Automation of Skip in Ready Mix Concrete Plant

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Abstract:
The wear is generating many problems in mechanical systems. By reducing it, we can increase the life of the components related to the system. In ready-mix concrete plant, the bucket hoist system is used to elevate the aggregate, cement and other such ingredients. The problem in the above system is the collision of bucket with the upper platform causing wear and tear of bucket and platform, affecting the life of system. This paper includes the design of bucket and hoist system and the main aim of presented work is to control the speed of bucket by means of DC motor, motor driver, 8051 µcontroller and PWM techniques.

Keywords: *Wear, Automation, Skip, Concrete plant, PWM*

1. Introduction

In last decades, the development of real estate and growth of infrastructure, RMC contributes 30% to 60% of total concrete used in these cities. Due to this, the technological development of Ready-Mix Concrete machinery is increased. The manual loading of aggregate, cement and additives are tedious work, another thing is that conventional machine is slow and mixes the concrete in small proportions.

RMC has helped in creating and boosting the demand for bulk cement. In fact, both are mutually complimentary and nurturing RMC would go a long way in modernizing the construction sector. Besides, both are today considered to be eco-friendly practices as they have the ability of minimizing wastage of raw materials and reducing pollution. The number of RMC plants in India, are growing rapidly and being relatively new ones having most up-to-date machinery and technology.

In latest plant, the aggregate and additives are placed in different hoppers. Now, hoppers door are opened and all the materials are drop down on the conveyor belt. This conveyor belt carries the material and allow to free fall in to the bucket known as “SKIP”. Skip is pulled by rope pulley mechanism, in which rope is wound on the drum and another end of rope is fixed with the bucket. In this drum is rotated by prime mover such as motor, gasoline engine, etc.

We observe the READY-MIX CONCRETE plant, in which bucket-hoist system is applied basically, there are two reasons causing the problem of wear:

1. Limit switches
2. Sudden stoppage of Rotor

2. Mechanical Design and Modeling of RMC Plant

Most of the components are designed and modeled as per the dimensions of the original plant.

2.1 Mechanical model

2.1.1 Main frame

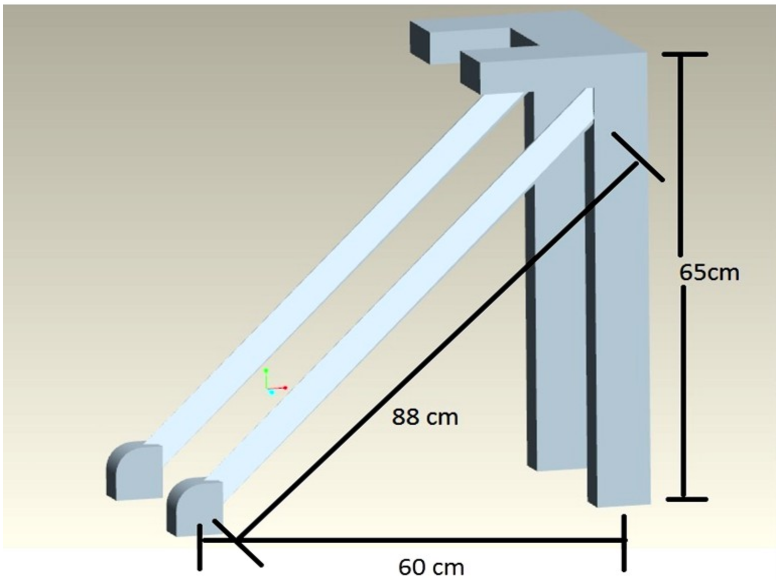

Fig. 1 3-D Model of main frame

This frame shows the rail on which bucket will travel from top to bottom and top platform on which motor and electronic circuitry is to be placed.

2.1.2 Shaft

Shaft is used for the transmission of torque and bending moment.
Shaft Dimensions: Ǿ 20mm x 150mm

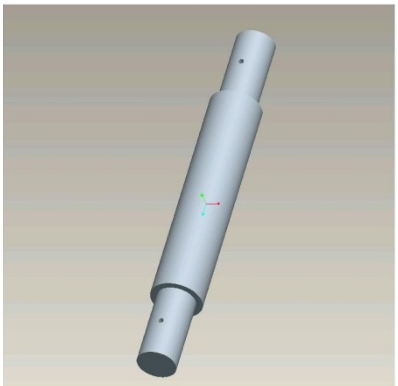

Fig. 2 Shaft

2.1.3 Bucket and wheel assembly

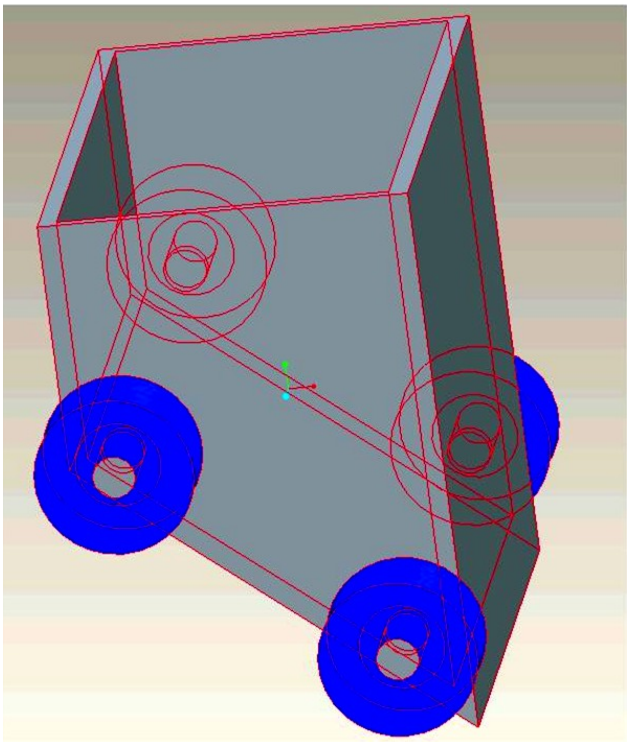

Fig. 3 Bucket and Wheel Assembly

2.1.4 Bearings
d (shaft or inner diameter) = 15 mm (0.5906")
D (outer diameter) = 35 mm (1.3780")
B (width) = 11 mm (0.4331")
r (radius) = 1 mm (0.039")

2.1.5 Rope wire design

Table 2.1

Rope Diameter		Minimum Breaking Strength	Safe Load	Weight
(in)	*(mm)*	*(N)*	*(N)*	Kg/m
1/6	4	4.89	24,4	0.00016
5/16	8	7.56	37,9	0.00024

3. Motor Interfacing Using Microcontroller 8051
3.1 DC motor
3.1.1 Technical specification of DC motor

- 300RPM 12V DC motors with Metal Gearbox and Metal Gears
- 18000 RPM base motor
- 6mm Diameter shaft with M3 thread hole
- Gearbox diameter 37 mm.

- Motor Diameter 28.5 mm
- Length 63 mm without shaft
- Shaft length 15mm
- 180gm weight
- 30kgcm torque
- No-load current = 800 mA, Load current = up to 7.5 A(Max)

3.1.2 Torque calculations for DC motor

For 7 seconds and 88cm to travel,
Acceleration, $a = 4.48 \times 10^{-4}$ m/sec^2

Here $F = \mu R_N = 0.17 \times 13.86 = 2.35$ N,
$R_N = W \times \sin\alpha = 19.61 \times \sin 45° = 13.866$ N
P_1 = Forces opposing the motion = component of weight + Inertia force + Frictional Resistance
$P_1 = m \times a + m \times g + F$
$P_1 = 167.49$ N

Torque on the drum shaft to accelerate load,
$T = P_1 \times r = 167.49 \times 20 = 209.36$ N.cm

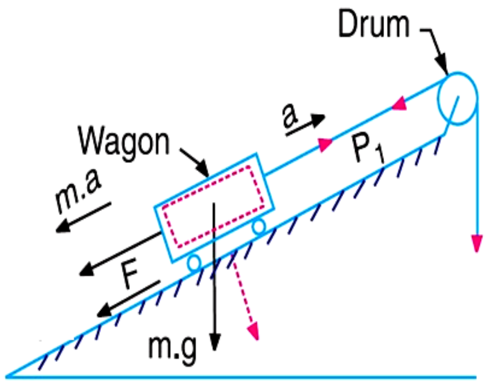

Fig. 4 Torque Calculation

3.2 Microcontroller at Mega® 89c51

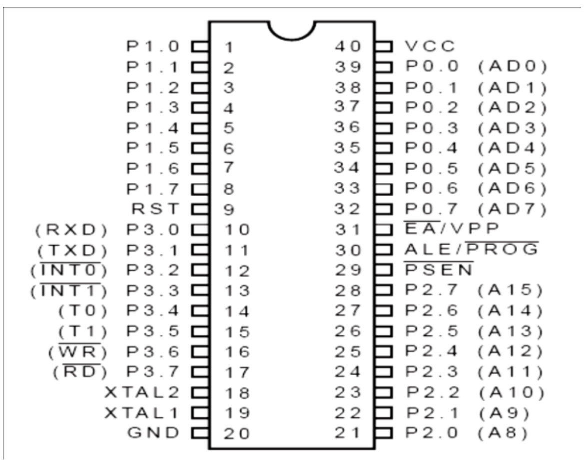

Fig. 5 Micro Controller

As we require 8-bit Controller with 40 pins, we selected AtMega 89c51 Microcontroller.

3.2.1 Pin description

VCC - Supply voltage
GND – Ground

Port 0, Port 1 and Port 2 are bi-directional I/O port, in which we used Port 0 for interfacing with Voltage Regulator (L7805) and H-Bridge Circuit (L298).

Port 3 is SFR port in which

P3.0 RXD (serial input port)

P3.1 TXD (serial output port)

P3.2 INT0 (external interrupt 0)

P3.3 INT1 (external interrupt 1)

P3.4 T0 (timer 0 external input)

P3.5 T1 (timer 1 external input)

P3.6 WR (external data memory write strobe)

P3.7 RD (external data memory read strobe

3.3 L7805IC

The L7800 series is a three terminal positive regulator available in several fixed output voltage, making it useful in wide range of application. We can get different output voltages like 5, 5.2, 6, 8, 8.5, 9, 12, 15, 18, 24V.

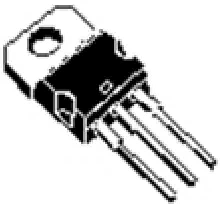

Fig. 6 L7805IC

3.3.1 Pin configuration

L7805 has three pin as shown in diagram.

Pin 1:- OUTPUT – Here the output is 5V.
Pin 2:- GROUND
Pin 3:- INPUT – Here the supply is provided of 12V.
Minimum output voltage is 4.8V.
Maximum Output Voltage is 5.2V.

3.4 H-Bridge IC (L298IC)

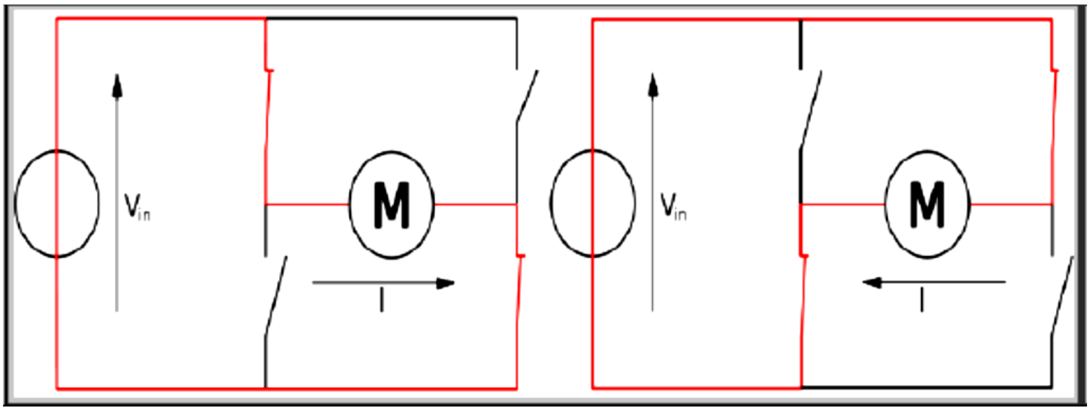

Fig. 7 Basic state of H-bridge

An H-bridge is an electronic circuit which enables a voltage to be applied across a load in either direction. These circuits are often used in robotics and other applications to allow DC motors to run forwards and backwards. H-bridges are available as integrated circuits, or can be built from discrete components.

3.4.1 L298 IC

Some basic features of the L298:
Operating supply voltage up to 46 V
Total DC current up to 4 A
Low saturation voltage
Over temperature Protection
Logical "0" input voltage up to 1.5 V
High noise immunity
Dual Full Bridge Channel

Table 2 Absolute Maximum Ratings of L298

Symbol	Parameter	Value	Unit
VS	Power Supply	50	V
VSS	Logic Supply Voltage	7	V
VI, Ven	Input and Enable Voltage	–0.3 to 7	V
IO	Peak Output Current (each Channel) – Non Repetitive (t = 100ms) –Repetitive (80% on –20% off; ton = 10ms) –DC Operation	3 2.5 2	A
Vsens	Sensing Voltage	–1 to 2.3	V
Ptot	Total Power Dissipation(Tcase = 75°C)	25	W
Top	Junction Operating Temperature	–25 to 130	°C
Tstg, Tj	Storage and Junction Temperature	–40 to 150	°C

3.5 Speed control methods in a DC motor

The motor speed can be controlled by controlling armature voltage and armature current. It is obvious that speed control is possible by varying

Flux per pole, Φ (Flux control)
Resistance Ra of armature circuit (Rheostat Control)
Applied voltage V (Voltage Control)

The above methods have some demerits like a large amount of power is wasted in the controller resistance. Hence, efficiency is decreased. It needs expensive arrangement for dissipation of heat produced in the controller resistance. It gives speeds below the normal speed.

3.5.1. PWM technique

By data obtained, we can draw a conclusion that these electric and electromechanical methods are less adaptive so electronic techniques are used for speed control. These methods provide higher efficiency, greater reliability, quick response, higher efficiency. One such technique is Pulse Width Modulation. We apply this technique in our project so as to control the speed of the DC motor.

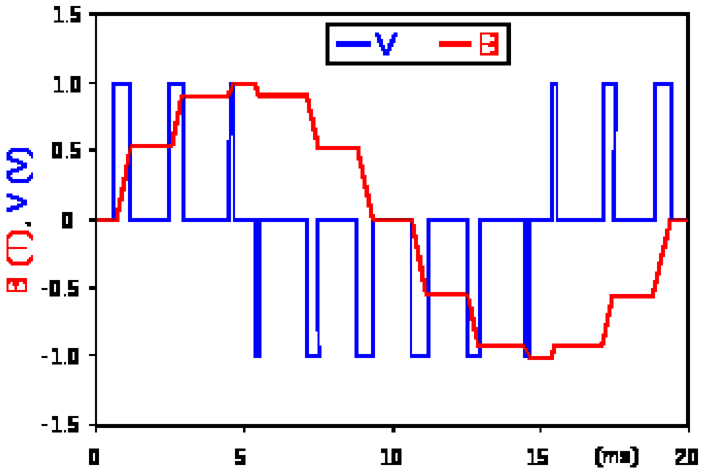

Fig. 7 PWM Technique

The average value of voltage (and current) fed to the load is controlled by turning the switch between supply and load on and off at a fast pace. The longer the switch is on compared to the off periods, the higher the power supplied to the load is. The PWM switching frequency has to be much faster than what would affect the load, which is to say the device that uses the power. Typically switching have to be done several times a minute in an electric stove, 120 Hz in a lamp dimmer, from few kilohertz (kHz) to tens of kHz for a motor drive and well into the tens or hundreds of kHz in audio amplifiers and computer power supplies. The term *duty cycle* describes the proportion of 'on' time to the regular interval or 'period' of time; a low duty cycle corresponds to low power, because the power is off for most of the time. Duty cycle is expressed in percent, 100% being fully on. In the interrupt service routine, the controller software computes new duty-cycle values for the PWM signals used to drive each of the three legs of the inverter. The computed duty cycles depend on both the measured state of the motor (torque and speed) and the desired operating state. The duty cycles are adjusted on a cycle-by-cycle basis in order to make the actual operating state of the motor follow the desired trajectory. Once the desired duty cycle values have been computed by the processor, a dedicated hardware PWM generator is needed to ensure that the PWM signals are produced over the next PWM-and-controller cycle. The PWM generation unit typically consists of an appropriate number of timers and comparators that are capable of producing very accurately timed signals.

In general, there is a small delay required between turning off one power device (say AL) and turning on the complementary power device (AH). This dead-time is required to ensure the device being turned off has sufficient time to regain its blocking capability before the other device is turned on.

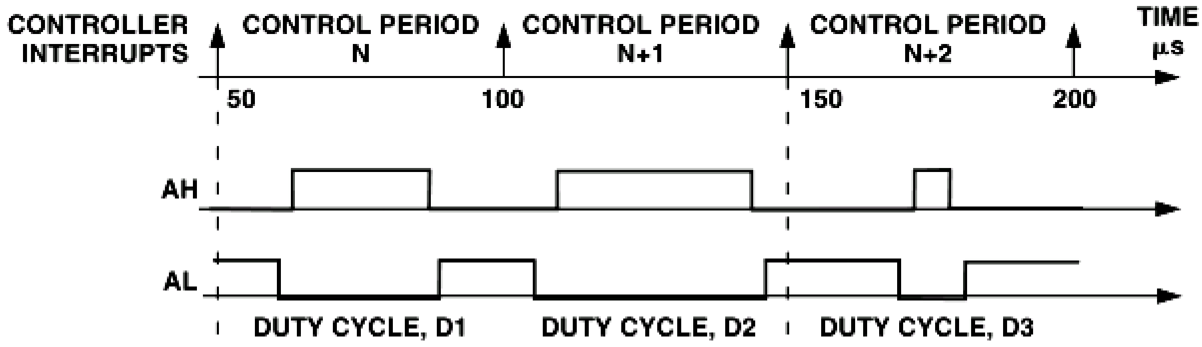

Fig. 8 Typical PWM waveforms

6. Conclusion

The bucket is to be carried from datum point to the top most platform. The prime mover is required to run the shaft on which wire is to be wounded, on the other end of the wire bucket is attached to it. We selected the DC motor as prime mover, which coupled the shaft with motor. As motor rotates in Clockwise Direction, the shaft attached to it, also rotates in clockwise direction, on which wire is to be wound and this wire carries the bucket from bottom to top most level. The components such as shaft, bucket and its wheel, main frame in PRO – Engineer software and these components are assembled in the workshop. The Atmel 8051 micro controller is controlling the DC motor by generating control signals by PWM method. The signals are so generated by micro controller; speed will decrease as bucket travel up to some distance. The program code is written in the Top View Simulator and then loaded into the 8051 micro controller. By all this, the function of project is to control the speed of bucket by micro controller.

Fig. 9 Final Assembly

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