The controller tracking the set point of 80 mg/decilitre level and then the meal disturbance with magnitude of 3.33g/minute is applied at 400th minute as a pulse which raises the glucose level of patient. The GA-IMC based controller rejects the meal disturbance effectively than GA-PID control. The GA-IMC regulates the glucose level within 40 minutes after having meal whereas GA-PD takes longer time to regulate the glucose level.

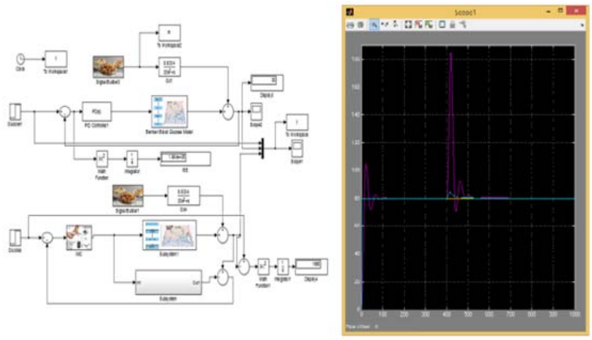

Figure 4 simulation of closed loop GA-PD, GA-IMC controller for blood glucose system

The optimised control value for minimum ISE is tabulated for GA-PD and GA-IMC in table 1,2.

Table.1 GA-PD Controller

	kp	ki	ISE
GA-PD	-0.0527	-2.37	1666

Table.2 GA-IMC controller

	λ	ISE
GA-IMC	-0.12	45810

The blood glucose level has to maintain a particular level while it increases, naturally pancreas inject the insulin to our body to maintain the glucose level whereas for type-1 diabetic patients pancreas doesn't inject the insulin so insulin pump injects the insulin The glucose sensor continuously monitoring the blood glucose level after a meal the glucose level is increases drastically it has refers to input disturbances to the process. The Process is first order with dead time process. The genetic algorithm based single loop PD controller is used for control the blood glucose system. Insulin pump there is a stepper motor it coupled with a injection needle shaft. If the glucose level increases the ID controller produces a control signal in terms of voltage to drive a stepper motor. The displacement of shaft is equivalent to injection of insulin into human body. The PD controller tuned using GA to achieve minimum ISE. The PD control signal affects the insulin system due to its oscillatory response; the time take to regulate the blood glucose is high. To overcome this complexity genetic algorithm based (GA) IMC controller is used.

In practice, the glucose level does not enter the blood stream immediately. Meals take some time to reach it into blood stream. Assume, the patient is taking 50g meal over 15 minutes. Hence 3.3g/minutes pulse is applied in simulation for 15 minutes. The glucose level increases suddenly due to the meal, and it is gradually reduced by applying insulin.

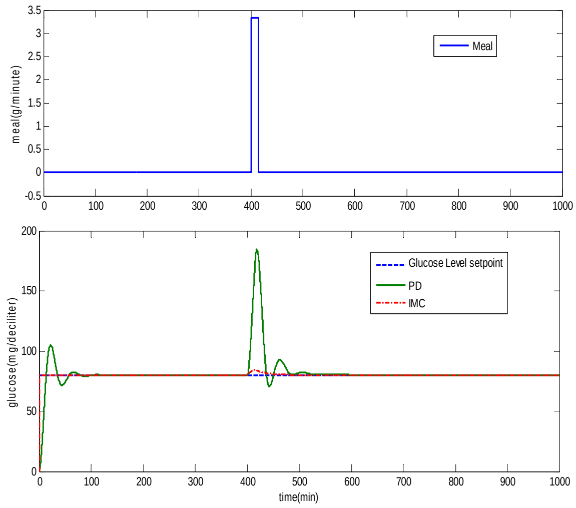

Figure 5 Comparison of GA-PD response, GA-IMC response to meal disturbance

6. Conclusion:

In this paper GA based PD controller proposed for blood glucose system The simulation part was done by taking Bergmann's minimal model as a reference model from which glucose and insulin kinetics where referred and then it is simulated. In the simulation, Glucose (meal) is taken as a disturbance which has to be controlled by infusing the insulin in blood of the patient which maintains the glucose level in blood as normal. It is inferred that GA-IMC and GA-PD controllers are compared. The superiority of GA-IMC is shown and discussed. The optimal selection of filter constant in IMC regulates the blood glucose level effectively.

There is major research effort to develop implantable glucose sensors and insulin pumps. The IMC is a model based control which requires exact model of blood glucose system, but the modelling varies patient to patient. The modelling has to be done for each patients using his glucose level data.

References:

[1]. Sawsan M. Gharghory, Mervat Mahmoud "Low power fuzzy control system for adjusting the blood glucose level " Microelectronics (ICM), 2016 28th International Conference on *IEEE*Xplore 2017

[2]. F. Chee; T. L. Fernando; A. V. Savkin; "Expert PID control system for blood glucose control in cr itically illpatients" IEEE transaction

[3]. Ilias Pagkalos, Pau Herrero, Christofer Toumazou "Bio-Inspired Glucose Control in Diabetes Based on an Analogue Implementation of a β-Cell Model" IEEE transaction

[4]. Sandhya and Deepak Kumar" Mathematical Model for Glucose-Insulin Regulatory System of Diabetes Mellitus" Advances in Applied Mathematical Biosciences. ISSN 2248-9983 Volume 2, Number 1 (2011), pp. 39-46

[5]. Ahmed Y. Ben Sasi , Mahmud A. Elmalki " A Fuzzy Controller for Blood Glucose-Insulin System" Journal of Signal and Information Processing, 2013, 4, pp no:111-117

[6]. A. Jayachitra and R. Vinodha "Genetic Algorithm Based PID Controller Tuning Approach for Continuous Stirred Tank Reactor"advances in Artificial Intelligence , Volume 2014
[7]. Bhawna Tandon, Randeep Kaur "Genetic Algorithm based parameter tuning of PID controller for composition control system" International Journal of Engineering Science and Technology (IJEST).
[8]. Jinhua Zhang , Jian Zhuang, Haifeng Du, Sun'an Wang "Self-organizing genetic algorithm based tuning of PID controllers" journal of Information Sciences Elseiverpublications Volume 179, Issue 7, 15 March 2009, Pages 1007–1018
[9]. Blood glucose control algorithms for type 1 diabetic patients:A methodological review,Katrin Lunze a, Tarunraj Singh b, Marian Walter a, Mathias D. Brendel, Steffen Leonhardt a Department of Electrical Engineering, RWTH Aachen University, Aachen 52074, Germany
[10]. A new approach to diabetic control: Fuzzy logic and insulin pump technology, Paul Grant Department of Medicine, Royal Sussex County Hospital, Eastern Road, Brighton, East Sussex, and United Kingdom.
[11]. B. Wayne Bequette "Process Control: Modeling, Design and Simulation (Prentice-Hall International Series in the Physical and Chemical Engineering Sciences)"