Case Study on Cycle Time Optimization by using Motion Simulation

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Abstract - *The success Since the 1980s, when computer-aided engineering (CAE) methods first became available in design engineering, finite element analysis (FEA) became the first widely adopted simulation tool. Over the years, it has helped design engineers study the structural performance of new products, and replace many time-consuming, costly prototypes with inexpensive computer simulations run on CAD models. Today, because of the growing complexity of mechanical products and increasingly fierce competition to bring new designs to market faster, engineers feel mounting pressure to extend the scope of simulation beyond FEA. Along with simulating structural performance with FEA, engineers also need to determine the kinematics and dynamics of new products before the building of physical prototypes. Since the early days of CAD, engineers have been able to use software to transform their ideas from sketches and calculations on paper into virtual models to assist with assembly work, as well as for exporting files for manufacturing, later this 3D CAD data to be utilized for different segments to reduce the prototype. Pick and place automation speeds up the process of picking up parts or items and placing them in other locations. Automating this process helps to increase production rates, here we are using motion simulation to ensure optimum usages of time to achieve productive benefits by adding simultaneous motion virtually and similar can be implemented in manufacturing processes.*

Key Words: CAE, FEA, CAD, Simulation, Pick and Place .

1. INTRODUCTION

In current scenario determining design parameters that lead to the best performance of a mechanical structure, device, or system is very crucial to optimize the machine performance it is essential for core of engineering design, or the systematic approach to design so utilization of the time and motion technique applied various industrial machine to achieve optimum performance and achieve maximum productivity within stipulated time. Through this philosophy, companies started classifying operations as value-added or non-value-added, always looking for process optimization. This article is dedicated to the application of a time and motion study, by means of the present study is composed of introduction, theoretical foundation, methodology, case study and final considerations. Emphasizing the demonstration of the case study results after the application of the time and motion study. According to the principles of lean manufacturing, there are three types of work that can be identified in production or service provision processes. Value-added, Non-value-added, and waste.

According to Mayer et al. (2015, p. 180), the work can be divided into work that adds value and work that does not add value. It should also be considered that work that does not add value can be necessary, due to the characteristics of the machines and processes. A large number of mechanical components, controls, computers and communication subsystems are found interconnected in a complex system this system will provide simultaneous operations to optimize the performance. Motion simulation provides complete, quantitative information about the kinematics including position, velocity, and acceleration, and the dynamics including joint reactions, inertial forces, and power requirements, of all the components of a moving mechanism. Motion studies can be time-based or event-based. Time-based motion studies describe the response to time-based changes in motion elements on the assembly motion. Event-based motion studies are defined with a set of motion actions resulting from triggering events.

Finite Element Analysis (FEA) is a complex numerical method used to solve complicated problems which contain a number of variable inputs such as boundary conditions, applied loads and support types.

In mechanical engineering, FEA is widely used for solving structural, vibration, and thermal problems. FEA is not the only tool available for numerical analysis.

The area of design optimization is where the performance of a design can be made drastically better than an initial naive implementation. Before discussing details of how to make the designs optimal from available various alternatives, this will also help designers to think proactively on various alternative solutions for optimize design.

2. Literature review

SK Qing ZHENG and Zhiqiang GAO discussed the particular motion control problem; the question investigated in this paper is how to select the most appropriate control law and its parameters. For the purpose of both performance optimization and ensuring the fairness of the controller comparison and selection, the parameters of each controller are optimized in the comparison study using They also discussed an interesting characteristic of motion control is the use of motion profile. How it gets there is also relevant. The velocity, acceleration and jerk (differentiation of the acceleration) all play important roles in a motion application and their desired trajectories are known as motion profiles. In this paper, a profile generator is used to produce a position control, a profile v(t), and the velocity profile v(t) from the desired set-point of one revolution.

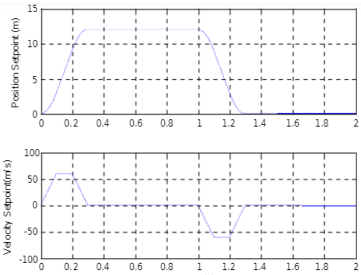


Fig 1: Position and velocity profiles.

For simplicity, the industry standard trapezoid velocity profile, shown in Figure 2.1, is use

The proposed optimization method is demonstrated in a motion control design case study, where the results convincingly show that the controller, based on the active disturbance rejection concept. In this paper, a conventional PID controller as well as its variations, and two alternative control algorithms are applied to address a class of motion control problems. Dean H. Ambrose has discussed about n approach for representing and analysing random motions and hazardous events in a simulated three-dimensional workplace. Technical data in this paper is based upon a project striving to reduce workers' risks from being hit by underground mining machinery in a confined space. Preliminary results show that response time significantly affects the number of collisions experienced by the virtual subject.

Noraishah Mohamad Noor, et.al. Has discussed this study described the implementation of Lean Production System (LPS) for process optimization in Automotive Manufacturing Industries. Objective of this study is to determine the process optimization at the Parking the purpose of this study is to eliminate waste that involve during the Parking Brake Assembly line running. To ensure the objective that been targeted is achieved, several analyses have been conduct by using specified method to overcome the problem and come out with the process optimization. Method that been use during the analysis calculates the Parking Brake Assembly time (take time and cycle time). Then identify waste of each operator based on the calculation result followed by the calculation of the required workstation for the process optimization. All the analysis that been conduct completely has result the identification of Parking Brake Assembly line process optimization. It is concluded that various motion simulation techniques are helpful for achieving productivity benefits with minimizing the competitiveness of the market develops a continuous search for improvement on processes, products and services in all organizations.

3. Experimental

Motion simulation is a hybrid field generally studying the control of mechanisms and machinery using electro-mechanical devices. It is somewhat unique in the way it combines many aspects of various kinds of engineering; mechanics and electronics, and with recent technological advances it also transcends into the related disciplines of control systems and all the computer hardware and software engineering that is associated. When analyzing complex machinery that is highly dependent on timing such as what is often part of an automated assembly line, this Motion Analysis feature can be extremely useful and powerful. Create a parametric model with assembly, define a set of tasks these tasks can be sequential or can overlap in time each task is defined by a triggering event and its associated task action task actions control or define motion during the task. Create a Gantt chart for sequence of operation and define the optimum sequence and eliminate the non-value added activities and schedule the sequence of operation with optimum result with simplified simultaneous operations.

Design Study functionality further by automatically running various combinations of multiple variables (if desired) in order to find the optimal configuration of Parameters which fit within desired Constraints and at the same time achieve the requested Goal (often simply to minimize mass). The distinction between a non-optimization Design Study and an Optimization Design Study is simply activation of the “Optimization” checkbox and definition of an associated goal(s). By default, when there are redundancies present, the Motion solver will attempt to remove redundant constraints automatically since otherwise it cannot solve the set of equations of Motion. With more complex mechanisms, this often does not work out very well and important constraints may get deleted leading to bodies separating or solver lockup. There may also be cases where the study solves but reaction forces seem incorrect. This is also often the result of redundant constraints being deleted automatically. This can be more simplified by taking example of pick and place machine.

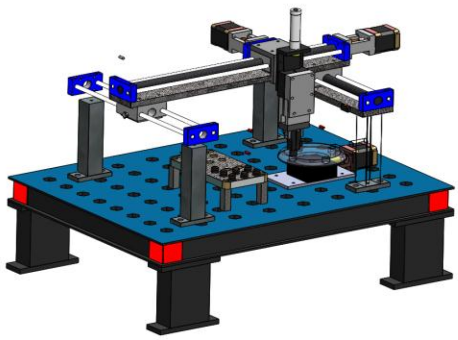


Fig 2: Pick and Place Final Machine.

Table -1: Variable value change during sequence of operation

Task Name	Description	Value	Duration	Profile	Start	End
Turn Motors On					0s	0s
Move Negative X	Move towards WB in X	108.5mm	1s	Linear	0s	1s
Move Positive Z	Move towards WB in Z	90mm	1s	Linear	0s	1s
Move Negative Y to WB	Move towards WP	55mm	1s	Linear	1s	2s
Close Gripper Arms	Grab the Work piece	-5.5mm	1s	Linear	2s	3s
Move Negative Y away from WB	Move away from WB	-30mm	1s	Cycloidal	3s	4s
Move Positive X	Move towards Rotary Table in X	-122.5mm	2s	Cycloidal	4s	6s
Move Ne9gative Z	Move towards Rotary Table in Z	-17.5mm	2s	Cycloidal	4s	6s
Move Negative Y to Table	Move towards Rotary Table in Y	33mm	1s	Linear	6s	7s
Open Gripper Arms	Release the Work piece onto Table	5.5mm	1s	Linear	7s	8s
Move Positive Y from Table	Move back to Intermediate Y position	-33mm	1s	Linear	8s	9s
Index Rotary Table	Rotate table by 0 degrees to vacant slot	90.00deg	1s	Linear	9s	10s
Reset Y	Move back to Initial Y position	-58mm	1s	Linear	10s	11s
Reset X	Move back to Initial X position	14mm	1s	Linear	11s	12s
Reset Z	Move back to Initial Z position	-72.5mm	1s	Linear	12s	13s
End Motion	Complete 1st Cycle				13s	14s

Table -2: Trigger for Sequence of operations with process status

Task Name	Description	Trigger	Condition
Turn Motors On		Time	
Move Negative X	Move towards WB in X	Time	
Move Positive Z	Move towards WB in Z	Time	
Move Negative Y to WB	Move towards WP	Move Positive Z	Task End
Close Gripper Arms	Grab the Work piece	Move Negative Y to WB	Task End
Move Negative Y away from WB	Move away from WB	Close Gripper Arms	Task End
Move Positive X	Move towards Rotary Table in X	Move Negative Y away from WB	Task End
Move Negative Z	Move towards Rotary Table in Z	Move Negative Y away from WB	Task End
Move Negative Y to Table	Move towards Rotary Table in Y	Move Positive X	Task End
Open Gripper Arms	Release the Work piece onto Table	Move Negative Y to Table	Task End
Move Positive Y from Table	Move back to Intermediate Y position	Open Gripper Arms	Task End
Index Rotary Table	Rotate table by 0 degrees to vacant slot	Move Positive Y from Table	Task End
Reset Y	Move back to Initial Y position	Index Rotary Table	Task End
Reset X	Move back to Initial X position	Index Rotary Table	Task End
Reset Z	Move back to Initial Z position	Index Rotary Table	Task End
End Motion	Complete 1st Cycle	Reset Z	Task End

SMULATION SCREEN WITH GANN CHART

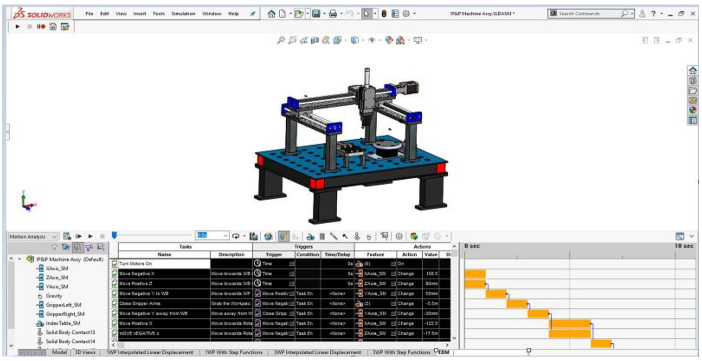


Fig 3: Simulation study

4. Results and discussion

Table -3: **Variable value change during sequence of operation**

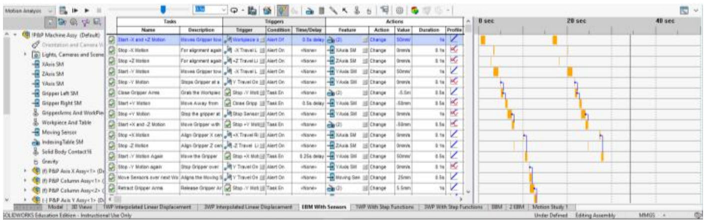
					Time	
Tasks Name	Description	Value	Duration	Profile	Start	End
Start -X and +Z Motion	Moves Gripper towards Workbench	50mm/s	1	Linear	0	1
Stop -X Motion	For alignment against work piece centre	0mm/s	0.1	Cycloidal	1	1.1
Stop +Z Motion	For alignment against work piece centre	0mm/s	0.1	Cycloidal	1.1	1.2
Start -Y Motion	Moves Gripper towards Workbench Object	50mm/s	1	Linear	1.2	2.2
Stop -Y Motion	Stops Gripper at a certain distance from workbench	0mm/s	0.1	Cycloidal	2.2	2.3

Close Gripper Arms	Grab the Workpiece	-5.5mm	0.5	Linear	2.3	2.8
Start +Y Motion	Move Away from Workbench after Grippers grab work piece	-50m m/s	0.5	Cycloidal	2.8	3.3
Stop +Y Motion	Stop the gripper at a certain distance away from workbench	0mm /s	1	Cycloidal	3.3	4.3
Start +X and -Z Motion	Move Gripper with work piece towards Rotary Table	-50m m/s	0.5	Constant Acceleration	4.3	4.8
Stop +X Motion	Align Gripper X centre over centre of hole on rotary table	0mm /s	0.1	Linear	4.8	4.9
Stop -Z Motion	Align Gripper Z centre over centre of hole on rotary table	0mm /s	0.1	Linear	4.9	5
Start -Y Motion Again	Move the Gripper with Workpiece towards Rotary Table	50m m/s	0.5	Linear	5	5.5
Stop -Y Motion again	Stop Gripper over Rotary Table	0mm /s	0.1	Cycloidal	5.5	5.6
Move Sensors over next Workpiece	Aligns the Moving Sensors over the next Workpiece on the bench	25mm	0.5	Linear	5.6	6.1
Retract Gripper Arms	Release Gripper Arms	5.5mm	1	Linear	6.1	7.1
Start +Y Motion for Reset	Move Gripper back to Start Position	-50m m/s	0.5	Linear	7.1	7.6
Start -Z Motion for Reset	Move Gripper back to Start Position	-50m m/s	0.5	Linear	7.6	8.1
Stop +Y and -Z at Reset Position	Reset Position Reached	0mm /s	0.15	Linear	8.1	8.25
Index Table by 90 degrees	Rotate Table to Next Vacant position	90.00 deg	1	Cycloidal	8.25	9.25

Table -5: Trigger for Sequence of operations with process status

Tasks Name	**Description**	**Trigger**	**Condition**
Start -X and +Z Motion	Moves Gripper towards Workbench	Work piece on Table Sensor	Alert Off
Stop -X Motion	For alignment againrst wok piece centre	-X Travel Left Limit Sensor	Alert On
Stop +Z Motion	For alignment against work piece centre		Alert On
Start -Y Motion	Moves Gripper towards Workbench Object	-X Travel Left Limit Sensor	Alert On
Stop -Y Motion	Stops Gripper at a certain distance from workbench	Y Travel On Bench Limit Sensor	Alert On
Close Gripper Arms	Grab the Work piece	Stop -Y Motion	Task End
Start +Y Motion	Move Away from Workbench after Grippers grab work piece	Close Gripper Arms	Task End
Stop +Y Motion	Stop the gripper at a certain distance away from workbench	Stop Sensor after Lifting Work piece	Alert On
Start +X and -Z Motion	Move Gripper with work piece towards Rotary Table	Stop +Y Motion	Task End
Stop +X Motion	Align Gripper X centre over centre of hole on rotary table		Alert On
Stop -Z Motion	Align Gripper Z centre over centre of hole on rotary table		Alert On
Start -Y Motion Again	Move the Gripper with Workpiece towards Rotary Table	Stop +X Motion	Task End
Stop -Y Motion again	Stop Gripper over Rotary Table	Y Travel On Table Limit Sensor	Alert On
Move Sensors over next Workpiece	Aligns the Moving Sensors over the next Workpiece on the bench	Y Travel On Table Limit Sensor	Alert On
Retract Gripper Arms	Release Gripper Arms	Stop -Y Motion again	Task End
Start +Y Motion for Reset	Move Gripper back to Start Position	Retract Gripper Arms	Task End
Start -Z Motion for Reset	Move Gripper back to Start Position	Retract Gripper Arms	Task End
Stop +Y and -Z at Reset Position	Reset Position Reached	Reset Position Sensor	Alert On
Index Table by 90 degrees	Rotate Table to Next Vacant position	Reset Position Sensor	Alert On

SIMULATION SCREEN WITH GANN CHART



5. CONCLUSIONS

This project work gives an idea about use of virtual simulation help us to change the sequence of operation which helps to reduce the cycle time require to complete the entire process. This will also helpful for designers to decide the sizing parameter for various motors and actuators, which helps to achieve the desired changes in design to achieve the end customer target. The following conclusions can be drawn from this research regarding the motion simulation.

Table -6: Comparison of result

Sr. No	Study	Initial	Final	Remark
1	No of operation	16	19	Sensor Added For Final which required start and stop
2	Time Required	14 sec	9.25 sec	Time Saved 4.75 sec
3	Trigger Process	Land Mark	Sensor	Automatic

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