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Improving Dc Motor Speed Control In A Watercanning Industry For An Increased Output Using Particle Swarmp Optimization (Pso)

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Abstract:

The reduction in the production capacity of water canning industry, has led to reduction in the financial growth of the industry. This reduction in the speed of dc motor that caused reduction in the production capacity of water canning bottle is overcome by introducing improving dc motor speed control in a water canning industry for an increased output using particle swarm optimization (PSO). Is done in this manner, characterizing the speed of a dc motor and its production output in a canning industry, simulating and validating and justifying the percentage of improvement of the production capacity in water canning industry conventionally and when PSO is incorporated. The DC Motor system is configured by MATLAB SIMULINK platform R2012a to be find which Method or algorithm will be used with the conventional controller the Proportional Derivative (PD) controller that will be improve this system like Particle Swarm Optimization (PSO) Algorithm has been utilized to improve from The performance of the Designed system. This proposed optimization methods could be applied for higher order system also to provide better system performance with minimum errors. The results obtained are highest conventional dc motor speed in a water Canning industry is 1500 rev/s while when PSO is incorporated in the system is1502 rev/s. With these results obtained an improvement in the motor speed when PSO is incorporated in the system is 2rev/s. The highest conventional crate of bottled water produced is 3132crates while that when PSO is introduced in the system is 3136crates of bottled water. With these results obtained the percentage improvement in the number of crates of bottled water when PSO is imbibed in the system is 0.13%. In our system design, we used Particle Swarm Optimization (PSO) Algorithm because we want to design a DC Motor system by use the algorithm of Particle Swarm Optimization to test the angular speed and also the error to improve which one of them is the best, the designed system to improve it by increasing the angular speed and reduce the error this will improve the efficient of it with 70%.

.Keywords **— DC Motor, Particle Swarm Optimization (PSO), Optimal Solution,**

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I. INTRODUCTION

Motors turn because of the interaction between two magnetic fields. This unit will discuss how these magnetic fields are produced in dc motors, and how magnetic fields induce voltage in dc generators. The basic principle of a dc motor is the creation of a rotating magnet inside the mobile part of the motor, the rotor. This is accomplished by a device called the commutator which is found on all dc machines. The commutator produces the alternating currents necessary for the creation of the rotating magnet from dc power provided by an external source. This figure shows that the electrical contact between the segments of the commutator and the external dc source is made through brushes. DC motor drives are widely used in applications requiring adjustable speed, good speed regulations and frequent starting, braking and reversing. Some important applications are rolling mills, paper mills, mine winders, hoists, machine tools, traction, printing presses, textile mills, excavators and cranes. Fractional horsepower DC motors are widely used as servo motors for positioning and tracking. Although, it is being predicted that AC drives will replace DC drives, however, even today the variable speed applications are dominated by DC drives because of lower cost, reliability and simple control. As per the control of DC motor, there are lot of methods to control the speed and position of the motor. The purpose of a motor speed controller is to take a signal representing the demanded speed and to drive a motor at that speed.

Particle Swarm Optimization (PSO) is firstly proposed by Eberhart and Colleagues. This optimization technique has been established to be robust in solving non-linearity and non-differentiability problems featuring, which is derived from the social-psychological theory. Research on swarm such as bird flocking and fish schooling derived the PSO technique. The population dynamics simulates a “bird flocks” behavior, where social sharing of information takes place and individuals can profit from the discoveries and previous experience of all the other companions during search for food instead of using evolutionary operators in the PSO algorithm such as mutation and crossover to manipulate algorithms.

DC Motor theory

The DC motor has two basic parts: the rotating part that is called the armature and the stationary part that includes coils of wire called the field coils. The stationary part is also called the stator. The armature is made of coils of wire wrapped around the core, and the core has a extended shaft that rotates on bearings. You should also notice that the ends of each coil of wire on the armature are terminated at one end of the armature. The termination points are called the commutator, and this is where the brushes make electrical contact to bring electrical current from the stationary part to the rotating part of the machine. The coils that are mounted inside the stator are called field coils and they may be connected in series or parallel with each other to create changes of torque in the motor. You will find the size of wire in these coils and the number of turns of wire in the coil will depend on the effect that is trying to be achieved. PSO was proposed to determine for the optimal poles for state feedback control to satisfy steady state and transient response specifications. In this research the state feedback controller was designed to control the speed and position for DC motor assuming all state are measurable, the PSO technique is used for evaluating the controller gains.

II. MATERIALS AND METHOD

Material: Materials used includes: MATLAB SIMULINK platform, Particle Swarm Optimization (PSO) Algorithm and Shunt Dc Motor.

In shunt DC motors the field is connected in parallel (shunt) with the armature windings. These motors offer great speed regulation due to the fact that the shunt field can be excited separately from the armature windings, which also offers simplified reversing controls. In shunt DC motors the field is connected in parallel (shunt) with the armature windings. These motors offer great speed regulation due to the fact that the shunt field can be excited separately from the armature windings, which also offers simplified reversing controls.

The two core components of any DC motor are a **stator** and an **armature**, or **rotor**. There can also be other components that perform critical functions. Thus, a brushed DC motor comprises the following units:

i. a stator with windings or permanent magnets;
ii. an armature, or rotor with windings;

Design Method: The methodology adopted in the optimization aims at the creation of a general purpose environment for modeling and optimizing industrial processes by exploiting the generality of the Unified Modeling Language (UML), the standard object-oriented system design language. One of the most interesting features of Unified Modeling Language is that its definition includes standard methods to define domain specific modeling dialects, so-called profiles in order to assure a proper fitting to the particularities of the field of the designated applications. Several such profiles were already defined and/or initiated by the Object Modeling Group (OMG). Despite the openness of Unified Modeling Language the use of standard profiles assures the additional benefit of using modeling and analysis tools.

Accordingly, in our research one of the most important guideline was the use of standard modeling paradigms and analysis tools to the greatest extent possible.

This restriction in the set of modeling and mathematical constructs allowed for the reuse of already existing tools and standard model exchange formats, on the other hand, modeling of complex processes, like an industrial manufacturing workflow requires a combination of different profiles. The model of such a system has to define both the qualitative and quantitative characteristics of all the major elements of this production process (resources, products, manufacturing sequences, orders, and the objective function of the optimization).

Specifically, Unified Modeling Language modeling of production processes requires

- a qualitative model of the manufacturing sequence (the logic of the production);
- a quantitative model of this process, defining the numerical attributes, like the production rates and yield factors of the individual machines, capacity
- Constraints at the storage locations, number of identical resources in the case of resource farms etc.
- similarly, qualitative and quantitative models of the resources, products and orders;
- the definition of the structure, factors and parameters of the objective function of the optimization within a single, concise UML framework.

a) To develop mathematical modeling for Automation industrial process.

This sub system accepts the initial value for the iterations. Then the system generates the optimal solution for the industrial process using linear method. The optimization system made use of Product mix problems for manufacturing industries using Innoson Technical and Industrial Company Limited as the source of our raw data. The data collected from the company on the raw materials needed to produce a particular product and the process is as follows.

- 750 tons or 730tons of raw materials is required per month
- 20 injection molding machines are installed in the factory
- 3 shift per day

- Each shift produces not less than 400 products per machine
- #500 or #400 million profit per month

The factor that affects the optimization of the product production includes:

- X1 - Availability of raw material
- X2 – Steady power supply
- X3– functionality of the machines
- X4 – Human factor; i.e work force

Maximize Z = 2x1 + 6x2 + 4x3
S.T 2x + 5x2 + 2x3 <= 38
4x1 + 2x2 + 3x3 <= 57
x1 + 3x2 + 5x3 <= 57
x1, x2, x3 >= 0

b) To characterize the speed of dc motor and its production output in a water canning industry.

The load for a DC motor is based on its armature current. If rated current of an motor is 16 A. Then half load means at which the armature current is half its rated value which is 8 A Similarly Quarter load is 4A and three fourth loads is 12 A.

The speed rating of a DC generator is the rated speed at which the machine should be operated which is specified in revolutions per minute (R.P.M or r/min). The machine is required to be operated at a rated speed in order to deliver the rated power at the rated voltage.

DC controls adjust speed by varying the voltage sent to the motor (this differs from AC motor controls which adjust the line frequency to the motor). Typical no load or synchronous speeds for an AC fractional horsepower motor are 1800 or 3600 rpm and 1000-5000 rpm for DC fractional hp motors.

Table 1: The collected parametric data is as shown below

S/N	VOLTAGE(Volts)	SPEED (rev/m)
1	0.90	32.77
2	5	182
3	10	364.1
4	15	546.1
5	20	728.1
6	25	910.2
7	30	1092
8	35	1274
9	40	1456
10	41.2	1500

c) Model of DC motor

DC machines are system with combinations of shunt-, series-, and separately-excited field windings which display the speed-torque for both dynamic and steady-state operation.

The mathematical model can be derived from a schematic diagram of a DC servomotor system.

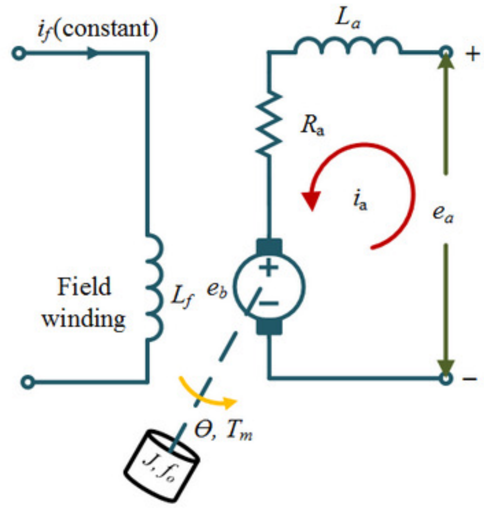

Figure 1: Schematic diagram of a DC servomotor system.

Analyzing the circuit to get the mathematical model, the following equations are generated.

$$V_0 = R_{a1} I_{a1} + L_{a1} \frac{dIa1}{dt} + e_0 \quad (1)$$

$$e_0 = U_e W_{m-1} \quad (2)$$

$$T_{m-1} = K_{i-1} I_{a-1} \quad (3)$$

$$J_{m-1} = I_{m-1} W_{m-1} + C w_{m-1} + T_n \quad (4)$$

Where

R_{a1} is equivalent motor resistance
L_{a1} is equivalent motor inductance
V_0 is applied voltage
$e_0$is Motor back emf
K_{i-1} is motor torque constant
I_{a1} is the armature constant
Ue is motor voltage constant
J_{m-1} is Torque generated by the motor
W_{m-1} is the motor speed
$T_n$is the load torque

Motor torque, T is related to the armature current I by a constant factor ki

$$T = K_i \quad (5)$$

The back electromotive force (emf), Vb is related to the angular velocity by

$$V_b = K_w = K\frac{d^{\theta}}{dt} \quad (6)$$

$$J\frac{d2\emptyset}{dt2} + b\frac{d\emptyset}{dt} = K_i \quad (7)$$

$$L\frac{di}{dt} + R_i = V - K\frac{d\emptyset}{dt} \quad (8)$$

Applying Laplace transform to equation (7) and (8) result in equation (9) and (10) below

$$Js^2\emptyset(s) + bs\emptyset(s) = KI(s) \quad (9)$$

$$LsI(s) + RI(s) = V(s) - Ks\,\emptyset(s) \quad (10)$$

Where s denotes the Laplace operator From equation (11)

$$I_{(s)} = \frac{V(s) - k\,s\,\emptyset\,s}{R + L\,s} \quad (11)$$

Then substituting this in equation (9) result in

$$Js^2 + bs\emptyset b_s = K\frac{Vs - Ks\emptyset\,(s)}{R + Ls} \quad (12)$$

Expanding and re- arranging of equation 12 yields the transfer function from input voltage, V(s) to the output angle $\emptyset inequation$ 14 $below$

$$Ga\,(s) = \frac{\emptyset(s)}{dx} = \frac{1}{s[(R+Ls)(Js+b) + K^2} \quad (13)$$

$$\text{Since } Wn = \emptyset \quad (14)$$

$$\text{Also } w(s) = s\emptyset(s) \quad (15)$$

Substituting $\emptyset$ (s) in equation (14) yields the transfer function of input voltage, V(s) to the output angular velocity, w as

$$G\,(s) = \frac{W(s)}{V(s)} = \frac{k}{(R+Ls)(Js+b) + K^2} \quad (16)$$

c) Optimization Model

The optimization model developed in this research work starts with the design of the objective function. The objective function design helps in optimizing the production output and also model to fuzzy logic controller from the optimized analysis result. The objective function is design to increase production output of the breweries. After the proper design of the objective function, the optimization algorithm starts by an arbitrary point from the objective and proceeds in a stepwise form towards the maxima or minima of the designated objective function by successive improvements. The simplex algorithm stops when the step towards the maxima or minima is smaller than a preset tolerance value determined from the data collected. The analysis was performed using **MATLAB** Optimization Program. This solution gives increase in production cost after analysis the data collected from Coca-Cola industry.

Maximize
P = 41.2v + 1500s + 44.7t ----------------------1
Subject to
41.2v + 1500s + 44.7t <= 3132--------------------2
41.2v + 1500s + 2t <= 140-------------------------3
41.2v + 1500s + t <= 70----------------------------4
Where
P is the total production output
V is the motor voltage
S is the speed of the motor
t is time taken for the production
To optimize the characterized speed of dc motor and its production process and the mathematical model for optimizing dc motor speed control in an industrial machine for an increased output becomes.

Maximize
P = 41.2v + 1500s + 44.7t ----------------------1
Subject to
41.2v + 1500s + 44.7t <= 3132--------------------2
41.2v + 1500s + 2t <= 140-------------------------3
41.2v + 1500s + t <= 70----------------------------4

Where
P is the total production output
V is the motor voltage
S is the speed of the motor
T is time taken for the production
Then, solving equations 1, 2, 3 and 4 using Matlab code

```
% Maximize p= 41.2v + 1500s +   44.7t   ---------------------------1
% Subject to 41.2v + 1500s + 44.7t <= 3132--------------------------2
%            41.2v + 1500s + 2t <= 140-------------------------------3
%            41.2v + 1500s + t <= 70---------------------------------4
        f=[-41.2;-1500; 44.7];
        A=[41.2 1500 44.7;41.2 1500 2;41.2 1500 1];
        b=[3132;149;70];
        Aeq=[0 0 0];
        beq=[0];
        LB=[0 0 0];
        UB=[inf inf inf];
        [X,FVAL,EXITFLAG]=linprog(f,A,b,Aeq,beq,LB,UB)
```

```
% Maximize p= 41.2v + 1500s +   44.7t   ---------------------------1
% Subject to 41.2v + 1500s + 44.7t <= 3132--------------------------2
%            41.2v + 1500s + 2t <= 140-------------------------------3
%            41.2v + 1500s + t <= 70---------------------------------4
        f=[-41.2;-1500; 44.7];
        A=[41.2 1500 44.7;41.2 1500 2;41.2 1500 1];
        b=[3132;149;70];
        Aeq=[0 0 0];
        beq=[0];
        LB=[0 0 0];
        UB=[inf inf inf];
        [X,FVAL,EXITFLAG]=linprog(f,A,b,Aeq,beq,LB,UB)
Optimization terminated.
X =
    0.0576
    0.0451
    0.0000
FVAL =
  -70.0000
EXITFLAG =
    1
```

Figure 2: MAT Lab the result of the optimized voltage of the motor

The result of the optimized voltage is 0.0576V. Then, the result of the optimized voltage of the motor 41.2 + 0.0576 =41.2576v
To design a conventional SIMULINK model for improve dc motor speed control in a water canning industry for an increased output

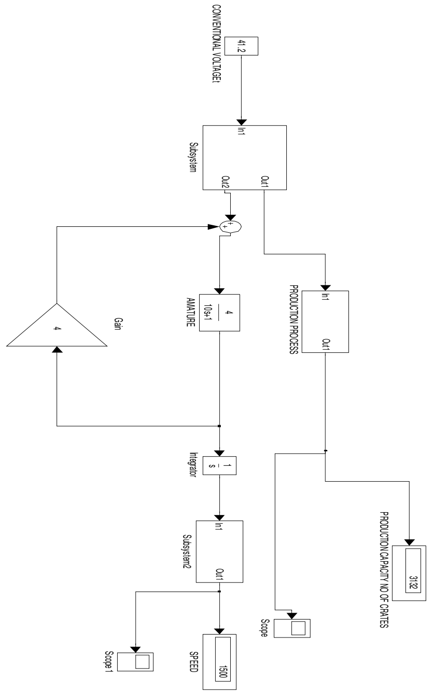

Figure 3: Designed conventional SIMULINK model for improve dc motor speed control in a water canning industry for an increased output.

III. RESULTS AND DISCUSSIONS

The results of the controllers are *compared* to each *other* and to the one with no control *in* order to clarify the features of the presented controllers.

Table 2: Comparing conventional and PSO dc motor speed in a water canning industry for an increased output

Time(s)	**Conventional dc motor speed in a water canning industry for an increased output.**	**PSO dc motor speed in a water canning industry for an increased output.**
0	0	0
1	0	0
2	0	0
3	0	0
4	0	0
5	0	0
6	0	0
7	100	110
8	200	220
9	500	530
10	1500	1502

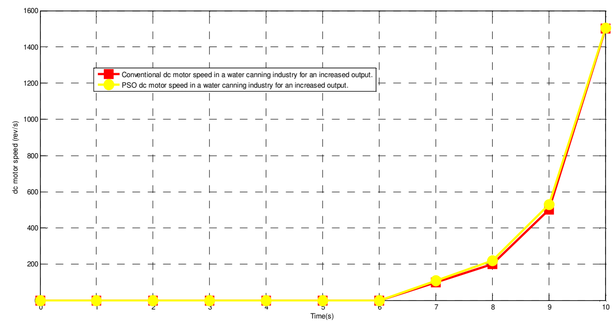

Figure 4 Comparing conventional and PSO dc motor speed in a water canning industry for an increased output.

Figure 4 shows comparing conventional and PSO dc motor speed in a water canning industry for an increased output. In figure.1 the highest conventional dc motor speed in a water canny industry is1500rev/s while that when PSO is incorporated in the system is1502rev/s. With these results obtained an improvement in the motor speed when PSO is incorporated in the system is 2rev/s.

Table 3 comparing conventional and PSO no of crate of water in improving dc motor speed control in a water canning industry for an increased output

Time(s)	Conventional no of crate of water in improving dc motor speed control in a water canning industry for an increased output(crates)	PSO no of crate of water in improving dc motor speed control in a water canning industry for an increased output(crates)
0	0	0
1	2000	2000
2	2600	2700
3	2900	3000
4	3132	3136
10	3132	3136

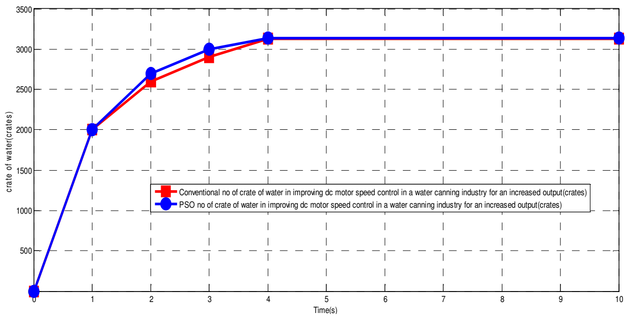

Figure 5 comparing conventional and PSO no of crate of water in improving dc motor speed control in a water canning industry for an increased output.

Figure 5 compare between conventional and PSO no of crate of water in improving dc motor speed control in a water canning industry for an increased output. In figure 5 the highest conventional crates of bottled water produced is 3132 crates while that when PSO is introduced in the system is 3136 crates of bottled water. With these results obtained the percentage improvement in the number of crates of bottled water when PSO is imbibed in the system is 0.13%.

IV. CONCLUSION

The decrease in the production capacity of water canny industry has led to decrease in the number of customers they have. This is solved by improving dc motor speed control in a water canning industry for an increased output using particle swarm optimization (PSO). To achieve this, it is done in this manner, characterizing the speed of a dc motor and its production output in a canning industry, designing a conventional SIMULINK model for improved dc motor speed control in a water canning industry for an increased output, optimizing the speed of a dc motor for an increase output in a canning industry, designing a SIMULINK model for improving dc motor speed control in a water canning industry for an increased output using particle swarm optimization (PSO), simulating and validating and justifying the percentage of improvement of the production capacity in water canning industry conventionally and when PSO is incorporated. The results obtained are highest conventional dc motor speed in a water canny industry is1500rev/s while that when PSO is incorporated in the system is1502rev/s. With these results obtained an improvement in the motor speed when PSO is incorporated in the system is 2rev/s. The highest conventional crates of bottled water produced is3132crates while that when PSO is introduced in the system is 3136crates of bottled water. With these results obtained the percentage improvement in the number of crates of bottled water when PSO is imbibed in the system is 0.13%.

Recommendations

In near future intelligence should be incorporated in the system to enhance the efficiency of the production capacity of bottled water industry.

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