Frequency Response Analysis (2)

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CDL Computational Design Lab

OUTLINE

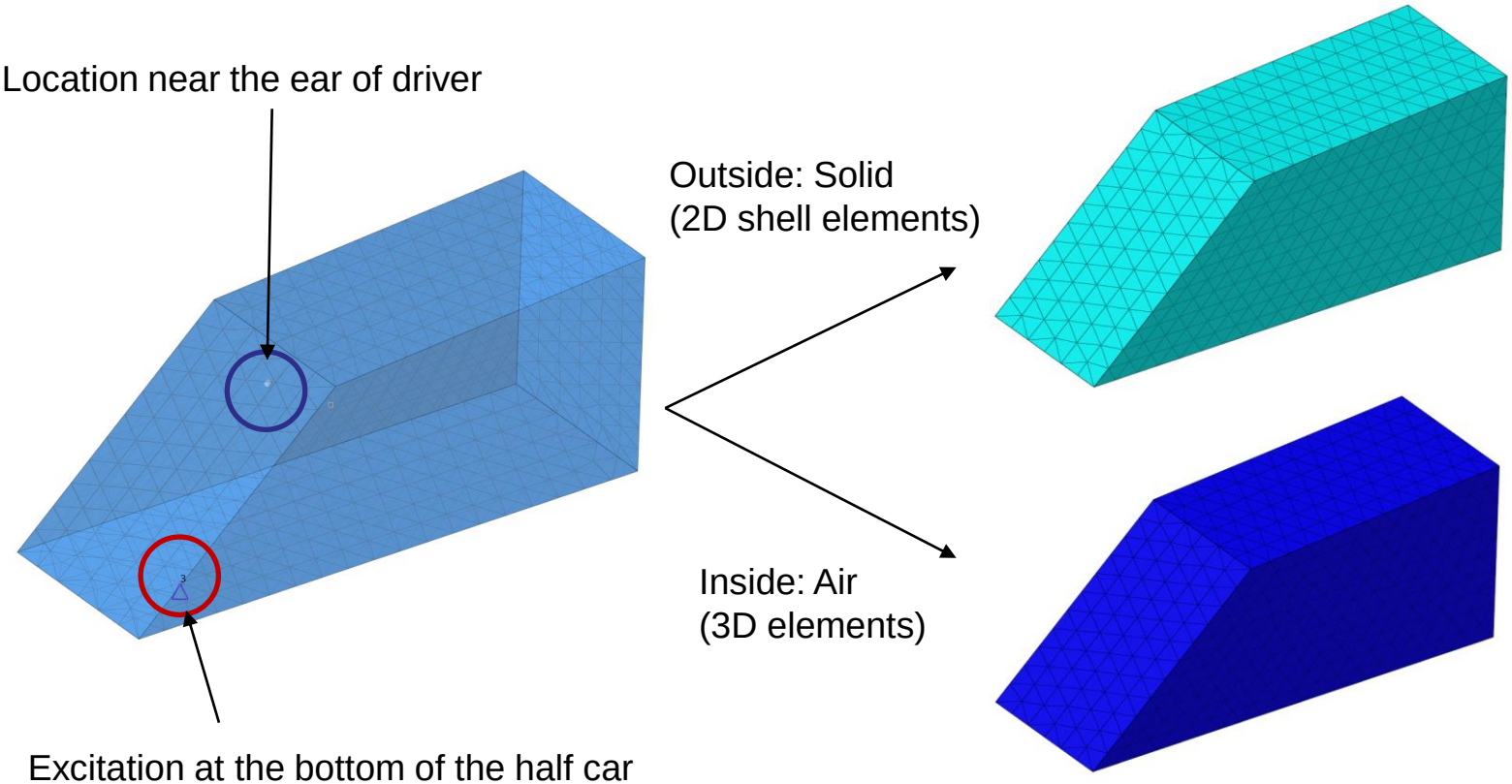
- **Lecture Goals**
  - ✓ 유체-구조 상호작용(fluid-structure interaction)을 받는 절반 차량(half car)모델에서 주파수 응답 해석을 수행하고 운전자 귀와 가장 가까운 차량 내부 위치의 소음 수준을 확인한다.

- **Contents**
  - ✓ Coupled frequency response analysis of fluid-structure model

- 해석 프로세스
  - 기하형상 생성
  - 재료 물성 및 특성 입력
  - 요소망 생성
  - 구속조건 설정
  - 하중조건 설정
  - 해석케이스 정의 및 해석 실행
  - 후처리

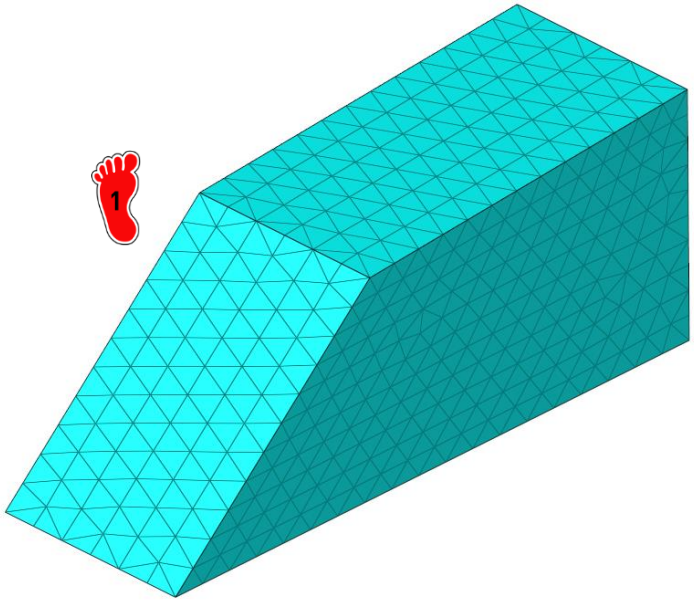
ACOUSTIC ANALYSIS OF A HALF CAR MODEL

- The purpose of this example is to evaluate the vibration characteristics of a half car model subjected to Fluid - Structure interaction. The fluid that is being referred to is air.
- Essentially, the noise level or the sound level is evaluated inside the car at a location near the ear of the driver which is the main response location inside the fluid.



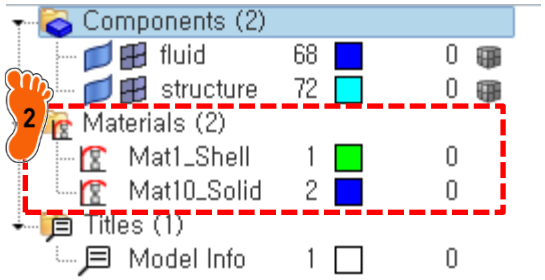
COUPLED FREQUENCY RESPONSE ANALYSIS OF FLUID-STRUCTURE MODEL

정적하중조건 설정 (1)



1 "Half_Car.hm" 불러오기

2 재료 생성 후 물성치 입력

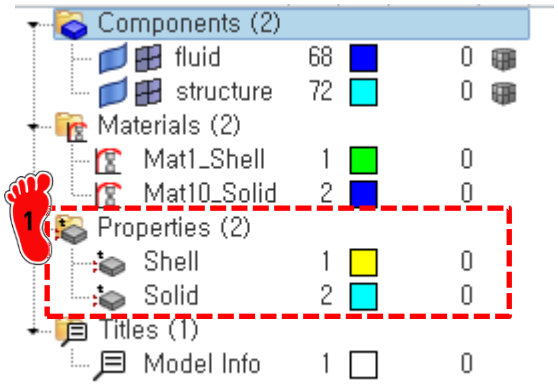


Name	Value
Solver Keyword	MAT1
Name	Mat1_Shell
ID	1
Color	
Include	[Master Model]
Defined	☑
Card Image	MAT1
User Comments	Hide In Menu/Export
E	210000,0
G	
NU	0,3
RHO	7,85e-09

Name	Value
Solver Keyword	MAT10
Name	Mat10_Solid
ID	2
Color	
Include	[Master Model]
Defined	☑
Card Image	MAT10
User Comments	Hide In Menu/Export
BULK	
RHO	1,2e-12
C	343000,0

*MAT10
→ Defines material properties for fluid elements in coupled fluid-structural analysis

정적하중조건 설정 (2)



Name	Value
Solver Keyword	PSHELL
Name	Shell
ID	1
Color	
Include	[Master Model]
Defined	☑
Card Image	PSHELL
Material	(1) Mat1_Shell
User Comments	Hide In Menu/Export
T	2.0
MID2	1
MID2_opts	☐
I12_T3	

Name	Value
Solver Keyword	PSOLID
Name	Solid
ID	2
Color	
Include	[Master Model]
Defined	☑
Card Image	PSOLID
Material	(2) Mat10_Solid
User Comments	Hide In Menu/Export
CORDM options	BLANK
ISOP	
FCTN	PFLUID
HOURGLS_OPT	☐
PSOLIDX	☐

1 Property 생성 후 재료 반영
(1) PSHELL
→ T=2.0 입력

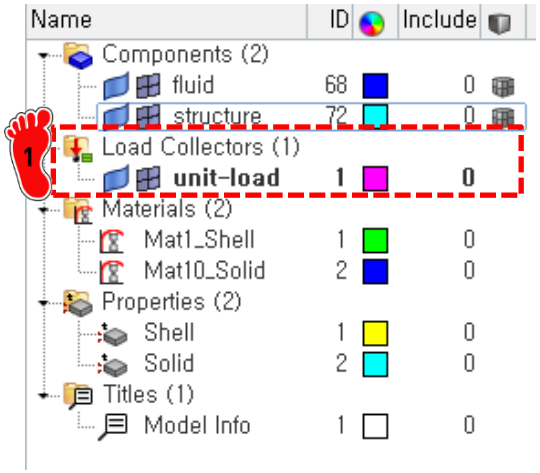
(2) PSOLID
→ FCTN: PFLUID 선택

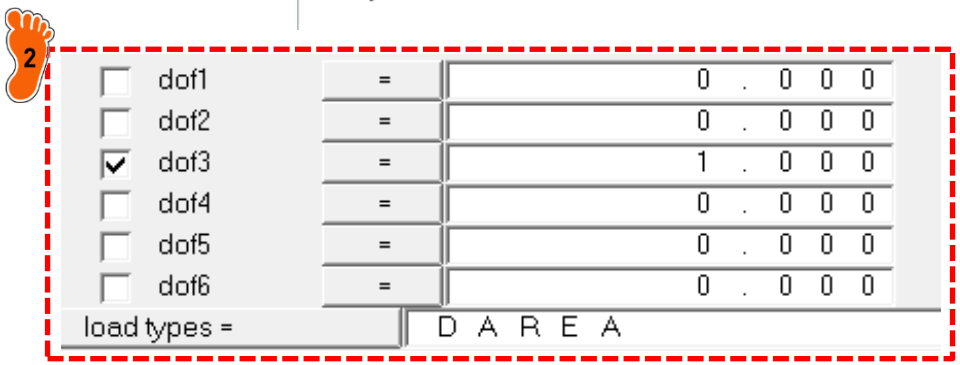
각 components에 생성한 property 부여

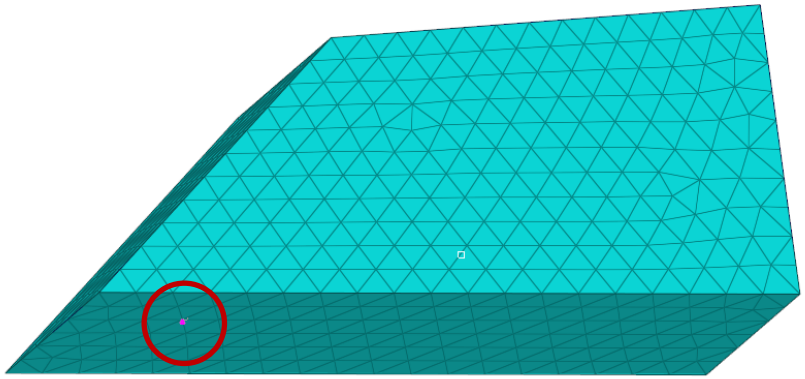
*FCTN
→ Fluid element flag

*PFLUID
→ Indicates a fluid element

주파수 의존함수 입력







1 Load collector 생성

2 BCs → Constraints → dof3만 체크 → 1 입력 → load types에 DAREA 선택

→ Node id: 10972 선택 (applies a unit load to the selected node)

* DAREA
→ Defines scale (area) factors for dynamic loads

동적하중조건으로 변환

Name	Value
Solver Keyword	TABLED1
Name	tabled1
ID	4
Color	
Include	[Master Model]
Card Image	TABLED1
User Comments	Hide In Menu/Export
XAXIS	LINEAR
YAXIS	LINEAR
TABLED1_NUM =	2
Data: x, ...	

1

2

TABLED1_NUM =

	x	y
1	0.0	1.0
2	1000.0	1.0

0 Hz부터 1000 Hz까지 동일한
크기를 갖는 주파수 의존함수

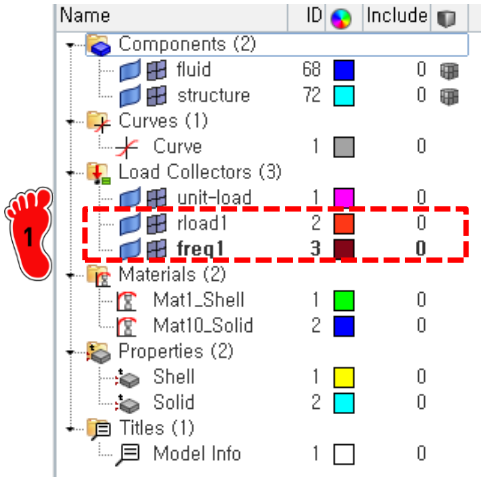
1 Ctrl + F → TABLED1 선택

2 TABLED1_NUM = 2 입력
Data sheet 클릭 후
테이블에 값 입력

Frequency Range Table
(X,Y): (0,1), (1000,1)

*TABLED1
→ tabular function for use in generating frequency-dependent dynamic loads

해석 케이스 설정 (1)



Name	Value
Solver Keyword	RLOAD1
Name	rload1
ID	3
Color	
Include	[Master Model]
Card Image	RLOAD1
User Comments	Hide In Menu/Export
EXCITEID	(1) unit-load
DELAY_OPTION	
DELAY	
DPHASE_OPTION	
DPHASE	
TC	(2) tabled1
TD	<Unspecified>
TYPE	

2

Name	Value
Name	freqi
ID	4
Color	
Include	[Master Model]
Card Image	FREQi
User Comments	Hide In Menu/Export
FREQ	
FREQ1	
NUMBER_OF_FREQ1 =	1
Data: ID, ...	
FREQ2	
FREQ3	
FREQ4	
FREQ5	

NUMBER_OF_FREQ1 =

	ID	F1	DF	NDF
1	4	0.0	1.0	200

1 Load collectors 생성

2 (1) RLOAD1
→ EXCITED: unit-load 선택
TC: tabled1 선택

(2) FREQi
→ FREQ1 체크
F1:0, DF:1, NDF:200 입력

*RLOAD1
→ frequency-dependent dynamic load of the form

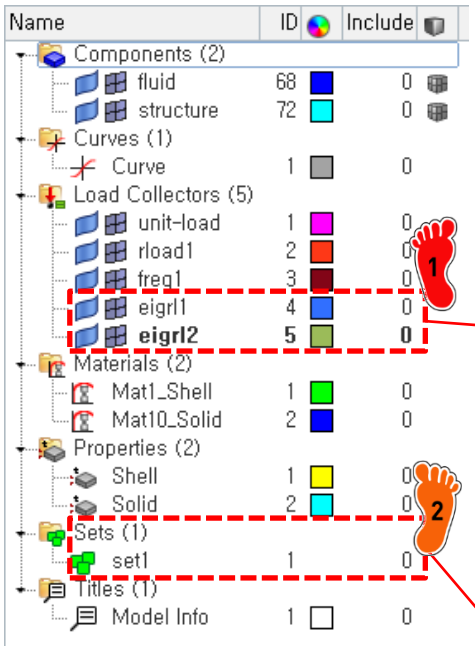
$$\mathbf{f}(\Omega) = A(C(\Omega) + iD(\Omega))e^{i(\theta - 2\pi\Omega\tau)}$$

A : EXCITEID (DAREA)
C : TABLED1

*FREQ1
: frequency response problems by specification

F1: a starting frequency,
DF: frequency increment,
NDF: the number of increments

해석 케이스 설정 (2)



Name	Value
Solver Keyword	EIGRL
Name	eigrl1
ID	4
Color	
Include	[Master Model]
Card Image	EIGRL
User Comments	Hide In Menu/Export
V1	
V2	600.0
ND	50
MSGLVL	
MAXSET	
SHFSCL	
NORM	MASS

Name	Value
Solver Keyword	SET
Name	set1
ID	1
Include	[Master Model]
Defined	☑
Card Image	SET_GRID
Set Type	non-ordered
Entity IDs	1 Nodes
User Comments	Hide In Menu/Export
TYPE	GRID
SUBTYPE	LIST
No of rows	1
ID	18881

1 Load collectors 두 개 생성

→ Card image: EIGRL
V1: 600, ND: 50 입력
(eigrl1, eigrl2 생성)

2 Set 생성
→ Card image: SET_GRID
Entity IDs: Node id
18881 추가
(half car inside 점)

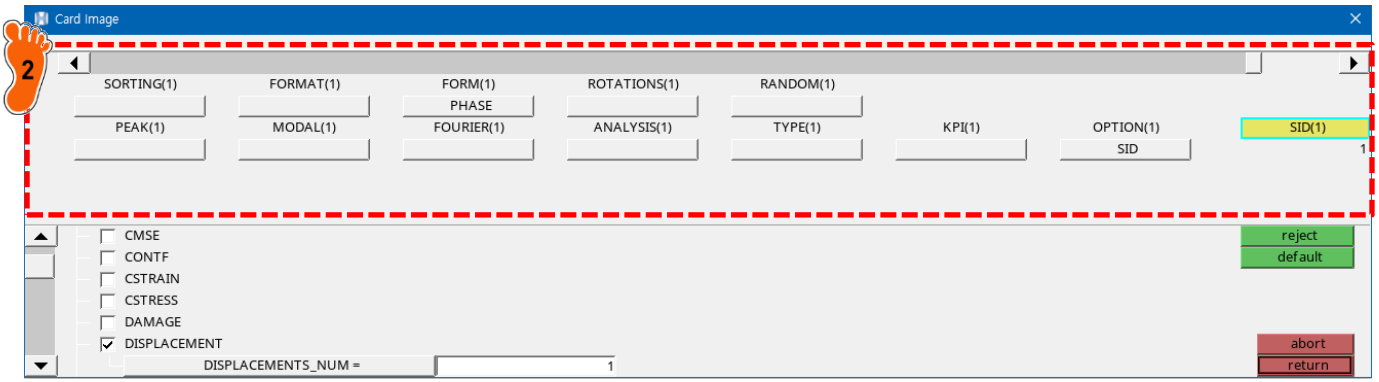
해석 케이스 설정 (4)

Name	Value
Solver Keyword	SUBCASE
Name	subcase1
ID	1
Include	[Master Model]
User Comments	Hide In Menu/Export
Subcase Definition	
Analysis type	Freq. resp (modal)
SPC	<Unspecified>
SUPORT1	<Unspecified>
DLOAD	(2) rload1
MPC	<Unspecified>
METHOD (STRUCT)	(4) eigrl1
METHOD (FLUID)	(5) eigrl2
FREQ	(3) freq1
SDAMPING (STRUCT)	<Unspecified>
SDAMPING (FLUID)	<Unspecified>
STATSUB (PRELOAD)	<Unspecified>

1 Load step 생성
Analysis type:
Freq. resp (modal)
DLOAD: rload1
METHOD(STRUCT): eigrl1
METHOD(FLUID): eigrl2
FREQ: freq1

2 Control card → GLOBAL_OUTPUT_REQUEST 클릭
→ DISPLACEMENT 클릭
→ Form(1): PHASE 선택
OPTIONS(1): SID 선택
SID(1): SET 선택

FORMAT	INCLUDE_BULK	K42GG	delete
GAPPRM	INCLUDE_CTRL	LABEL	disable
GLOBAL_CASE_CONTROL	INFILE	LOADLIB	enable
GLOBAL_OUTPUT_REQUEST	A2GG	M2GG	
GRDSET	B2PP	M2PP	next
GROUNDCHECK	K2GG	MDSDIR	prev
HISOUT	K2PP	MECHCHECK	return



해석 케이스 설정 (5)

Defines model parameters for the fluid-structure interface

	[INTER]	[INFOR]	[FSET]	[SSET]	[NORMAL]	[SKNEPS]	[DSKNEPS]	
ACMODL	DIFF	ALL						+
	[INTOL]	[ALLSET]	[SRCHUNIT]	[MAXSGRID]				

INTER: Fluid-structure interface type
INFOR: Defines whether grids or elements identified by FSET and SSET are to be used to define the fluid-structure interface

	KEYWORD	FREQ
OUTPUT	HGFREQ	ALL
OUTPUT	H3D	ALL
OUTPUT	OPTI	ALL

H3D: Hyper3D format

OPTI: OptiStruct ASCII format

number_of_outputs = 3

AUTOSPC: automatically constrain stiffness singularities and near singularities with single point constraints

	V1
PARAM, AUTOSPC,	YES

	[G_V1]
PARAM, G,	0.060

G: uniform structural damping coefficient for dynamic analyses

	[VALUE]
PARAM, GFL,	0.120

GFL: uniform fluid damping coefficient for dynamic analyses

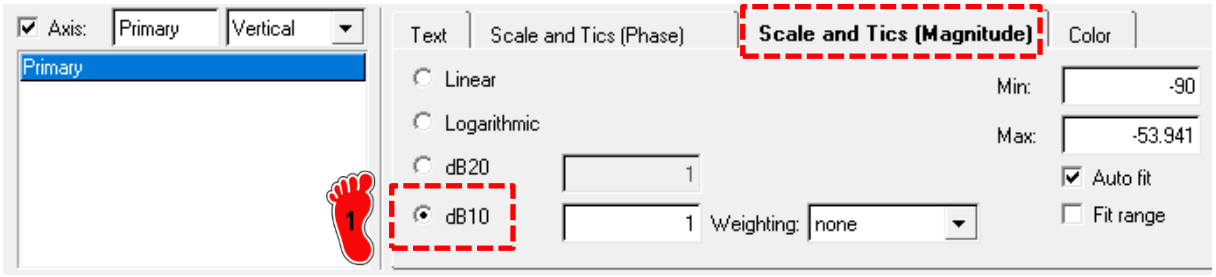
Control cards에서 다음과 같은 항목 선택

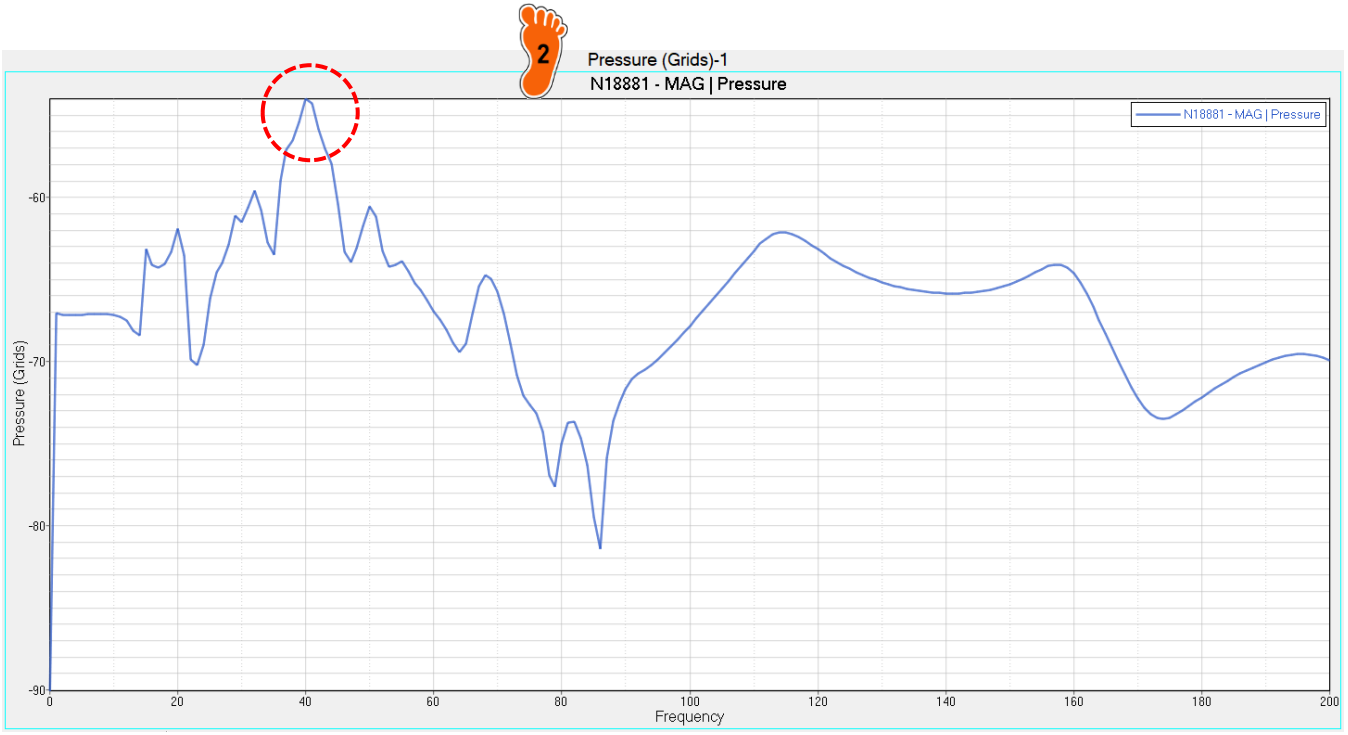
1 ACMODL 설정 (2개)
(model parameters for fluid-structure interface)
→ INTER: Diff 선택,
INFOR: ALL 선택

2 OUTPUT 설정 (3개)
→ HGFREQ, H3D, OPTI

3 PARAM 설정 (3개)
→ AUTOSPC: YES 선택,
G: 0.06 입력,
GFL: 0.12 입력
(균일 감쇠 계수)

해석 케이스 설정 (6)





1 Vertical axis (Pressure) 더블 클릭 후, Scale and Tics (Magnitude) 탭 선택 → dB10 클릭

2 결과 확인