International Journal of Applied Power Engineering (IJAPE)
Vol. 3, No. 1, April 2014, pp. 9~14
ISSN: 2252-8792

Load Flow Analysis for Process-Tank Loading Power Generation Networks Interconnection

Radita Arindya
Satyagama University Jakarta, Indonesia

Article Info

Article history:

Received Aug 14, 2013
Revised Dec 7, 2013
Accepted Jan 4, 2014

Keyword:

Load flow analysis
Network interconnection
Power generation
Tank loading

ABSTRACT

Establishment of interconnection links between Process-Tank Loading electrical networks bring some advantages as there are excess capacity at Process which can be utilized in principle to feed Tank Loading. Some result of power system study will be as an input for operational purposes. Concerning Motor Starting Studies and Load Flow Studies and taking into account that the transformer is off load tap changing, the best tapping position for Isolation Transformer is at -5% (primary side). The best technical power generation configuration is proposed with configuration 2 (two) Process -TEG and 1 (one) Tank Loading-TEG running with 2 (two) interconnection, provided with appropriate load shedding system. Bare in mind that during smooth power transfer from each Process-TEG which requires 3 (three) Process-TEG running in parallel, there is an issue on kA capacity of Process switchgear. Existing setting of protection relay shall be reviewed according to the result of protection coordination study.

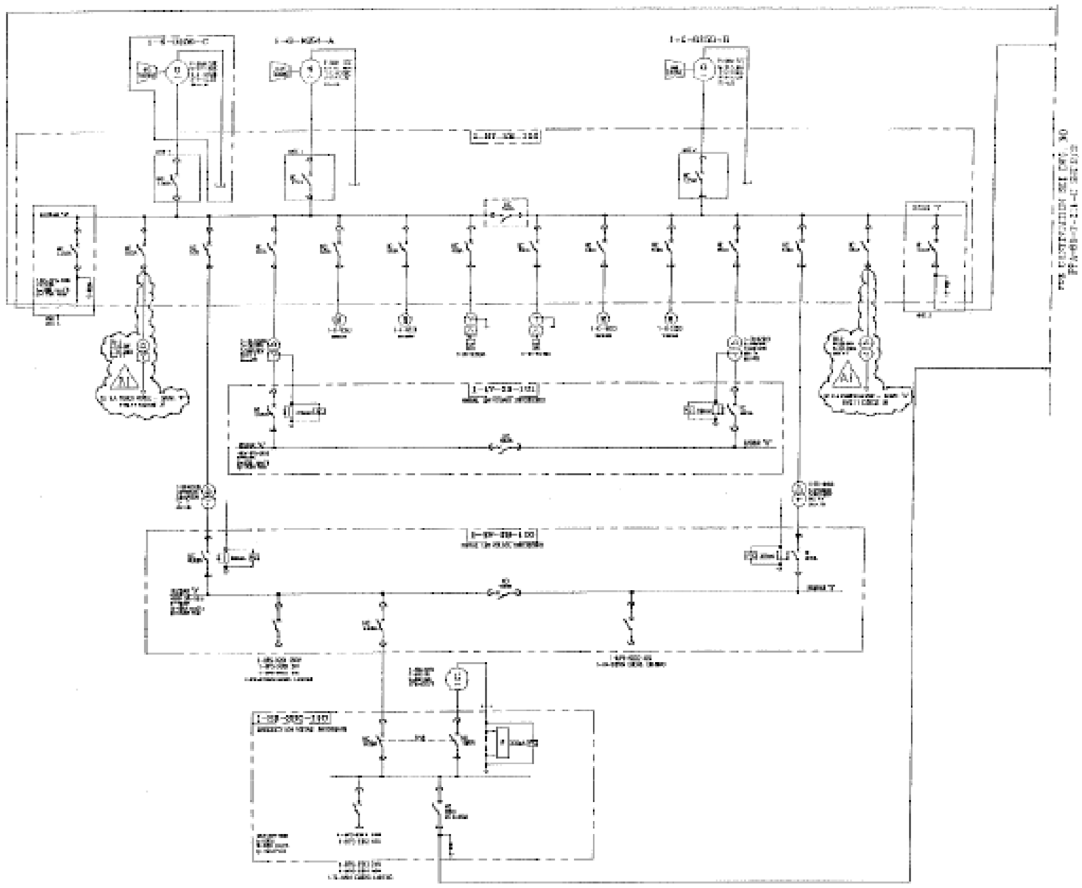
Corresponding Author:

Radita Arindya,
Satyagama University Jakarta,
Indonesia.
Email: raditatech@yahoo.com

1. INTRODUCTION

The two electrical networks at Process -Tank Loading are not interconnected. As Tank Loading-TEG power generation is less efficient and smaller capacity than Process one, it is more exposed to trip and system instability problem. Therefore, electrical interconnection between Process -Tank Loading to increase electrical network stability and reliability in tank loading and to avoid loss of production when 1 (one) tank loading-TEG is unavailable. The idea of interconnection process-Tank Loading has been putting on the table since Phase#1, but due to Tank Loading switchgear rating, instead of direct connection by cable, isolation transformer shall be inserted as fault current limiter.

Hence, the excess capacity at Process can be utilized in principle to feed Tank Loading. This solution will improve the process reliability of Tank Loading. After Process-Tank Loading interconnection completion, decommissioning two Tank Loading TEGs is foreseen. Purpose of this document are electrical power system studies regarding establishment and system behavior of Electrical Interconnection System between Power Plant through isolation transformer. The studies are comprised as following Load Flow Study



Based on progress meeting for Electrical Power System Study, cases and scenarios had been defined, as described in the following clauses.

2. LOAD FLOW

There are ten cases for Load Flow Study, summarize as below:

LF Case:	Generator		Interconnection		Event
	Tank Loading	Well	Line A	Line B	
1	1	2	ON	ON	Loading on + CSU On
2	1	2	ON	OFF	Loading on + CSU On
3	1	3	ON	OFF	Loading on + CSU On
4	1	3	ON	ON	Loading on + CSU On
5	0	3	ON	OFF	Loading on + CSU On
6	0	3	ON	ON	Loading on + CSU On
7	2	2	ON	ON	Loading on + CSU On
8	2	2	OFF	ON	Loading on + CSU On
9	?	?	ON	ON	Loading only, and minimum generation
10	3	0	ON	OFF	Start-up Process TEG, with power from Tank Loading

Specific Limitation and Assumption for each Study
Load Flow Study:

- Generation at Process is simulated as isochronous (swing operation mode) and generation at Tank Loading simulated as 5% droop (voltage control operation mode) with based load set at 1.8MW each (voltage control operation mode)
- All Transformer is energized from HV side
- Tapping (off-load tap changer) of interconnection transformer are on primary side (or PROCESS side) as per manufacturing drawing
- For Case#10, load at Process during black start assume at about 400kW

3. LOAD AND POWER BALANCE

For Process, the final Power Balance figure is based on the latest observation trough DCS monitor at Main Control Room, under the main Operational Office, for Tank Loading, will used existing documentation. From document, generation and load consumption of Tank Loading and Process are summarized in table below:

Area	Installed Generator	Normal Operation	Load
Tank Loading	6.6 MW (3x2.2 MW CENTAUR TEGs)	2x	4.7 MW
Process	27 MW (3x9 MW MARS TEGs)	2x	10 MW

Tank Loading load of 4.7 MW is including tanker loading operation and compressor running. Process load of 10 MW (3 trains of gas turbine compressor, estimated total 1.5 MW). Power consumption of Process excludes future water injection pumps), and smokeless Nitro flare (1MW).

The Process generation has capacity of 18 MW (2 TEGs in operation). With total Process load of 10 MW, at least 8 MW of spare generation capacity will be available at PPA. Hence, the excess capacity at Process in principle can be utilized to feed Tank Loading.

Observation on Load and Power Balance at Process

The observation on Process Load and Generation:

Table 1: Process - Load and Power Balance – current operation

TAG #	Designation	Rated		Observation		Calc
		KW	KVA	P (KW)	Q (KVar)	Util (%)
Load at PPA :						
1K-4550	LP Boostr 800KW	800		771	445	96%
1K-4820	Refrg. Compr. Train A - 1900KW	1,900		1,442	580	76%
1K-4920	Refregrant Comp. Train B - 1900KW	1,900		1,343	537	71%
1K-5020	St.by refrigernt Comp - 1900KW	1,900		1,442	580	76%
TR-9250A	Load 1-LV-SB-100 bus A		2,500	253	63	10%
TR-9260A	Load 1-LV-SB-101 bus A		2,500	148	140	8%
TR-9250B	Load 1-LV-SB-100 bus B		2,500	364	275	18%
TR-9260B	Load 1-LV-SB-101 bus B		2,500	262	112	11%
6-HV-SB 100 A				1,244	417	
6-HV-SB 100 B				550	443	
	TOTAL LOAD			**7,819**		
Generation at PPA :						
1-G-9250-C	Gas Turbine Generator C - 9MW	9,000	11,250	2,606	1,225	29%
1-G-9250-A	Gas Turbine Generator A - 9MW	9,000	11,250	2,655	1,142	30%
1-G-9250-B	Gas Turbine Generator B - 9MW	9,000	11,250	2,654	1,269	29%
	TOTAL GENERATION			**7,915**		
	SPINNING RESERVE (2 GTG)			**10,085**		
	SPINNING RESERVE (3 GTG)			**19,085**		

There is a small discrepancy between total load and total generation, as the observation is sequentially noted from the figure displayed on the screen of the DCS, due to load fluctuation and accuration of the measurement system.

From the historical graph report for a month period on power generation, showed that 3 (three) generators were running with average power generation on each generator is about 2.6-2.7MW (or about 30% of its rated power). It means also that for PPA, only 1 (one) normal operating condition is occurred.

There are other loads which not running currently (like glycol reboiler); therefore for the purpose of simulation of Load Flow, 10MW figure will be used, instead of 7.8MW (with some factor applied for each glycol reboiler load). Hence, the final load and power balance of PROCESS as follow:

Table 2: PROCESS - Load and Power Balance - for simulation purpose

TAG #	Designation	Rated		Observation		Calc
		KW	KVA	P (KW)	Q (KVar)	Util (%)
Load at PPA :						
1K-4550	LP Boostr 800KW	800		771	445	96%
1K-4820	Refrg. Compr. Train A - 1900KW	1,900		1,442	580	76%
1K-4920	Refregrant Comp. Train B - 1900KW	1,900		1,343	537	71%
1K-5020	St.by refrigernt Comp - 1900KW	1,900		1,442	580	76%
TR-9250A	Load 1-LV-SB-101 bus A		2,500	253	63	10%
TR-9250B	Load 1-LV-SB-101 bus B		2,500	364	275	18%
TR-9260A	Load 1-LV-SB-100 bus A		2,500	148	140	8%
TR-9260B	Load 1-LV-SB-100 bus B		2,500	262	112	11%
6-HV-SB-100 A				1,244	417	
6-HV-SB-100 B				550	443	
	TOTAL LOAD			**7,819**		
Additional Load to be considered at PPA :						
1-H-520G	Glycol Reboiler 1-H-520G	1,000		730		73%
1-H-540G	Glycol Reboiler 1-H-540G	1,000		730		73%
6-H-970G	Glycol Reboiler 6-H-970G	1,000		730		73%
	TOTAL LOAD (incl. GLYCOL REBOILER)			**10,009**		
Generation at PPA :						
1-G-9250-C	Gas Turbine Generator C - 9MW	9,000	11,250	2,606	1,225	29%
1-G-9250-A	Gas Turbine Generator A - 9MW	9,000	11,250	2,655	1,142	30%
1-G-9250-B	Gas Turbine Generator B - 9MW	9,000	11,250	2,654	1,269	29%
	TOTAL GENERATION			**7,915**		
	SPINNING RESERVE (2 GTG)			**7,991**		
	SPINNING RESERVE (3 GTG)			**16,991**		

Load and Power Balance at Tank Loading

Load and Power Balance at Tank Loading will be based on existing , which subject to different operation scenario, which are:

- Loading Operation : 4,708 KW total load
- No Loading Operation : 3,508 KW total load
- Loading Operation and CSU Compressor Off : 4,168 KW total load
- No Loading Operation and Compressor Off : 2,968 KW total load

In general, for the purpose of simulation of Load Flow, 4.7MW figure will be used.

Load and Power Balance after Interconnection Process-Tank Loading

From the result of Load Flow Study, the brief Load and Power Balance after interconnection Process-Tank Loading can be shown on table below:

Table 3: Load and Power Balance after Interconnection PPA-TANK LOADING

No	Generator TLA	Generator PCK	TOTAL Gen [MW]	Simulation Produced [MW] (study)	Calc Spinning Reserve	Event	LOAD [MW] PPA (study)	LOAD [MW] TLA (study)
1	1	2	20.2	14.812	5.388	TLA Loading On + CSU On	10.076	4.736
2	1	2	20.2	14.818	5.382	TLA Loading On + CSU On	10.077	4.741
3	1	3	29.2	14.814	14.386	TLA Loading On + CSU On	10.072	4.742
4	1	3	29.2	14.811	14.389	TLA Loading On + CSU On	10.073	4.738
5	0	3	27	14.904	12.096	TLA Loading On + CSU On	10.076	4.828
6	0	3	27	14.841	12.159	TLA Loading On + CSU On	10.077	4.764
7	2	2	22.4	14.774	7.626	TLA Loading On + CSU On	10.076	4.698
8	2	2	22.4	14.770	7.630	TLA Loading On + CSU On	10.076	4.694
9	0	2	18	14.032	3.968	Loading only (CSU off, incl. its Utilities)	10.076	3.956
10	3	0	6.6	5.112	1.488	PPA Black Start w/ about 400kW load and power from TLA	0.408	4.704

4. LOAD FLOW STUDIES

There were few studies regarding Load Flow on Process -Tank Loading interconnection before project execution, This Load Flow Study result will confirm the above studies, subject to some recommendations. The result of Load Flow will be used as reference for operational purpose such as setting of Tap position for the Interconnection Transformer.

Summary of Load Flow Studies

Table 4: Summary of Load Flow Studies

No	Generator TLA	Generator PCK	Interconn Lines Line A	Interconn Lines Line B	Event	LOAD [MW] PPA (study)	LOAD [MW] TLA (study)	V level (%) HV SB (PPA)	V level (%) HVS 11 (TLA)	Remark for Transformer Tapping Position
1	1	2	ON	ON	TLA Loading On + CSU On	10.076	4.736	99.95%	100.00%	-2.5% Tap on TX 2-1/2
2	1	2	ON	OFF	TLA Loading On + CSU On	10.077	4.741	99.95%	98.58%	-2.5% Tap on TX 2-1
3	1	3	ON	OFF	TLA Loading On + CSU On	10.072	4.742	99.97%	98.60%	-2.5% Tap on TX 2-1
4	1	3	ON	ON	TLA Loading On + CSU On	10.073	4.738	99.97%	100.00%	-2.5% Tap on TX 2-1/2
5	0	3	ON	OFF	TLA Loading On + CSU On	10.076	4.828	99.96%	99.01%	-5% Tap on TX 2-1
6	0	3	ON	ON	TLA Loading On + CSU On	10.077	4.764	99.96%	99.48%	-2.5% Tap on TX 2-1/2
7	2	2	ON	ON	TLA Loading On + CSU On	10.076	4.698	99.96%	99.12%	0% Tap on TX 2-1/2
8	2	2	OFF	ON	TLA Loading On + CSU On	10.076	4.694	99.96%	98.26%	0% Tap on TX 2-1/2
9	0	2	ON	ON	Loading only (CSU off, incl. its Utilities)	10.076	3.956	99.95%	100.00%	-2.5% Tap on TX 2-1/2
10	3	0	ON	OFF	PPA Black Start w/ about 400kW load and power from TLA	0.408	4.704	99.47%	100.00%	0% Tap on TX 2-1

5. CONCLUSION AND RECOMMENDATION

From the table#4 above, prelimininary conclusion are as follows:

- Process-Tank Loading interconnection through isolating transformer shown better performance of overall system, such as: better voltage regulation, more flexibility in term of numbers of generation run especially on Tank Loading side
- Operation of MK-6610 CSU (steady state) does not require all 3 (three) Tank Loading-TEG running
- Optimal tapping of Isolation Transformer is at +2.5% Tap (on primary side)
- Maximum voltage drop occurred in case#5, therefore adjustment on tapping to +5% Tap is required, but subject to Off Load Tap Changer, tapping position must be decided at +2.5% Tap or +5% (on primary side)
- Minimum generation configuration (with Tank Loading on Loading only operation) achieve by running only 2 (two) TEG at Process with spinning reserve 3.968MW, so more economic operation can be achieved
- Technically, the best generation configuration is 2 (two) PPA-TEG and 1 (one) Tank Loading-TEG., with either 2 or 1 interconnection link
- The most reliable generation configuration is 2 (two) PPA-TEG and 2 (two) Tank Loading-TEG, with either 2 or 1 interconnection link
- During Process start up using power from Tank Loading, all 3 (three) Tank Loading-TEG shall run

REFERENCES

[1] William D. Stevenson, Jr. *Analisis Sistem Tenaga Listrik*, Penerbit Erlangga, 1993.
[2] P. Van Harten (Setiawan). *Instalasi Listrik Arus Kuat Jilid 1,2,3*, Penerbit Bina Cipta, 1992.
[3] A.N. Afandi. *EDSA : Software Aplikasi Tenaga Listrik*, Penerbit Graha Ilmu 2010.