Diagnostics Tutorial Guide

Use Pythia Software for Diagnosis

General Description of the Practice

The purpose of the practice is to enhance the understanding of the Gas Path Analysis by using **Pythia** computer software. The basic procedure of the practice is:

- Implant an engine component degradation
- Select measurable parameters
- Simulate clean and degraded engine performance/measurements
- Search potential degraded components with linear and non-linear GPA.
- *Fill in the "Work Sheet" with obtained results.*
- Analyze the results, find out the degraded component and the level of degradation, and finally explain how the degraded component is found.

Procedure of the Practice

Copy the whole PYTHIA software folder and put it on C drive.

- 1. Load PYTHIA by double-clicking *PYTHIA* icon in C:/Pythia vs 5.1/.
- 2. Click on *START* button to activate a login window. Provide password and press *OK* button to access PYTHIA
- 3. Click on *Diagnostics* button
- 4. Click on *File* menu and click on *Open Existing Engine Model*
- Find '*Tutorial Model*' in folder C:/Pythia vs 5.1/My Projects/, double click on the file "tutorial model" to open the engine model. Click on *Make Engine* button to update the model route.
- 6. Implant a component degradation in the following steps:
 - Go to menu *Build Simulation* and choose *Degradation*
 - □ Tick the checkbox for "COMPRE 1"
 - □ Implant "-1" to *Efficiency* (means -1% drop in efficiency Index)
 - □ Implant "-3" to *Flow Capacity*: (means -3% drop in flow capacity Index)
 - Go to File menu and click on Save and then Return



- 7. Select measurement parameters:
 - □ Go to menu *Build Simulation* and click on *Measurement* to open measurement setting window
 - Click on the Radio button at the left-hand side of *Measurement Setting* window
 - Choose the measurable parameters:
 - Click on **COMPRE** brick on the engine model bar
 - Select "SV" under Data Type
 - Choose station "3" under *Station Vector*
 - Choose "P Total" under *Station Vector*
 - Click on ADD button to add P3 to the Measurement Setting window
 - In the same way to select *T3*, *P8 and T8* respectively and click on ADD button to add them to the *Measurement Setting* window
 - Click on the Radio button for COMPRE 1 PCN, and then click on ADD button
 - Click on the Radio button for *Fuel Flow*, and then click on ADD button
 - □ Click *Save* menu to save the setting
 - □ Click *Return* menu to leave the window

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- 8. Simulate measurement samples of degraded model engine:
 - Click on *Simulate* menu and then choose *Measurement Samples* menu
 - □ Choose *Degraded* under *Engine Status* menu
 - Choose Without Noise and Bias under Measurement Uncertainty button
 - Click on *START* button to start the simulation
 - □ Press *STOP* button to terminate the simulation after several samples are simulated
 - □ Go to *File* menu and choose *Save As*. Give a user defined file name (such as '*degraded*') and click on *Save* button to save the simulated measurement samples to a data file called "degraded.dat" for degraded engine model
 - □ Click on *Return* menu to leave the window

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- 9. Imagine that test data for the degraded engine are available in a data file called "degraded.dat". You are supposed to upload test data into *Pythia* software to conduct diagnostic analysis as follows.
- 10. Data acquisition to upload the test data
 - □ Go to *Build Analysis* menu, choose *Data Acquisition Preprocessing* and then click on *From File*
 - □ Go to *File* menu and choose *Open Degraded Data*. Select the data file ('*degraded.dat*) and open it. The measurement samples are shown on the screen. As all samples have the same values, they are shown on straight lines.
 - □ You may move the Slider under *Degradation Data Acquisition* window to choose a particular sample. If you do not move the Slider, the first sample is chosen.
 - Go to *File* menu, choose *Save* and then choose *Selected Sample*
 - □ Click *Return* to leave the window

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- 11. GPA setting assuming the *compressor* is the potentially degraded component:
 - □ Go to *Build Analysis* and choose *Fault Quantification* and then click on *Gas Path Analysis*. The GPA setting window will appear.
 - On this window you have the second chance to re-select measurement parameters for diagnosis if necessary. In this case, the checkboxes on the left-hand side of the measurement parameters should be ticked, which means that all measurements are selected.
 - □ Select <u>COMPRE</u> as the potential faulty component under Component Selection and click on Add button to add COMPRE 1 to the Choose Potential Faulty Component to Search window.
 - Go to *File* menu and choose *Save*
 - □ Click on *Back* menu

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12. Search compressor degradation with linear and non-linear GPA in the following steps:

- □ Go to Analysis menu and choose Fault Quantification and then choose Gas Path Analysis
- □ To start a linear GPA prediction, go to *Run* menu and click on *Linear GPA*. The predicted degradation will be shown on the screen.
- □ Record the predicted results on the *Work Sheet* on the next page.
- □ Go to *View* menu and choose *Linear GPA Result File* to view the details of the prediction
- Click on *Show Fault Signature Bar Char* button to view fault signature bar chart
- Click on Show GPA Result Bar Char button to see result bar chart
- Click on *Implanted Fault* menu and choose *Know*
- Click on *View* menu and choose *Implant Fault* to view implant degradation
- □ To start a non-linear GPA prediction, go to *Run* menu and choose *Non-Linear GPA*. The predicted degradation will be shown on the screen.
- □ Record the predicted results on the *Work Sheet*.
- □ Go to *View* menu and choose *Non-Linear GPA Result File* to view the details of the prediction.
- □ Press *Show GPA Result Bar Chart* to see result on a bar chart
- □ Press *Back* menu to leave the window.
- 13. Search burner degradation by assuming that the <u>BURNER</u> as the potentially degraded component in the following steps:
 - Go to Build Analysis and choose Fault Quantification and then Gas Path Analysis
 - □ Press **DELETE ALL** button
 - □ Select the <u>BURNER</u> as the potential faulty component and press Add button to add it to the searching list
 - □ Go to *File* menu and choose *Save* and then *Back*
 - Go to Analysis and choose Fault Quantification and then Gas Path Analysis
 - Go to *Run* menu and choose *Linear GPA* to get liner GPA results
 - □ Record the predicted degradation on the *Work Sheet*
 - □ Go to *Run* menu and choose *Non-Linear GPA* to get non-linear GPA results
 - □ Record the predicted degradation on the *Work Sheet*.
 - □ Click *Back* to leave the window.
- 14. Search turbine degradation by assuming that the <u>*TURBIN*</u> as the potentially degraded component as follows:
 - Go to Build Analysis and choose Fault Quantification and then Gas Path Analysis
 - □ Press **DELETE ALL** button
 - Select the <u>TURBIN</u> as potential faulty component and press Add button to add it to the searching list
 - Go to *File* menu and choose *Save* and then *Back*
 - Go to Analysis menu and choose Fault Quantification and then Gas Path Analysis
 - Go to *Run* menu and choose *Linear GPA* to start liner GPA prediction
 - □ Record the predicted results on the *Work Sheet*
 - Go to *Run* menu and choose *Non-Linear GPA* to start ono-linear GPA prediction

- □ Record the predicted degradation on the *Work Sheet*.
- □ Click on *Back* to leave the window

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Turbine

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- 15. Analyze the results on the *Work Sheet* and try to answer the following questions:
 - □ Assume that the actual degradation may be the compressor, the burner or the turbine. Which component is more likely to have degraded and why? Show the evidence to support your answer.
 - □ Compare the results from the linear and the non-linear GPA and assess which result is better and why?

		Ι	nstrumenta	tion Set					
1	Compressor Shaft Speed (PCN 1)								
2	Compressor exit total pressure (P3)								
3	Compressor exit total temperature (T3)								
4	Exhaust total temperature (T8)								
5	Exhaust total pressure (P8)								
6]	Fuel flow rate							
		Imp	lemented D	egradati	ion				
Compone	ent:		Compre	Compressor					
Efficienc	y Index drop η _c (9	%):	-1	-1					
Flow cap	acity Index drop	Γ _c (%):	-3	-3					
		GP	PA Diagnost	ic Resul	ts				
			Linear	Linear GPA Non-Linea					
Fault Case	Componen	ıt	Degradation (%)	GPA Index	Degradation (%)	GPA Index			
1	Compressor	η _c r							
_		$\Gamma_{\rm c}$							
2	Burner	η_b							
		η_t							

Work Sheet