ANNEXURE –A

The strengths and weaknesses of the proposed control schemes for TCTILS are listed below:

<table>
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<tr>
<th>PROPOSED SCHEMES</th>
<th>STRENGTH</th>
<th>WEAKNESS</th>
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</table>
| ADD-PI           | • simple to design  
                  • operator can easily tune  
                  • easy to maintain  
                  • industrially accepted  
                  • based on traditional linear controller design  
                  • Minimise the interaction effect and also produces better closed loop specifications for each loop independently in each pair of linearised operating regimes | • establishing the accurate dynamic model and decoupler is not possible for certain process  
                  • difficult to implement system identification methods to get accurate model of the process due to existence of noise & disturbances in industries  
                  • time consuming design procedure  
                  • difficult to implement on processes having high degree of non linearity and interaction |
| AMFC             | • Model is not required  
                  • Reduces complicated unknown coupling dynamics better than ADD-PI & ATFC schemes  
                  • Produces better control performance than ADD-PI & ATFC schemes  
                  • Practically implementable  
                  • Reduces computational burden compared to existing centralised ATFC scheme  
                  • based on traditional linear | • Difficult to design due to selection of fuzzy membership functions and fuzzy rules are difficult and cumbersome  
                  • Very difficult to tune the AMFC parameters optimally due to large numbers of decision variables.  
                  • difficult to implement on processes having high degree of non linearity and interaction |
<table>
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<tr>
<th>controller design</th>
<th>NDMC</th>
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<tbody>
<tr>
<td>• Minimise the interaction effect and also produces better closed loop specifications for each loop independently in each pair of linearised operating regimes better than ADD-PI control scheme</td>
<td>• Step response model is required which can be easily obtained from industrial process</td>
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<td>• based on traditional linear controller design</td>
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<td></td>
<td>• Produces better control and robust performances than AMFC and existing industrial ADD-PI &amp; GSA-DMC schemes due to nonlinear interpolation of linear DMC controller outputs using T-S FIS</td>
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<td>• Produces ameliorated control signal compared to ADD-PI and AMFC schemes</td>
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<td></td>
<td>• Reliable for a broad class of process applications</td>
</tr>
<tr>
<td></td>
<td>• Minimise the interaction effect and also produces better closed loop specifications for each loop independently in each pair of linearised operating regimes better than ADD-PI &amp; AMFC schemes</td>
</tr>
<tr>
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<td>• difficult to implement on processes having high degree of non linearity and interaction</td>
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The conditions in which the proposed control schemes are expected to perform better for TCTILS are listed below:

**ADD-PI control scheme**

i) The dynamic model and decoupler established for each pair of linearised regions should be accurate

ii) If noise & disturbances exist in industry fields, sufficient remedial techniques should be adopted in the preprocessing stage, to implement system identification methods to get accurate dynamic model and decoupler of the process

iii) Performs better on processes having low and medium degree of non linearity and interaction

iv) Controls TCTILS effectively until the variation of process parameter($\beta_{12}$) is upto 50% from its nominal value

**AMFC scheme**

i) Proper selection of membership functions, rules and adequate number of membership functions will provide better performance

ii) Proper tuning of scale factors, membership functions, rules and rule’s weight is highly required for the better performance

iii) Performs better on processes having low and medium degree of non linearity and interaction

iv) Controls TCTILS effectively until the variation of process parameter($\beta_{12}$) is upto 50% from its nominal value

**NDMC scheme**

i) Performs better on processes having low and medium degree of non linearity and interaction
ii) Performs better if unmodeled dynamics and nonlinearities present in the process having less effect

iii) Controls TCTILS effectively until the variation of process parameter($\beta_{12}$) is upto 50% from its nominal value

**Common conditions**

- i) Input flow range : 0 - 500 LPH
- ii) Raising input flow rate : +100 LPH /sec
- iii) Falling input flow rate : - 100 LPH /sec