SOFT STARTING ARRANGEMENTS AVAILABLES FOR HOT ROLLING MILLS FOR ENERGY CONSERVATION

A.M.BISEN [(1)], Dr. P.M. BAPAT [(2)] and Dr. S.K. GANGULY [(3)]

ABSTRACT

The conventional rolling mills in India are producing a major part of structural steel requirement of the country. The energy conservation in these rolling mills can be achieved mainly by reducing the size of the prime mover i.e. main electric motor. The power consumption per ton can be considerably decreased through proper selection of electric motor since it has been an observation by many surveyors[1] that the selection of electric motor of the rolling mill has been almost five to ten times on the higher side which can be easily verified from the power consumption and motor working data.

Flywheel is a mechanical storage device. Largest size of flywheels are frequently recommended for smooth running of rolling mills. The main difficulty encountered in selecting large capacity flywheel or flywheel gear box system is the starting of the mill with smaller capacity electric motor. The starting characteristic of electric motor is not suitable for starting such rolling mill with very high inertia flywheel. In such condition it becomes very essential to introduce the soft starting arrangement for the electric motor so that considerably small size motor can start the flywheel effectively.

Soft starters are used for the smooth start-up control of three-phase induction motors. The soft starter is functionally located between the Flywheel and the electric motor. In selecting the correct soft starter to suit the application the peculiarities of the soft start should be considered. In the prevailing conditions we use the motor of high horse power due to the fact that the flywheel requires high torque to be driven initially. For the same reason the efficiency of the flywheel is very low initially. Once the flywheel stores sufficient power which is required at the start up, the flywheel then requires less power than given initially. If we somehow are able to increase the efficiency of the flywheel using a flexible electrical, mechanical, hydraulic or flexible drives with different combinations (Electrical, Mechanical, Hydraulic) then the motor of less horse power can thus be installed to run the flywheel.

This paper gives an idea of available type of the soft starting arrangement for a rolling mill so that horse power of motor can be reduced without affecting the working of the mill. Hence optimum selection of the soft starting arrangement is to be done so that initial and billing cost will be less.

(1) **Professor ,Deptt. Of Mech. Engg , School of Engg.& I.T., MATS University, Raipur (C.G.)**
(2) **Professor Deptt. Of Mech. Engg , Cummins College of Engg. Pune (M.S.)**
(3) **Professor Deptt. Of Mech. Engg , B.I.T. Durg (C.G.)**

[*]-indicates the reference no

1.INTRODUCTION

An electric drive motor with a flexible drive and large rotary torque is used as a driving device for hot rolling mill. As we all know that the flywheel used in machines serves as a reservoir which stores energy during the period when the supply of the energy is more than the requirement and releases it during the period when the requirement of energy is more than supply. Flywheel is a mechanical storage device alternative to chemical and electrical storage devices for storing the energy Flywheel can also be used in the rolling mills apart from steam engines, internal combustion engines, reciprocating compressors and pumps.

In the prevailing conditions we use the motor of high horse power due to the fact that the flywheel requires high torque to be driven initially. Once the flywheel stores sufficient torque which is required at the start up, the flywheel then requires less torque than required initially. If we somehow are able to increase the starting torque supplied to the flywheel using a flexible electrical, mechanical, hydraulic, flexible drives or with different combinations (Electrical, Mechanical, and Hydraulic) then the motor of less horse power can be installed to run the flywheel and the whole rolling mill. It has the positive effect on economy, reduce the production cost, increase the production and reduce the power consumption.

Hot rolling is a metalworking process that occurs above the recrystallization temperature of the material. After the grains deform during processing, they recrystallize, which maintains a microstructure and prevents the metal from work hardening. The starting material is usually large pieces of metal, like semi-finished casting products, such as slabs, blooms, and billets. If these products came from a continuous casting operation the products are usually fed directly into the rolling mills at the proper temperature. In smaller operations the material starts at room temperature and must be heated. This is done in a coal, gas or oil-fired soaking pit for larger work pieces and for smaller work pieces induction heating is used. As the material is worked the temperature must be monitored to make sure it remains above the recrystallization temperature. Hot rolling is used mainly to produce sheet metal or simple cross sections, such as rail tracks, bars etc.

2.THEORETICAL CALCULATION

In order to show the problems related to flywheel, We have collected some of the data from one of the steel rolling mill of Raipur(C.G.)India, where they are using A flywheel of 10 tons capacity with a radius of 1m.and electric motor of 1000 horse power. By using the relationship

$$I=MK^2,\quad W=2\prod N / 60,\quad T=I*\acute{\alpha} \quad \text{and } P= 2*\prod *N *T / 4500$$

The Requirement of time for the Electric motor to achieve the required rpm is calculated and shown in Table 1. The flywheel weight and radius is constant. The 3 phase indication motor characteristics is considered.

Sr. No.	MOTOR H.P.	R.P.M.	TIME (in Sec.)
2	1000	75	8.16
3	1000	125	22.67
4	1000	300	131.09=2.18 min.
5	1000	500	363.63 =6.06 min.
7	500	75	16.71
8	500	125	45.76
9	500	300	261.67 =4.36 min.
10	500	500	726.25 =12.10 min.
12	333	75	24.52
13	333	125	68.42
14	333	300	394.93 =6.58 min.
15	333	500	1090.14 =12.10 min.
17	250	75	32.77
18	250	125	90.71
19	250	300	522.61=8.71 min.
20	250	500	1452.51 = 24.20 min.

Table no . 1 REQUIREMENT OF TIME ON THE BASIS OF H.P. OF MOTOR AND R.P.M OF FLYWHEEL

3. DISCUSSION

As per the theoretical calculation and motor characteristics of 3 phase induction motor, the time required to accelerate the flywheel at desired rpm which is practically very difficult to achieve. Hence, there is a tendency to utilize motor with more horse power motor than required.

4. NEED OF SOFT STARTING ARRANGEMENT

As the flywheel rpm is constant and the motor is to take this much time to recover the full load .So the rolling mills are having the two option either to run the flywheel at low r.p.m. so to give the motor more H.P. or the use high H.P. motor initially to accelerate the flywheel. The only solution available for the rolling mills which is generally used is of using the high H.P.

motor to accelerate the flywheel. So by using this arrangement, high H.P. of motors is required. But it has been found by researchers that the motor requires very less H.P. in running condition of flywheel and the maximum energy is consumed by the motor it self

5. SOFT STARTING ARRANGEMENTS AVAILABLE

There are many solutions are available on the soft starting but the optimum is to be selected depending upon the surrounding conditions of the rolling mill. There are many more factors is to be considered in selecting the optimum soft starting arrangement. The soft starting arrangements are available in Mechanical, Electrical , Electronics , Hydraulics and the combinations are available. The best design suited design is depends upon the inputs , desired outputs and the constraints.

5A. Speed controller with speed detector

A control device for the purpose of achieving highly precise rolled material. The response and robust stability of the rolled material tension and looper height are specified and a controller is designed so that the rolling mill main motor and looper operate in concert to suppress variations in rolled material tension thereby achieving stable optimum control which is responsive to the rolling state and rolling conditions.

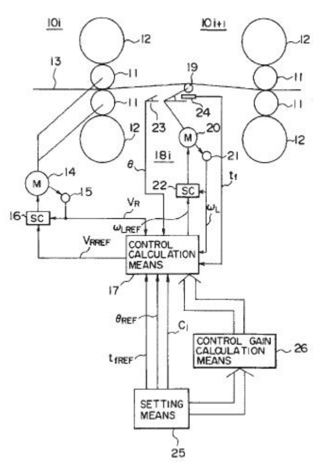

Figure no . 1 SPPED CONTROLLER WITH SPEED DETECTOR

A main rolling mill electric motor speed detector which detects a rotational speed of said rolling mill main electric motorA main electric motor speed control means which compares the detected value of said speed detector with a main electric motor speed reference value and controls the rotational speed of said rolling mill main electric motor; A tension detection means which is disposed between said number of stands and which detects a tension of said material which is being rolled by said stands. A looper which controls the tension in said rolled material by means of adjusting a height of said looper. A height detector which detects the height of said looper; a looper electric motor which drives and adjusts the height of said looper. A looper electric motor speed control means which compares the detected value of said looper electric motor speed detector with a looper electric motor speed reference value and controls a drive speed of said looper electric motor wherein said looper electric motor speed reference value is formed based on the detected values of the tension detection means the height detector, and the looper electric motor speed detector.

5B. Speed controller with current controller

An electric control arrangement for controlling the speed of a roll driving motor for rolling mills for manufacturing hollow blocks is described. A power controller determines from the speed, field strength and armature current of the driving motor, the actual value of the motor power, compares the latter with a reference value, and generates a controlled variable which is fed to a current controller of the control arrangement to control the motor so that the motor delivers constant power.

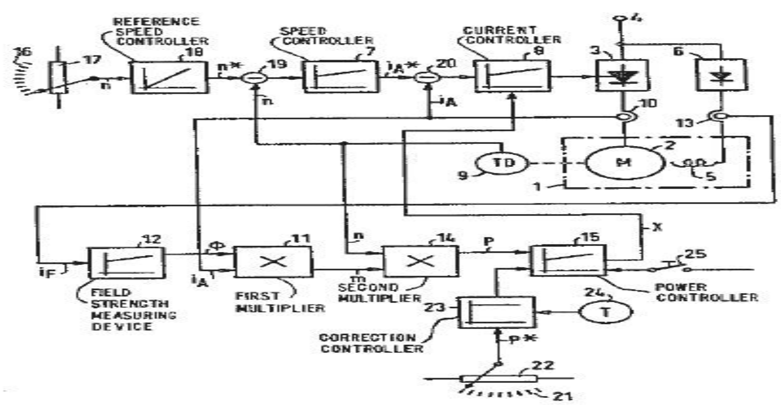

Figure no . 2 SPPED CONTROLLER WITH CUURENT CONTROLLER

In an electrical control arrangement for controlling the speed of a rolling mill driving motor having an armature winding and a field winding supplied with electrical current from a supply network, the driving motor being coupled to and driving rolls of a rolling mill for manufacturing hollow blocks, the control arrangement including a speed controller for controlling the speed of the motor, a current controller for controlling the armature winding current coupled to the speed controller, means coupled to said driving motor for determining the actual speed of the motor and means coupled to said armature winding for determining the armature winding current of the motor, said speed controller being coupled to means for generating a reference speed value and said means for determining the actual speed of the motor whereby said speed controller generates a signal proportional to a desired value of the armature winding current, said signal being supplied to said current controller, the improvement comprising. First means coupled to the field winding for determining the field strength generated by said field winding of the motor; Second means for generating a reference motor power value; control means comprising first multiplier means coupled to said means for determining the armature winding current and to said first means, for generating, at an output thereof, a signal proportional to the torque developed by said driving motor, second multiplier means coupled to said means for determining the actual speed of the motor and to the output of said first multiplier means, for developing, at an output thereof, a signal proportional to the actual power developed by said motor, and third means coupled to said second means and to the output of said second multiplier means for comparing the actual value of the motor power with said reference power value to form a control signal, said control signal coupled as a control input to said current controller whereby said current controller maintains the power of said motor substantially constant, and means for selectively deactivating said control means whereby said control arrangement maintains the speed of the driving motor substantially constant, instead of maintaining the power of said motor substantially constant.

In an electrical control arrangement for controlling the speed of a rolling mill driving motor having an armature winding and a field winding supplied with electrical current from a supply network, the driving motor being coupled to and driving the rolls of a rolling mill for manufacturing hollow blocks, the control arrangement including a speed controller for controlling the speed of the motor, a current controller for controlling the armature winding current coupled to the speed controller, means coupled to said driving motor for determining the actual speed of the motor and means coupled to said armature winding for determining the armature winding current of the motor, said speed controller being coupled to means for generating a reference speed value and said means for determining the actual speed of the motor whereby said speed controller generates a signal proportional to a desired value of the armature winding current, said signal being supplied to said current controller, the improvement comprising:

5C. With the Help Of Gear Box

We need such a flexible system of gear box (sliding or constant type of gear box) that we don't need to change the gears manually to compensate for the low power required after the initial tractive effort used to drive the flywheel.

functions of gear box

It may be used to transmit large power with high efficiency, reliable service and compact layout.

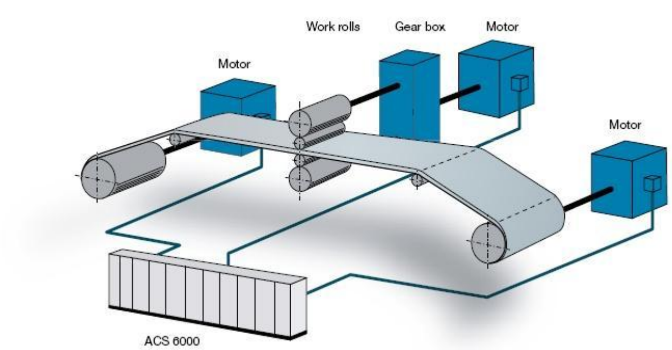

Figure no .3 GEAR BOX SYSTEM

The mill consists of one or two mill stands and two or three reels. The material may be recoiled several times for which high torque and speed accuracy and reliability is required. A wide range of initial products is produced in one mill and one of the reel motors is always regenerating. The reel motors have a very long field-weakening Range and wide speed and load variations can cause disturbances in the network.

Different Examples Used In Current Days:

Universal rolling mill installed at Trade Arbed Luxembourg. This is the world's largest first stand for heavy section beams.

Function:

To transmit power between the main motor and pinion box with a torque limiting device. The mill reverses up to 200 times per hour.

Previous Solution:

Gear coupling

Renold Hi-Tec Solution :

Renold Hi-Tec 325WB coupling with a safe set SR1100 unit. With No maintenance required.

DATA	**SPEED**	**TORQUE**
Nominal Torque	60-120RPM	1200kNm
Maximum Torque		6500kNm

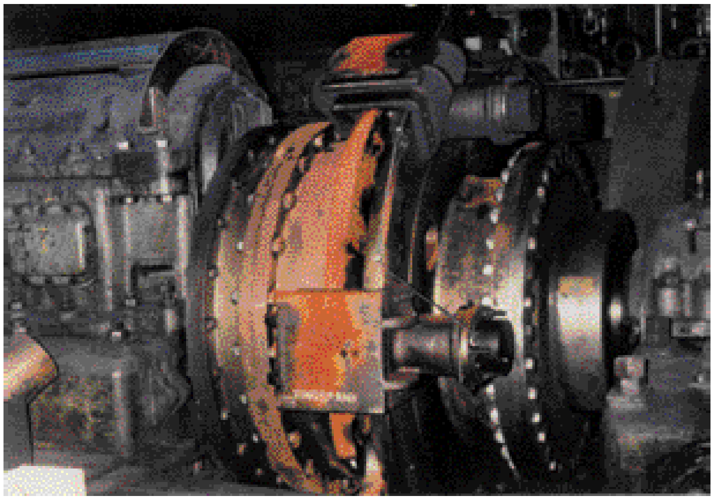

Figure no . 4 RENOLD HI-TEC 325WB COUPLING

Application in Rohrenwerke Bous pilger mill.

5D. Torque Converter

The construction of a torque converter is similar to that of the fluid flywheel, the only difference being that it has an additional stationary member called the stator or the reaction member and all the members have blades or vanes of specific shape.

The operation of the two, however is, not similar. Whereas the fluid flywheel transmits the same torque as given to it by the engine shaft, the torque converter increases the torque in a ratio of about 2 : I to' 3 : I. Thus it serves the same purpose as that of a gear box and that too in a better way. Whereas in the gear box the torque variation is only in finite number of steps, in the case of torque converter torque output variation is continuous. However, the efficiency of a torque converter is high only within narrow limits of speed.

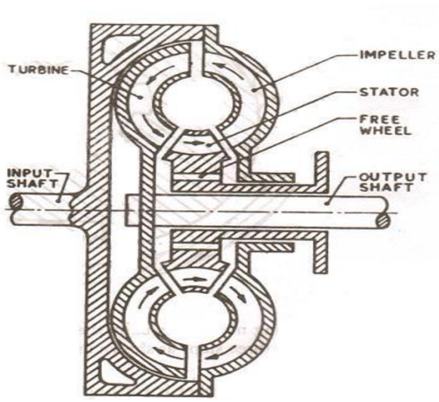

Figure no . 5 Torque Converter

5E. Cyclo Converter

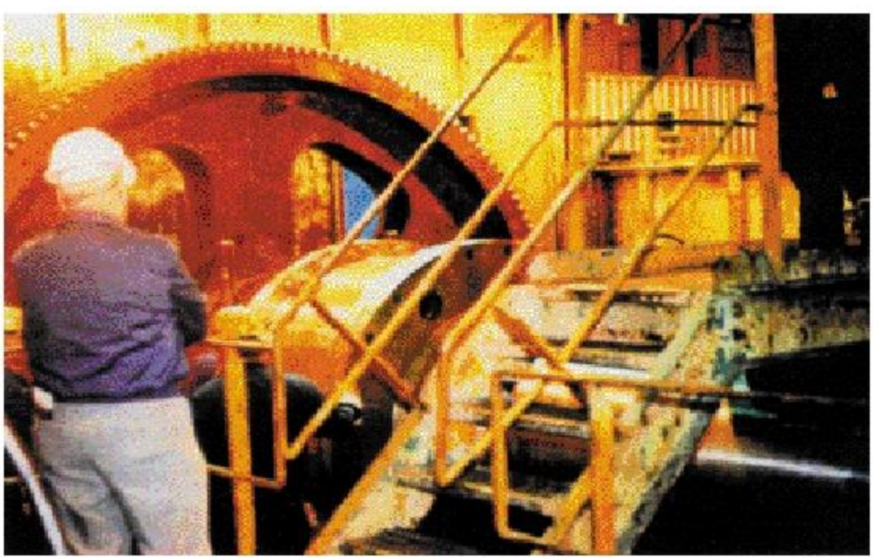
Figure no .6Cyclo Converter

The most common cycloconverter in rolling mills uses an open circuit or non-circulating current configuration. Three anti-parallel thyristor bridges are connected via commutating reactors to a single secondary transformer system. Each of these bridges feeds one motor phase that is electrically isolated from the other phases. The galvanic isolation in the motor minimizes the torque ripple and current ripple, making it possible to have only one main transformer for the drive. The output phase voltage is formed from sequences of the line voltage by sinusoidal modulation. In effect, three symmetrical voltage systems are applied to the motor winding. Due to the line-commutated converter and torque ripple requirements, the output frequency is limited to 45% of the line frequency. Each disruption in continuous current flow causes a small torque ripple. This makes it essential to minimize the current zero time periods as much as possible. With the help of special thyristor voltage-sensing modules, it is possible with the control systems to reduce these periods to less than 1ms and to keep torque ripple significantly below 1%. The cycloconverter is a highly efficient drive system. The robust design of the cycloconverter is especially a good solution for drives with maximum speed requirements below 660/790rpm (50/60 Hz) such as roughing mill drives and over 90 % of finishing mill drives

Through phase control, the cycloconverter transforms the line-side AC system with constant frequency and voltage into a system with variable frequency and voltage. The cycloconverter features outstanding efficiency while providing sinusoidal output currents across the entire working range and the rapid and flexible setting of frequency and current. This makes the cycloconverter still the best choice for all types of drives that must provide low-harmonics torque. With a maximum output frequency of approximately 45% of its input frequency, the cycloconverter is suitable for all slow-rotation variable speed drives. Siemens converters are modular in design and best-suited to high output. Air cooling makes them independent of water supply, deionization, and associated equipment – without sacrificing a high overload capability.

5F.Combination of electrical and mechanical system

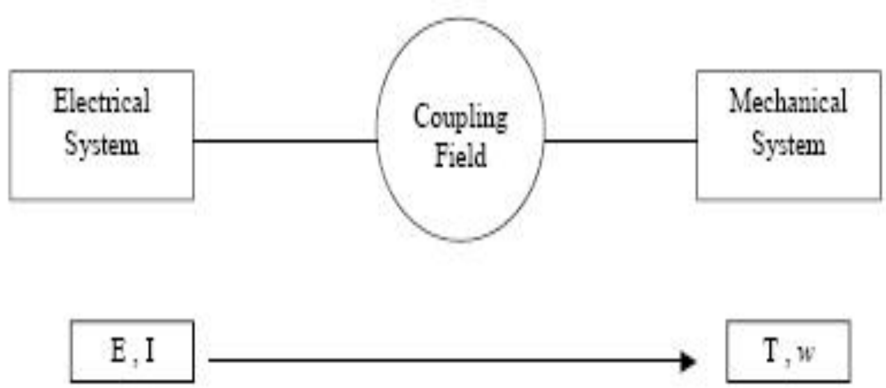

Figure no .7 Combination of electrical and mechanical system.

Figure no .8 Application of Combination of electrical and mechanical system

Product technologies are focused on achieving the highest-quality products. Siemens VAI provides advanced mechanical actuators, electrical and automation control systems and applied process know-how to deliver gauge, profile/flatness, temperature and surface quality with the highest level of consistency. Advanced roll stack actuators such as Smart Crown and DSR can be custom- selected according to your specific mill design.

Features

Our mill stand equipment is designed for the highest rolling loads and main drive torques, which ensures the correct development of material property and maximized throughput. Hydraulic systems to provide controllable, responsive, precise, safe and efficient operation. These include hydraulic edger, HGC, work roll bending and shifting, side guides and shears. Smart Crown roll contour guarantees enhanced flatness control. For perfect cooling and contour control we provide pulse-modulated work roll spray bars. The main benefits is Highest production rates ,Optimized yield ,Flexible production , Tight tolerances for strip thickness, flatness, and high surface quality with Low costs for operation, maintenance, and minimum downtimes

5G. Multivariable control on tandem coupled motors

Today most rolling mills are using DC-motors. Since the motor lifetime is longer than the converter or electronics lifetime, the converter is commonly replaced or revamped and the motor is kept. Therefore it is interesting to study how improved control, applied to existing motors and mechanics, can improve performance. Many of these DC-motors are tandem coupled and suffer from insufficient dynamic performance, due to increased production and quality requirements. This is especially true in hot rolling mill applications such as Wire Rod Mill block drives, shear drives, Hot Strip Mill main stands and various types of reversing mills, where the load torque goes from zero to maximum torque in tens of milliseconds.

Today the industry standard is a PI controlled single-input single-output (SISO) system with one speed sensor and the two motors in a master-slave configuration. Two distinctly new control configurations are proposed for tandem coupled DC motors. The results are compared to standard SISO configuration results. The proposed controller structures are based on standard P/PI-controllers. These controllers are industrial standard and well known for process engineers who may need to tune the controllers by hand. Extra emphasis is placed on using configurations that can be widely used in the industry in the future. Therefore, the performance of advanced control strategies, like H∞ or LQG, is not investigated. Note that no effort is made to optimize speed step performance.

The proposed control configurations are not optimized in order to handle load sharing between the motors at speed reference steps. There are several possible solutions for that case, using two degree of freedom .

1. Multi-input single-output (MISO): Existing sensor configurations, but one separate controller for each motor, instead of the hard master-slave connection. 2. Multi-input multi-output (MIMO): An additional shaft torque sensor is used in conjunction with one separate controller for each motor. These sensors are becoming cheaper and cheaper and are increasingly used also for supervision systems. Measured shaft torque is used for feedback control.

The proposed control configurations are not optimized in order to handle load sharing between the motors at speed reference steps. There are several possible solutions for that case, but they are not investigated here.

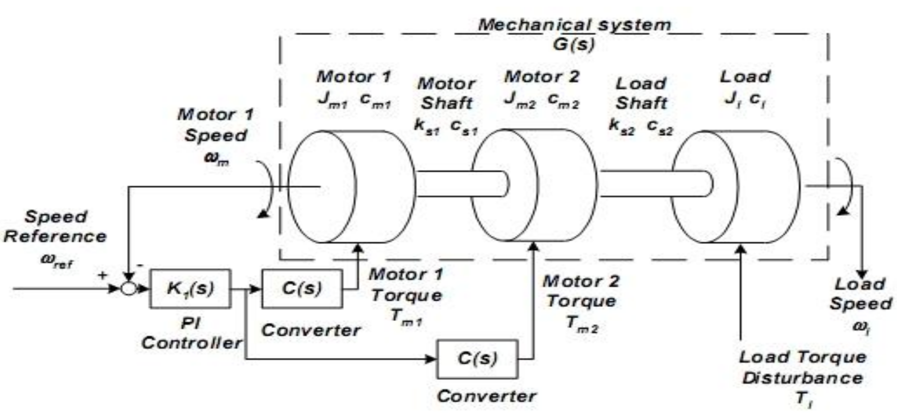

Figure no.9 Standard master slave connection (SISO)

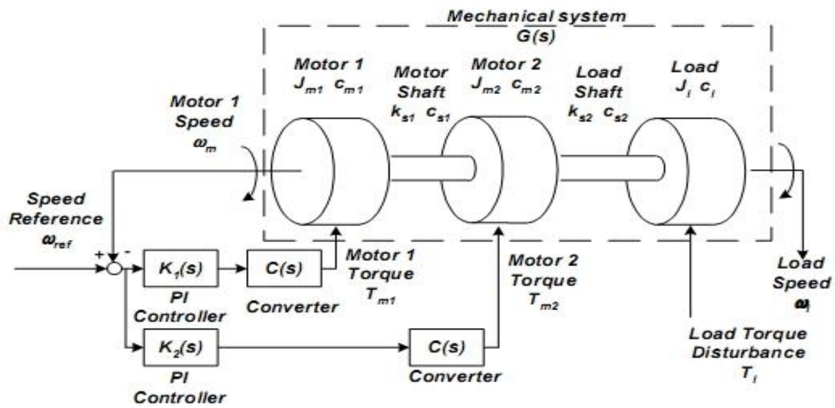

Figure no .10 Separate motor controllers (MISO)

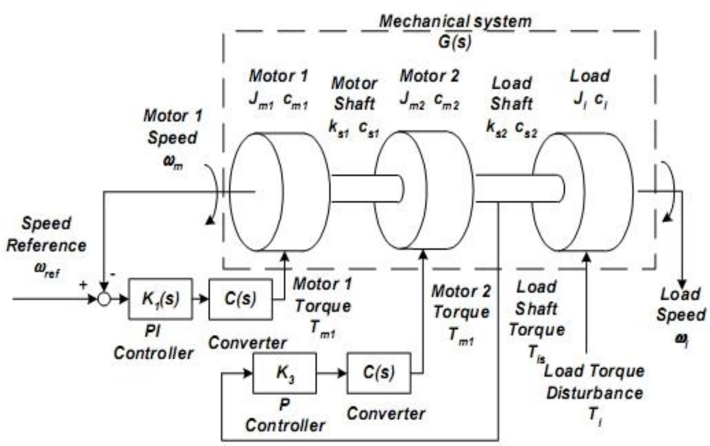

Figure no .11 Extra torque sensor (MIMO)

5 H. SIMPLE SOFT STARTING ARRANGEMENT USING FLAT BELT DRIVE

In many factories in the past flat belts have been widely used to drive the machines in the factories. They are convenient to install and operate and are reliable. In modern times machines are driven individually generally using electric or hydraulic drives. In the past belts were generally made from leather. Now belts are also manufactured from a wide range of elastomeric including urethane, neoprene, hyperons, EPDM, and silicone. Stretch, semi-stretch, and no-stretch belts are available. Belts are often reinforced with textiles and fibers and metal reinforced belts are available. Belts can be provided with durable surface coatings and coatings providing anti-static properties. Generally the flat belts are used for low power transmission but now a days the flat belts are designed to transmit the desired power at desired speed.

At high speed, centrifugal force tended to throw the heavier V-belts out of their grooves. Alignment of driving and driven pulleys assumed greater importance. Flexing losses result in V-belt efficiency several percent below that of a modern flat belt (which can reach 98%). And the typical elastomeric V-belt is less resistant to attack by lubricants or ultraviolet radiation.

Hence, flat belts still have their place. Solid leather is no longer the material of choice, although often still used for outer surfaces because of its superior resistance to oil. A central core of nylon is common. Anyone applying or designing a motor today for a flat belt power transmission drive must get from the specified the particulars on the belting itself and the pulleys, then consult with the belt manufacturer on how to arrive at the shaft pull. Pulley diameters today are seldom less than 8", but widths may be from 2" up to 15" or more.

Complete analysis of any belt drive involves two steps. The first is selection of the belts and pulleys themselves-suited to the power to be transmitted, the environment, and the motor starting conditions. Supplier and handbook information is readily available to guide this process. The second step is evaluation of the belt pull (the force applied to the motor shaft by a properly tensioned belt) and its effect on the motor is up to the motor designer.

EXPERIMENTAL SETUP FOR VERIFICATION OF FEASIBILITY OF SOFT DRIVE BY USING FLAT BELT DRIVE

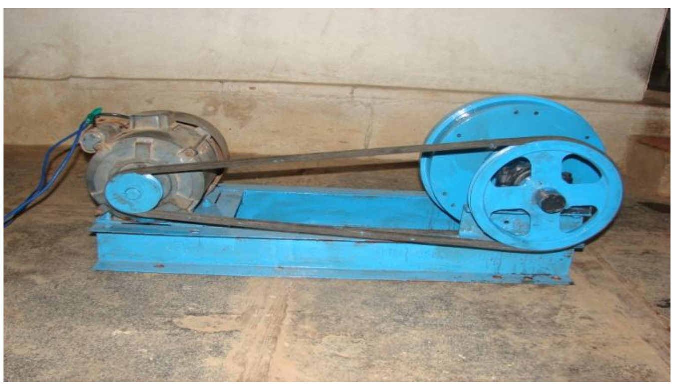

Figure no .12 Initial SETUP

Figure no .13 Final SETUP

The flat Belt drive is used for soft starting arrangement. The flat belt is used to energies the flywheel. In the starting condition the motor is not capable to start the flywheel , hence a sliding arrangement is used. By using the this arrangement , motor is capable to start the flywheel as it act as a clutch.

The various reading is recorded and the time taken by the motor to achieve the full load is recorded as given in Table No.2

Sr.no.	Time in sec.	R .p.m. of motor	r.p.m. flywheel
1	0	1467	0
2	0-5 sec.	1450	0
3	5-10 sec.	1388	0
4	10-15 sec	1382	131
5	15-20 sec	1350	250
6	20-25 sec	1348	282
7	25-30 sec	1306	375
8	30-35 sec	1314	502
9	35-40 sec	1333	622
10	40-45 sec	1310	734
11	45-50 sec	1360	831
12	50-55 sec	1395	880
13	55-60 sec	1413	909
14	60-65 sec	1422	922
15	65-70 sec	1424	926
16	70-75 sec	1425	918
17	75-80 sec	1423	912
18	80-85 sec	1421	924

Table no . 1 MOTOR AND FLYWHEEL R.P.M.

6. DISCUSSION & CONCLUSION

This experimental setup prepared for the verification suggested that 200 horse power motor comparatively starts the rolling mill.

1) It is the opinion of the author that this simple design presented in the paper may become the future of the rolling mills of new decade and definitely we solve the energy crises.

2) To design a some more alternative arrangement which can serve this purpose.

3) To select the flexible drives available in mechanical, electromechanical, chemical, electronics system and designed a suitable soft starting arrangement for the rolling mills.

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