Available Transfer Capability based Congestion Management in Restructured Power System

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Abstract— Congestion is a common condition which creates considerable impact on performance of power system in deregulated environment. Information of Available Transfer Capability (ATC) helps to alleviate problem of congestion by giving power transfer capability available in the system for a particular transaction. After surveying, work presented in this paper has implemented sensitivity based approach like DCPTDF (DC Power Transfer Distribution Factor) for ATC calculation. To validate performance of these approaches, a 6-bus sample system is considered with thermal limit constraint. The DCPTDF method was found to be faster than other conventional method.

Key words: ATC (Available Transfer Capability), Deregulated Power system, DC Power Transfer Distribution Factor (DCPTDF)

I. INTRODUCTION

Many electrical power utilities, worldwide, have been compulsory to change their way of operation and business, from vertical integrated to unbundled open market structured [1]. Effective management of power transaction ensures the secure and economic operation of power system. As the real-time operation and control of restructured power system is a mainly based on transactions, it would be better if the system studies are also based on power transactions. The assessment of ATC for the economic utilization of the available system components with regards to system security plays a vital role of time operation of the system. ATC is a measure of how much additional power could be transferred over the existing network [2]. A number of method have been proposed for the ATC evaluated. One of the method is Continuation Power Flow (CPF) method. It's very mathematically complicated in spite of its popularity has the demerits of its complexity [3].

Repeated power flow method repeatedly solves conventional power flow equations at a succession of points along the specified transfer directions [4]. Compared to the CPF method, the implementation of RPF method is much easier and the time for convergence time is less. It considers the thermal limit, voltage limit, and stability limit. DC power transfer distribution factor method (DCPTDF) is give fast estimation of ATC and it depends on many assumptions. Therefore this method gives less accurate results. AC power transfer distribution factor method gives accurate results as compared to DC power transfer distribution [5].

II. AVAILABLE TRANSFER CAPABILITY (ATC)

ATC is a measure of the transfer capability remaining in the physical transmission network for further commercial activity over and above already committed uses.
Mathematically, ATC is defined as:

ATC = TTC – ETC- TRM – CBM

Where, TTC = Total transfer Capability
TRM = Transmission Reliability Margin
ETC = Existing Transfer Commitments
CBM = Capacity Benefit Margin
Equation can be rewrite as,

ATC = TTC + ETC

A. *Total Transfer Capability (TTC):*

It is defined as the largest flow in transmission lines for which there are no thermal overloads, voltage limit violations, voltage collapse and any other system security problems like transient stability.

B. *Existing Transfer Commitments (ETC):*

It refers to the power transfer capability that must be reserved for already committed transaction.

C. *Transmission Congestion:*

In deregulated power system, congestion occurs when the transmitted power exceeds the capacity or transfer limit of the transmission line. Therefore it is necessary to manage congestion in deregulated power system. Congestion management is one of the most challenging tasks in the deregulated environment for ISO. Calculation of ATC gives information about network condition.

III. DC POWER TRANSFER DISTRIBUTION FACTOR (DCPTDF) METHOD

DC power transfer distribution factor method is called linear sensitivity method because it relates one change (transaction) to other change (line flow). A transaction is a specific amount of power that is injected at one bus (generator bus) and removed at another bus (load bus). DC power transfer distribution method use DC load flow model.

A. *DC Load Flow Model:*

Serval assumption is taken for DC load flow model.

1) Transmission lines are lossless.
2) Resistance is less than the Reactance.
3) Voltage Magnitudes at each bus is 1 per unit.
4) Small variation in angles.
5) Reactive power flow is not considered.
6) Only angles of complex bus voltages vary.

With above assumptions, the Newton - Raphson load flow equations are modified.

$$P_i = \sum_{j=1}^{n} \left(B_{ij} (\delta_i - \delta_j) \right) \quad (1)$$

The real power flow in line connected between bus i and j using DC power flow equation is given below:

$$P_{ij} = \frac{1}{x_{ij}} (\delta_i - \delta_j) \quad (2)$$

B. DC Power Transfer Distribution Factor:

The amount of a transaction and line flow is represented by DCPTDF. It is also called sensitivity because it relates amount of one change to another change.

$$DCPTDF_{ij,lm} = \frac{\Delta P_{ij}}{P_{lm}} \quad (3)$$

Calculation of DCPTDF using DC model:

$$DCPTDF_{ij,lm} = \frac{X_{il}-X_{jl}-X_{im}+X_{jm}}{x_{ij}} \quad (4)$$

ATC calculation using DCPTDF method:

ATC is determined by recognizing the new flow on line from node i to j, due to a transaction from node l to m. The new flow on line is the sum of original flow P_{ij}^{0} and the change.

$$P_{lm,ij}^{max} = \frac{P_{ij}^{max}-P_{ij}^{0}}{DCPTDF_{ij,lm}} \quad (5)$$

ATC is the maximum allowable transactions over all lines.

$$ATC_{lm} = min\left(P_{lm,ij}^{max}\right) \qquad \forall ij \quad (6)$$

IV. FLOW CHART OF DCPTDF METHOD

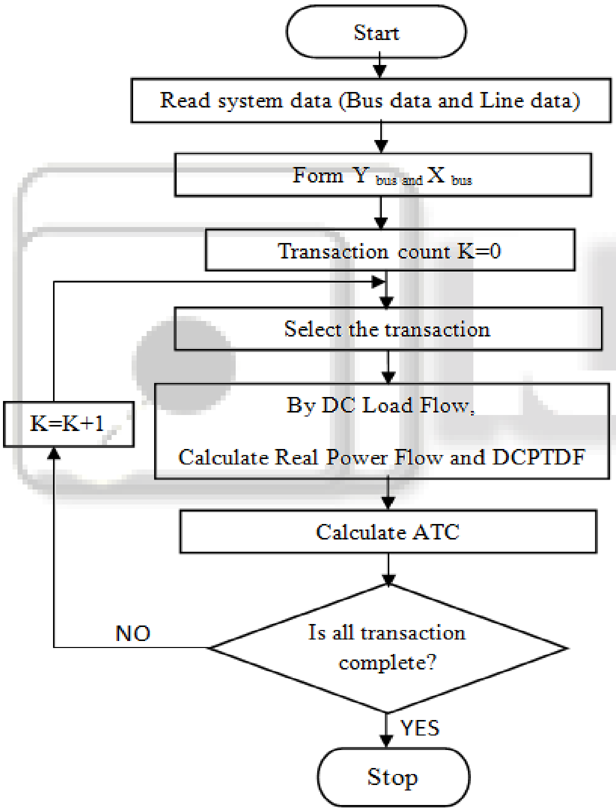

Fig. 1: DCPTDF Method Flow Chart

V. RESULTS AND DISCUSSION

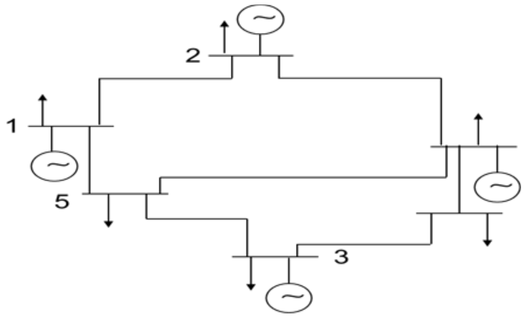

Fig. 2:

Bus Number	Bus Type	Voltage (p.u.)	Angle δ	Load (MW)	Load (MVAR)	Generation (MW)
1	1	1.1	0	70	10	18
2	2	0.9	0	45	10	100
3	2	1	0	50	10	86
4	2	1	0	30	10	130
5	0	1	0	35	10	0
6	0	1	0	100	10	0

Table 1: Bus Data for 6 Bus Sample Systems

From Bus	To Bus	Resistance (p.u.)	Reactance (p.u.)	Line Charging (p.u.)	Line Limit (MW)
1	2	0.04	0.08	0.02	100
1	5	0.04	0.08	0.02	100
2	4	0.04	0.08	0.02	100
3	5	0.04	0.08	0.02	100
3	6	0.04	0.08	0.02	100
4	5	0.04	0.08	0.02	50
4	6	0.04	0.08	0.02	100

Table 2: Line Data for 6 Bus Sample Systems

Line i-j	P_{ij}^{max} (MW)	DCPTDFs of i-j line	ATC(MW) Using DCPTDFs
1-2	100	-0.4667	
1-5	100	0.4667	
2-4	100	0.5333	
3-5	100	0.1333	42.75
3-6	100	-0.1333	
4-5	100	0.4000	
4-6	100	0.1333	

Table 3: Atc Values for Transaction between Bus 2 And 5 Using Dcptdf Method

The above results are obtained by DCPTDF using MATLAB. DCPTDFs methods indicate change in line flow due to a particular power transaction gives rough idea of ATC.

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