CHAPTER 3
RESEARCH GAPS & OBJECTIVES

The reduction of order of the system has become a topic of interest in the past few years for the increased complexity of the systems. So, more advanced reduction techniques are developing daily to facilitate the control engineers. The purpose is to develop an approximation of reduced-order from a complex system of higher-order by employing a technique of reducing the order so that the reduced-system is obtained as highly accurate. In the starting age of model order reduction development, the technique of reducing the order by balanced truncation or internal balancing of the system was proposed, which possessed the low value of relative error. After more developments, the value of error was reduced more. With the development of more reduction techniques, the value of ISE is reduced to a much lower extent for a different types of systems. Hence, the system's accuracy improved with the invention of reduction techniques for reducing the order of the systems of a high order. Furthermore, the use of blended or hybrid approaches was presented by many academicians, in which more than one technique was applied to reduce the same system. These blended techniques reduced the ISE to a much lower value as compared to previous techniques. Later on, the system's stability was also taken as a measure of the performance of reduction methods. Thus, the use of mixed approaches kept into consideration the feature of stability along with accuracy. Also, the multivariable systems were reduced by this approach with a single variable, which made the reduction possible in real-time systems.

The clustering techniques induced in the blended approaches made the more accurate decision on the system's performance of reduced order. The value of ISE was decreased drastically with the induction of clustering. The implementation of optimisation-based techniques made the concept of MOR more effective by reducing the integral square error to a lower value. More accurate blended approaches are developing day by day to reduce the value of ISE to a lower value. The parameters justifying the system's performance are kept similar for high order and low order. The MOR technique hence employed help (i) in deriving the control law simply, (ii) in reducing the time complexity, (iii) in reducing space complexity, (iv) in minimizing the efforts of controller designing, (v) in simplifying the simulation for better understanding of the system behaviour. Some researcher has designed LFC controller by employing an order reduction technique. Still, the research is required to be extended for obtaining better results by changing either the method of controller design or the technique used for order reduction.

Based on the literature study performed in the research work, the following research gaps are obtained:

1. The techniques developed in the literature are helpful in the reduction of ISE amongst the high and reduced-order systems. To make the system of reduced-order more accurate, the value of error must be as minimum as possible. So, there is always the need for new MOR techniques, reducing the error to a much lower value.

2. Most developments in the techniques of reduction in order are seen in the blended approaches. So, a blended approach needs to be designed to have more accuracy than other approaches and increase the similarity in the performance parameters.

3. The most effective technique for reducing the order of the system is clustering. But it has a limitation that the only highly dominant poles are utilised for forming the denominator multinomial of the system of reduced-order. In contrast, the less dominant poles are truncated. So a technique including all poles in the system of reduced-order is needed.

4. It has been reported while comparing the original and reduced-order system, the performance index used is Integral square error, so other performance indices can also be used to check the system accuracy.

- Integral square error in the time domain and frequency domain
- Integral absolute error in the time domain and frequency domain
- Integral time absolute error in the time domain and frequency domain
- Peak overshoot in the time domain
- Rise time in the time domain
- Steady-state error in the time domain
- Settling time in the time domain
- Gain margin in the frequency domain

- Phase margin in the frequency domain

5. The use of MOR is not limited to the reduction of the system of higher-order. The MOR techniques can also be applied to design a suitable controller for a complex system to compensate for the parameter changes in the system. So, the MOR technique can also be used to make the design of the compensator easier.

6. The simplest and most accessible form of LFC controller is achieved by IMC based approach. So an IMC based controller is suitable to design to eliminate the effect of load variation on the frequency and power of the system.

7. The design complexity involved in the design of the controller is high because the power systems are forming large order equations. So these large equations are needed to be reduced to a lower order to reduce the large computations.

8. The 2-DOF controllers are increasing the controller's efficiency by rejecting the effect of load variations more effectively. So a 2-DOF controller is the need of time to obtain minimum variation in the frequency and load.

3.1 OBJECTIVES OF RESEARCH

Based on the literature survey and research gaps, the proposed research work is performed to obtain the following objectives:

1. To select the transfer function/state-space model of a dynamic system.
2. Using computational techniques to reduce the order of a higher system and compare it with existing techniques.
3. To check the error between the original and reduced system based on performance indices and responses.
4. Controller Design using original & reduced-order model.