CHAPTER II

LITERATURE REVIEWS

Model predictive control has been developed since year 1970. The development has been done continuously for responding to the more application requirements. In the early stage, the model is linear type but this could not solve lot of constraint problems. Later phase, the algorithm has been developed to nonlinear type so that it could be able to control the highly nonlinear process and be able to solve lot of constraint problems. Furthermore, it can increase the performance in controlling nonlinear process which has constraint. From literature review found that model predictive control give a better control than the simple linear control.

Model predictive control, Receding horizon control or Moving Horizon Control is a control system that uses process model for estimating the process response together with the optimization technique for finding proper manipulated variable in up front. The model could be either linear or nonlinear type. Objective function could be adapted with the process. As a result, model predictive control system can be well applied to any processes. The model predictive control system algorithm calculate the new proper manipulated variables from state variables in which represent the process behavior every cycle. This make the control system be able to control the process changes even though the model slightly mismatch or contain a lot of noise. More over, the control system is able to keep the process within safety limits without too many adjusting the manipulated variables.

2.1 Applications of model predictive control in chemical industry

Richalet (1976) developed Model Predictive Heuristic Control, MPHC, by IDCOM. The model is an impulse response type which is linear between input variables and internal variables. The efficiency can be controlled by adjusting future output predictive gain by reference trajectory. The model also combined constraints for control. The algorithm had been applied to control Fluid Catalytic Cracking Unit, FCCU. The application used to control the temperature of the key tray. Later, the algorithm also applied to Polyvinyl, which has lot of constraints.

Grosdidier (1987) used algorithm of Quadratic Program in stead of finding the solution by iteration. This algorithm was used in Shell company.

Cutler and Ramaker (1979) proposed the details of Dynamic Metric Control, DMC. Prett and Gillette (1979) applied DMC for a fluid catalytic reactor. The DMC model is based on linear step response. The behavior of the future output are predicted in the way of tracking set-points The proper inputs can be calculated by using least square error for finding the solution. In the research literature had applied to control the temperature of metal melting furnace. It could obviously show the better efficiency than the normal PID controller. For applying DMC to Fluid Catalytic unit the constraint optimization used linear programming, LP, technique. Later, Prett and Garcia (1988) had proposed Discreate State Space Dynamic Metric Control, DMCss.

In conclusion, the first generation of the applied industrial model predictive control is based on heuristic and dynamic metric models. Later, Shell's engineers developed dynamic metric control in form of Quadratic Program, QP, so called Quadratic Dynamic Metric Control, QDMC. With QDMC, constraints clearly appeared in the algorithm for control. The form of control was not difference from the Dynamic Metric Control only beside the calculation for proper inputs were the solution of the quadratic program in which Garcia had applied with Pyrolysis Furnace for controlling burners.

In year 1922, the state estimation had been developed and been used with control. The QDMC had applied this technique with Kalman filter for controlling temperature in a polymer reactor. Found that, the linear QDMC could not be used for non open loop stability processes.

Garcia (1982) had proposed an internal model control algorithm. Namely, the internal model control was a Single Output Single Input (SISO) or Multiple Input Multiple Output (MIMO) linear model. Basically, the internal model control was used to control units which had delay time. Later, Clark developed Model Based Predictive Control, MBPC. The well-accepted algorithm is Generalized Model Predictive, which was more robust, reduced control action calculation, could be applied to non-minimum phase process response. Example of unstable open loop process control is applying for 2 nonlinear processes which are motor control for wood polishing and pH control by nonlinear model.

Lee and Sullivan (1988) proposed Generic Model Control, GMC. Which could use nonlinear process model for generic model controller directly in order to depict the required process response. Therefore the model did not nessary required to be linearised first. For controller tuning, it could easily be done by just adjusting 2 parameters to get the required responses. Later, Cott and Macchietto (1989) had applied Lee and Sullivan's generic model for controlling exothermic batch reactor temperature together with reaction heat released estimation of Jutan and Uppal (1984). It was named exponential filter. The control results indicated good process temperature control. But this techinique was still not good enough. Later, someone proposed reaction heat estimation by Kalman filter which was used in Bonvin and Valliere (1989) and Kershenbaum and Kittisupakorn (1994)'s researches. It was found that the estimation could estimate close to the actual heat released.

The next generation, model predictive, Qin (1997) had developed using nonlinear model for control called Nonlinear Model Predictive Control, NMPC. This NMPC could be able to handle more than one objective function which is also harder to find the solution. Calculating control action could be obtained by solving online optimization and used nonlinear proces model for future output prediction.

Leblein and Perkins (1999) applid model predictive control for improving control and optimization for fluid catalytic unit of a gas separation plant which has a lot of disturbances and parameter uncertainty and effectes process optimization at its operating point such as heat transfer coefficient, catalyst quality, feed quality, market demand and etc..