end extend the view to see the entire hull.
- 5. Set the view to Y to and zoom in to see the bulb
- 6. Create a Scope and name it bulb_delta_length, make it default by clicking on it with middle mouse button.

- 7. Create 3 points and locate them as specified below:
 - 1. p1(0.81,0,0)
 - 2. p2(-1,0,0)
 - 3. p3(-5,0,0)
- 8. Select these points and create a B-Spline curve, make sure it is 2nd order.



9. Create a Design Variable, name it delta_length, set the value to 1.



10. Now replace the Z coordinate of the p3 with this design variable

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11. Select the curve, create Delta Shift and name it length



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13. Make the baseline the default scope

- 14. Select bulb_delta_length scope and make a copy of it, rename it to bulb_delta_height
- 15. Go to that scope and rename length with height and delta_length with delta_height
- 16. Edit the height Delta shift, mark Delta Z in the General section and set factor to 1

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17. Now you should have two scopes as in the picture below:



18. Create Delta Sum name it delta_bulb and use delta_lenght and delta_height as input.

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19. Select the bulb offset group and create and Image Offset Group and name it bulb



- 20. Use the delta_bulb Delta Sum transformation as an Image transformation.
- 21. Now go to the offset group assembly and replace the existing bulb group with the image that was just created
- 22. You should be able to see that the Image Offset changes its shape when you edit delta_length and delta_height design variables.



- 23. Create a scope and name it bulb_tip_position and make it default
- 24. Create point at the tip of the bulb

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25. Select this point and create Image Point and use the delta_bulb Delta Sum transformation as an Image transformation.



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27. By using 3DPoint:x and getMax(0) functions of the Image bulb tip point and transom offset section create a formula to measure the Length Over All. This will be used as a constraint during the optimization.

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28. Add another parameter which will compute wave resistance in kN, name it Rw

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29. Rescale eval_V to get the value in m^3

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Value	22405.48381635 comp.getResults().getProgramData("XPAN"). getElementAt("V") * (162 ^ 3)] 🖸	

30. Add a Constraint, name it LOA_constraint. Monitor LOA parameter and set the max value to 172

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31. Add a Constraint, name it Displ_constraint. Monitor eval_V parameter and set the min value to 22381.9

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Tutorial 2 part 2 – Ensemble Investigation

1. Create Ensemble Investigations



2. Set the parameters according to the image below:

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2	LOA_Constrain	t	•		8				
3			•						

- 3. Save the Project.
- 4. Run Ensamble Investigation.
- 5. When the calculations are finished the following result table should be available. Notice That some of the Design Variants violate the constraints.

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			Attribute	Active	Active			
۹			Name	delta_height	delta_length	Rw	Displ_Constraint	LOA_Constraint
			Scope	bulb_delta_height	bulb_delta_length			
			Reference					
			Lower Bound	-1	-2	26.319114	> 22381.9	< 172
Ð			Upper Bound	1	2	26.54825		
,			Feasible Designs: 33.333333 %				55.555556 %	77.77778 %
٦			Mean Utilization Index				96.713386 %	48.395715 %
			Mean	0	0	26.428745	22382.688	170.928
			Sample Standard Deviation	0.8660254	1.7320508	0.082876061	23.960222	1.8776342
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		Σ	EnsembleInvestigati	-1	-2	26.361546	22371.307	169.95839
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		Σ	🗾 EnsembleInvestigati	1	2	26,483344	22393.844	171.89761

Tutorial 3 part 1 – Forebody optimization – shoulder – Surface Delta Shift

For this tutorial you need to use Friendship FRAMEWORK together with SHIPFLOW.

- 1. Import roro_medium SHIPFLOW configuration from **DVD:\AdvancedTraining\Tutorial_Advanced_3\source**
- 2. Save the project as roro_opt_shoulder.fdb
- 3. Go to 3DView end extend the view to see the entire hull.
- 4. From the CAD menu select Surfaces | Planar B-Spline Surface



5. Use the settings as below to cover the forward part of the hull

Create Feature: SurfacePlaneBSpline		
Description	F f1	SurfacePlaneBSpline
Creates a simple B-Spline surface in a plane at a specified elevation.	Plane Settings	
The number of control vertices can be set for the surface's	Plane	Y - (Z,X)
u- and v-direction (parameter domain). The surface is defined via a lower corner position and an upper corner position, each specified by two input values. Optionally, 3D	Elevation	0 .
points can be automatically generated from the control	Control Points	
ventices vector data too.	CP in U-Direction	7
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	Create Control Points	
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	Start First Axis	-8.18
	Start Second Axis	0.85 🔹 🥐
	Upper Corner Po	sition
	End First Axis	3 🔹 🤊
	End Second Axis	66 🔹 🔹
		🕞 Execute 🛛 🔇 Cancel

6. The resulting patch should resemble the one shown below



7. Create two Design Variables, name them lower and higher



8. Select points of the delta surface as in the picture (2nd row from the bottom, columns 3,4 and 5) and replace their y-coordinate with lower Design Variable



9. Select points of the delta surface as in the picture (4th row from the bottom, columns 3,4 and 5) and replace their y-coordinate with higher Design Variable

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10. Cretate Surface Delta Shift transformation based on the surface patch that was added earlier. Name it surface_transformation.

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11. Set it up to use surface patch and act in Y direction.

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12. Create image of the hull offset group, name it hull.

13. Use surface_transformation as the Image transformation



14. In the offset group assembly replace the original hull group with the image.

FScope FScope FScope FOffsetG FImageO FParame FSurface		 SHF_Import_as_off_ror ○ offsets_bulb ○ offsets_hull ○ offsets_stern ◇ as_as_off_rorom ◇ hull > higher > lower surface_transformation 	om			
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15. Test if the set up works by modifying lower and higher design variables and see if the hull offset changes shape.



- 16. Set both lower and higher design variables to 0 and run the calculations.
- 17. When the calculations are finished create parameters for evaluations by double clicking on values of CWTWC, Sref and V.

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18. Rescale eval_V to get the value in m^3



19. Add another parameter which will compute wave resistance in kN, name it Rw

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20. Add a constraint minDispl for minimum Displacement and set it to 22382.5

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minDispl		FInequali	:yC	ons G	trai	nt ?)
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Tutorial 3 part 2 – NSGA-II Optimization

1. Create NSGA-II Design Engine (genetic algorithm optimization)



2. Set it up according to the image below, lower bound -0.5, upper bound 0.5, evaluation set to Rw and minDispl as a constraint.

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- 3. Save the project and run the optimization.
- 4. It should take less than 10 minutes on a laptop and the result should resemble the one below

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•		⊾ higher	lower	⊾ R₩	🗾 minDispl
	Attribute	Active	Active	Objective	Considered
	Name	higher	lower	Rw	minDispl
	Scope				
	Reference				
	Lower Bound	0.034462501	-0.48252842	26.477462	> 22382.5
	Upper Bound	0.32258335	-0.13480583	26.789355	
	Feasible Designs: 100 %				100 %
	Mean Utilization Index				14.088096 %
	Mean	0.14153887	-0.31459144	26.608682	22405.15
	Sample Standard Deviation	0.12580706	0.18908665	0.13280971	17.558579
	Error-free: 100 %	100 %	100 %	100 %	100 %
Ν	Msga2_01_des0000	0.12043183	-0.48252842	26.789355	22429.941
ΝΣ	🕅 Nsga2_01_des0001	0.034462501	-0.16776532	26.5537	22400.186
ΝΣ	🕅 Nsga2_01_des0002	0.088677806	-0.13480583	26.477462	22388.561
Ν	🕅 Nsga2_01_des0003	0.32258335	-0.47326619	26.614211	22401.912

5. This is just an example setup and the optimization parameters should be refined as well as more generations in the NSGA-II should be used.

Tutorial 4 part 1 – Appendage modelling – overlapping grids

There are currently several appendage types in SHIPFLOW. In this tutorial, three of them will be used: rudder, propeller shaft and shaft bracket. All parameters for the respective appendage are given in the description of the RUDDER, SHAFT and BRACKET commands in the Users Manual. Like other commands that specify the geometry, the appendage commands are given in the XFLOW section of the command file. The commands may be repeated to specify several appendages of the same type.



Figure 1: Rudder, shaft and bracket grids.

The appendage grids are not intended to be used independently, they are normally embedded in a grid that covers the computational domain of the un-appended configuration. This is usually the grid generated by XGRID, but there is also the possibility of generating a rectilinear grid with the BOX command. In the example command file below the Hamburg Test Case is appended with a rudder.

- 1. Create a directory which you will use for storing the files used during the assignment
- 2. Import "ropax" configuration from **DVD:\AdvancedTraining\Tutorial_Advanced_4\source**
- 3. Examine the rudder, bracket and shaft parameters.

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4. Run the computation with 0 iterations. This will generate the grids and the overlap information.

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5. During the computations important information will be printed in the Task Manager

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HIPFLOW 5.0.00 (Rev. 8859	3
xch2 location changed to:	1.025000000000
Starting xchap 5.0 \$Revision	: 8859 \$
Commercial license	
Command file ropax read.	
Computing overlap	
No of frames	: 5
No of grids	: 5
No of points	: 452146
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Total no of cells	: 544933
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6. When the computation is finished examine the generated grid. Look at the component grids and the interpolation and outside classification points. Observe how the appendages intersects the hull and each other.





Now the geometry is changed to deliberately create a "leak"

1. Create a Design Variant. Delete the shaft and the bracket from the variant, and change the zcomponent of the rudder origin to -1. Also add xchap | overlap | noleakcheck.

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2. Run the variant.

- 3. The progam detects the leak and prints an error message "ERROR: Less than 20% of the cells..." and stops.
- 4. To find the leak, set the parameter xchap>overlap>nfill=70 and re-run. Nfill limits the number of recursions so that the outside points don't contaminate the whole domain and that makes the leak easier to find.
- 5. Re-run the variant and examine the resulting classification. Notice that the Outside cells "spill out" at the top of the rudder since it is an open geometry.



Tutorial 5 part 1 – Complex Appendage modelling

For this tutorial you need to use Friendship FRAMEWORK together with SHIPFLOW.

- 1. Import case_ID SHIPFLOW configuration from **DVD:\AdvancedTraining\Tutorial_Advanced_5\source**
- 2. Import duct.igs IGES file.
- 3. Save the project as kvlcc2_ESD.fdb
- 4. Check the setup, make sure you see the offset sections and duct surface on your screen.



5. In order to create a volume grid for the imported duct grid we shall first make a surface mesh using the surface and thereafter use a hyperbolic grid generator to expand this mesh into 3D.

6. Select the duct surface and create a mesh using Mesh Engine, name it duct_mesh



- 7. Switch off visibility of the offset sections and imported duct surface, notice that the mesh that was just created is extremely coarse and does not represent the object accurately.
- 8. Refine the mesh dimensions and use stretching factor according to the example below



9. To the xchap configuration add volume object

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10. Now we will use the duct_mesh to create volume grid, apply settings according to the illustration

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- 11. The setup of the duct is ready but we should add support for this structure. We will use two wings created using rudder objects.
- 12. In the xflow configuration add two rudder objects with the following settings



- 13. Make sure that the number of xchap iteration is set to 0 and start the computations.
- 14. While the computations are running there should be many warning messages appearing in the TaskMonitor, these usually would not appear. However, since this example case is for demonstration only and uses extremely coarse grids the solver may give various warnings.
- 15. When the computations are finished, display surface meshes on the duct and supporting it blades as well as on the refinement of the hull. The correct set up should resemble the one below.



* Note that the grids used in this tutorial is not fine enough for design applications.

Tutorial 5 part 2 – Appendage optimization

- 1. Continue the work from the previous part or open the file kvlcc2_ESD.fdb located in **DVD:\AdvancedTraining\Tutorial_Advanced_5\intermediate**
- 2. We will optimize the supporting blade angle of attack using systematic variations with Ensemble Investigation.
- 3. First we will have to prepare a self propulsion setup in order to have objective function for the optimization.
- 4. Turn on the propeller.



5. Add selfprop command to xflow configuration and use the settings as below, make sure that the Pow command points to the right file which was in source directory for this Tutorial.

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- 6. Set number of xchap iterations to 10 and start the case, it should take about 10 minutes on a laptop
- 7. When the calculations are finished go to the TableViewer and by double clicking on the KQ and JV create parameters.



8. Now add additional parameter PD that will represent delivered power using the following formula

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9. Create two Design Variables which will be used as input for angle of attack, name them

AOA_port and AOA_stb and set both to 20.

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10. In the xflow | rudder configurations replace the Angle with the Design Variables

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11. Add Ensamble Investigation

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- 12. Use both AOA_port and AOA as Design Variables and add variation +/- 5 degrees
- 13. Use PD for Evaluation of the results.

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- 14. There will be 9 different variants created if you run this case and each should be run until convergence. Moreover, the grids should be much finer to give good results so we will only look at the grid modifications.
- 15. Go to xchap configuration and in control add grids command to prevent from running the

solver. Also use xchap only in the xflow|program configuration. Now you can start the Ensemble Investigation.

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16. When the computations are finished check the different variants and verify that the angle of attack was varied appropriately. Since the actual xchap solver was not run there will be no valid flow calculations.

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- * The calculation execution with the Grids keyword will result with PD = nan.
- ** Keyword Grids is used only to check correctness of the grids, RANS solver is not executed
- *** Note that the grids used in this tutorial is not fine enough for design applications.