Design & Development of a Telescopic Beam for EPM Lifter System

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Abstract – ***Sheet metal is an important component required in many manufacturing industries. The equipment used for handling heavy metal sheets directly affects the working efficiency, safety, productivity, working area and production time. Need of an efficient and a failsafe material handling system has increased over past few years. Conventionally EPM (Electro Permanent Magnetic) Lifter for transportation of heavy sheets. But it is only applicable for specific sizes of metal sheets. We are thus designing a Telescopic EPM Lifter Beam to overcome this limitation. The Telescopic EPM Lifter consists of electrically actuated two telescopic arms which can be extended for larger sizes of metal sheets as well as retracted for smaller sizes. It is a remote controlled actuating device. An EPM (electro permanent magnet) is made from a coil of wire that acts as a magnet when an electric current passes through it and stops being a magnet when the current. This is used for lifting heavy weight metal sheets. This sheets are transported with the help of horizontal crane. After reaching required location the electric current is stopped and magnet gets demagnetized and the metal sheet is unclamped. This type of material handling equipment is very efficient, less time consuming, needs less manpower.***

Key Words**: EPM Lifter, Telescopic beam, Spreader Beam, Magnetic Lifter Beam**

1.INTRODUCTION

Presently, the varying sizes of steel plates are handled within the bay of Fabrication block, for loading on the various CNC Flame cutting Plasma Arc cutting machines by using clamps/slings. This is a very cumbersome, fatigue oriented & risky method of plate handling. In order to ensure, efficient handling of various sizes of steel plates, some times hot upto 300ºC, of varying thickness and varying lengths a heavy duty, fail safe and practically maintenance free and efficient Electro-Permanent Magnet (EPM) handling system is proposed.

1.1 OVERVIEW OF MATERIAL HANDLING EQUIPMENT

Material handling (MH) involves short-distance movement that usually takes place within the confines of a building such as a plant or a warehouse and between a building and a transportation agency. It can be used to create time and place utility through the handling, storage, and control of material, as distinct from manufacturing (i.e., fabrication and assembly operations), which creates form utility by changing the shape, form, and makeup of material. It is often said that MH only adds to the cost of a product, it does not add to the value of a product. Although MH does not provide a product with form utility, the time and place utility provided by MH can add real value to a product, the value of a product can increase after MH has taken place.

1.2 ELECTRO PERMANENT MAGNETIC LIFTER (EPM)

Sheet metal of varying sizes is one of the many inevitable and essential components used for number of industrial applications. For most of the mass productive manufacturing processes , sheet metal plays an important role in fulfilling the needs like dimensional accuracy , total production cost , easy manufacturing ,efficient production time and lesser manufacturing complexity. So in order to achieve maximum work efficiency , the material handling of sheets is most vital part. An EPM lifter is used as material handling equipment.

Electro permanent magnetic lifter is combination of permanent as well as electro magnet which is required to clamp or unclamp the job. Combination of telescopic beam and EMP lifter is also known as SPREADER system. This system is more efficient than conventional EPM lifter system. Main motto of designing of such system to reduce work space and increase productivity. Spreader beams lift loads with single or multiple attachment points. They handle a variety of loads such as long bundles, rolls, cylinders, and machinery. Below is the list of components is going use in this system. Applications are, loading/ unloading plates from Railway Wagons/ trucks, For storing in Plate yards, For feeding plates onto a flame/ plasma cutting machine table, one at a time.

2. SPECIFICATION AND MATERIAL PROPERTY

2.1 SPECIFICATION

1) Lifting Capacity- 15 tonne(max)
2) Material to be lifted- Metal Plate
3) Dimensions of Plate-
4) Length-[3000mm (min) to 12000mm (max)]
   Width – [500mm(min) to 2500mm (max)]
   Thickness- [3mm]
5) Weight of plate to be lifted-15000kg(max)
6) Weight of entire system to be restricted to 2000kg.
7) Length of beam should be 6200mm(retracted) and 9200mm(expanded).
8) Electrical powered linear actuator telescopic beam using induction geared motor.
9) Beam should have lifting lug.
10) Inner magnet should have hanging provision at pitch of min 3200 mm.

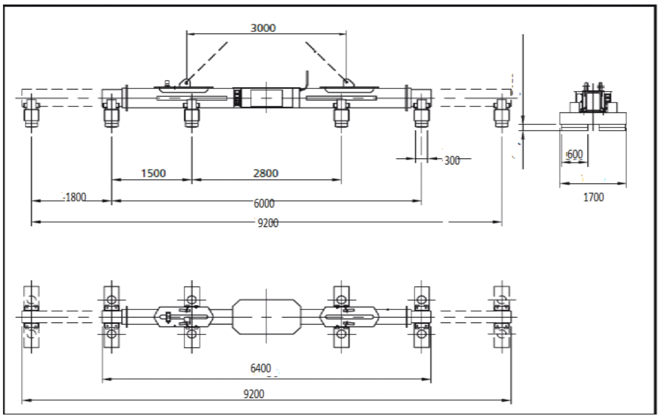


Fig1

2.1 MATERIAL PROPERTY

PLAIN CARBON STEEL(C45)
No: 1.0503
Former brand name:
International steel grades:
BS: C45, 50CS, 080M46
AFNOR: C45, AF65C45, 1C45
SAE: 1045
Material group: Steel for quenching and tempering according to DIN EN 10083

Chemical Composition: (Typical analysis in %)
C 0.42,0.50 **Si** <0.40 **Mn** 0.50,0.80 **P** 0.045
S <0.10 **Cr** 0.40 **Mo** <0.10 **Ni** <0.63

Application: Plain carbon steel for mechanical engineering and automotive components.

Hot forming and heat treatment:
Forging or hot rolling: 1100 - 850°C
Normalising: 840 - 880°C/air
Soft annealing: 680 - 710°C/furnace
Hardening: 680 - 710°C/furnace
Tempering: 550 - 660°C/air

Mechanical Properties:

Diameter d [mm]	< 16	>16 – 40	>40 – 100	>100 – 160	>160 – 250
Thickness t [mm]	< 8	8<t<20	20<t<60	60<t<100	100<t<160
0,2% proof stress $R_{p0.2}$ [N/mm²]	min. 490	min. 430	min. 370	-	-
Tensile strength R_m [N/mm²]	700 - 850	650 - 800	630 - 780	-	-
Fracture elongation A_5 [%]	min. 14	min. 16	min. 17	-	-
Reduction of area Z [%]	min. 35	min. 40	min. 45	-	-

Fig2

3. CONFIGURATION

The proposed system should consist of a telescopic spreader beam, fabricated from high strength steel, suspended from the hook of the EOT crane thru chains suitable system. Spreader beam should have a fixed structure, around 6.2- m , from which 4 Nos. EPM's, of 2 MT capacity each, should be hung from spring suspension, at a pitch of around 2.8 m. Further motorized adjustable arms, with pair of 4 MT EPM's hung on each side & stroke of around 1500 mm, are to be provided on the either side of fixed structure. This would enable varying of pitch distance for outer magnets from 6 m to 9 m, which in turn would help in lifting of plates of varying lengths. Thus the system should have the capacity to lift plate of maximum weight 10 MT using all these 8 EPM's. The hanging chains should be made from Grade 80 high strength Alloy Steel chain with a Centre Bull ring for suspending from Crane Hook or Stranded Wire rope. Each Magnet should be suspended with spring to take care of the bendiness of plates for secured lifting. The EPM Telescopic Spreader beam is to be hung from a single hook. All magnets are to be inline. A suitable stand is provided to support the spreader beam when EPM system is not in use. The entire system should have an absolute built-in safety in case of any power / cable failure and should be free from battery backup. This safety system should have automatic switching device "Dautanac – System" for prevention of dropping of hanging load. When chains are stretched, it should cuts power supply to the control unit, thus the module cannot be operated during lifting and traversing the load. The duty cycle of the system should be 3 to 4 hours non-stop operation in each shift of 8 Hours (on two shifts working basis). The EPM should have the facility of switching ON/OFF (MAG/ DEMAG cycle) by either Radio Remote Control (RRC) or from a control pendant or from the control panel on the system itself, by means of suitable selector switch.

4. DESIGN PROCEDURE

Whole system is divided in three main parts and those are: Fixed beam; telescopic beam; Actuation mechanism. Considering whole beam as assembly of these parts calculations are done.

Failure is likely to be caused by

1) Bending

2) Cracks due to high stress

Bending in beams: When the applied external load on a member of a structure is higher than that of its load bearing capacity, it undergoes the deformation in various regions (plastic and elastic region) which results in the bending of a member. A bending moment is the reaction induced in a structural element when an external force or moment is applied to the element causing the element to bend. The most common or simplest structural element subjected to bending moments is the beam. The example shows a beam which is simply supported at both ends.

Cracks due to high stress: Cyclic loading causes fatigue stresses induced in a structural member. This stresses when exceeds the maximum permissible stress allowed to the particular material, it undergoes cracking . These cracks are further increased by loads. This weakens the strength of a structure and it may undergo failure.

4.1 DESIGN OF MAIN BEAM

Main beam is considered as simply supported beam. It has two vertical reactions from downward direction coming directly from magnets that are clamped to the metal sheet while working condition. Maximum load that has to be lifted is 12 ton. This load gets equally distributed to the respective magnets and thus it is assumed that the main beam undergoes the uniformly distributed load. Also the structure is symmetric and horizontal hence the lifting load will be automatically distributed symmetrically about its clamping point to the crane.

The moment of resistance of the beam section is the moment of couple formed by the total tensile force in the steel acting at the centre of gravity of reinforcement and the total compressive force (C) in the concrete acting at the centre of gravity (c.g.) of the compressive stress diagram.

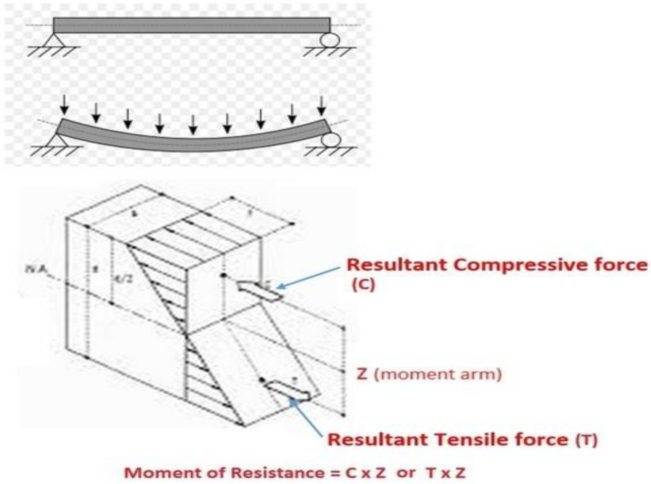


Fig3

We know that,

Moment of Resistance = Maximum Bending Moment

Let,

σ_{perm}= Maximum Permissible Stress(N/mm^2).
Z = Sectional modulus (mm^3)
I = Moment of inertia(mm^4)
W = Uniformly distributed load(KN/m)
l = Length (mm)
b = Width(mm)
t = Thickness(mm)
y_{max} = Maximum distance from neutral axis(mm)

Moment of resistance (M.R.) = $\sigma_{perm} * Z$
Maximum Bending Moment = $(Wl^2)/8$ N/mm^2
The Main beam and the telescopic beams are taken as a square tubes of plain carbon steel which is easily available in the industry. Selection of a ready made tube reduces the manufacturing processes and so the production cost. Applying trial and error method we checked its capacity under the principle that,

Maximum applied UDL < The load bearing capacity.
We are designing the beam with the following constraints.

Length of Main Beam: 5600mm

By trial and error method and selecting the following dimensions from the industrial standard catalogue for C45 sqaure tubes.

t= 12 mm b=360mm

Calculations,

Selected tube:- 360*360 (cross section)

12 mm thickness

I= 1/12[B^4-b^4] = 1/12[360^4-336^4]

I= 337.5544*10^6 (mm^4)

Z= I/ y_{max} = I/180= 1.8753 (mm^3)

M.R. = σ_{perm} *Z

σ_{perm} *F.O.S= Syt (factor of safety =2.5)

σ_{perm} =340/2.5 N/mm^2 ,6perm=136 N/mm^2

M.R.= 136*1.8753*10^6

M.R.= 255.0408*10^6 (N-mm)

Since M.R.= Max bending moment= $(Wl^2)/8$

M.R. =$(Wl^2)/8$ l=6200 mm

255.0408*10^6*8/(6.2)^2= W

W=53.0782 (KN/m)---- capacity for 6200mm

Application load-
Extreme load = 15000kg+ self weight

E.L= 15 ton+ 2.3

E.L.= 17.3 ton

U.D.L= 17.3*9.81/6.2 = 27.3730 (KN/m)

(U.D.L)practical < Capacity

Design is safe

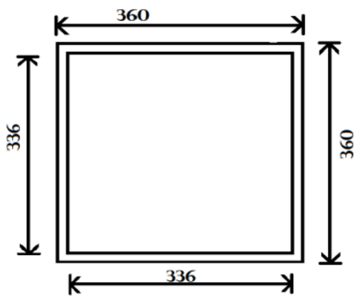
Weight of beam= density*volume

Volume= (l1*b1*h1)-(l2*b2*h2)

V=0.0935m^3

M= density*volume

=7850*0.0935= 734.3078 kg



4.1 DESIGN OF TELESCOPIC BEAM

Referring Indian standards for hollow square tubes and selecting following dimensions.
b =260 mm t = 10 mm Length=2700mm
Applying same principle as applied for fixed beam.

Considering the telescopic beam as a cantilever beam.

I= 1/12[B^4-b^4] = 1/12[260^4-240^4]

I= 104.8333*10^6 (mm^4)

Z= I/ y_{max}= I/130

Z=0.8025*10^6(mm^3)

M.B.M.= M.R.= = σ_{perm} *Z

For cantilever beam maximum bending moment=$(Wl^2/2)$

$(Wl^2/2)$=136*0.8025*10^6

W=37.8988 (KN/m)

Application load
Extreme load = 3ton at each telescopic beam + self weight
E.L= 3 ton+ 212 kg

E.L.= 3.212 ton

U.D.L= 3.212*9.81/1.8 = 17.505 (KN/m)

(U.D.L)practical < Capacity

Design is safe

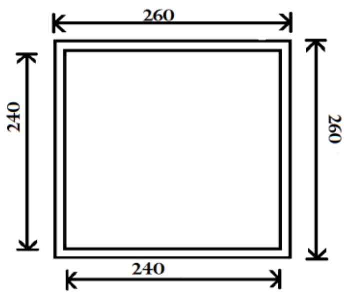
Weight of beam= density*volume

Volume= (l1*b1*h1)-(l2*b2*h2)

V=0.027 m^3

M= density*volume

=7850*0.027 = 212 kg each



4.3 DESIGN OF BRACKET FOR MAGNET

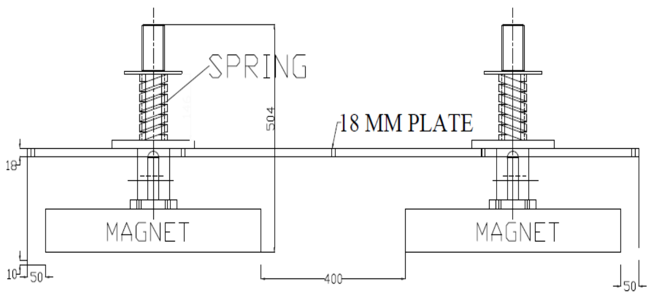


Fig.4

This bracket is designed according to the standard procedure of UPTECH engineering magnetic cover design.

Magnet dimensions
Length – 600mm
Height – 95mm
Width – 350mm
Weight – 100kg (with tolerance)

Washer dimensions
Inner diameter – 90mm
Outer diameter – 120mm
(Selected according to the respective standard spring used)

The Fig.4 shows assembly of EPM magntes along with the pin clamping mechanism. These magnets are supported to the spring to tolerate the sudden jerks caused while dettatching sheets . This jerk may induce vibrations in a structure. Load is transmitted from the magnet to the spring and having sufficient spring constant it distributes it over its laps . Further, spring is mounted on a 18 mm thick plain carbon steel with the help of appropriate washer. This makes the load to be transmitted to this thick plate which will be rib welded to the main beam. Ultimately the load is transmitted to the beam through these components. For the covering purpose thin sheet metal of respective dimension is tapped to the thick plate from all the sides. This structure thus formed is a cover and load transmitting mechanism.

4.4 SELECTION OF BEARING AND CAM FOLLOWER

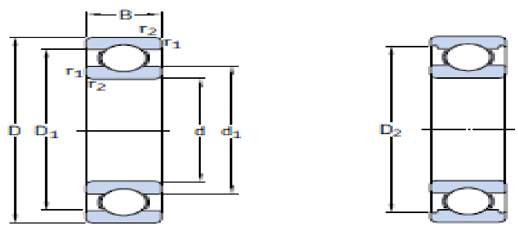


Fig.5

Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Speed ratings Reference speed	Limiting speed	Mass	Designation
d	D	B	C	C_0	P_u				
mm			kN		kN	r/min		kg	–
60	78	10	11,9	11,4	0,49	17 000	11 000	0,11	61812
	85	13	16,5	14,3	0,6	16 000	10 000	0,2	61912
	95	11	20,8	15	0,735	15 000	9 500	0,29	* 16012
	95	18	30,7	23,2	0,98	15 000	9 500	0,41	* 6012
	110	22	55,3	36	1,53	13 000	8 000	0,78	* 6212
	130	31	85,2	52	2,2	11 000	7 000	1,7	* 6312
	150	35	108	69,5	2,9	10 000	6 300	2,85	6412
65	85	10	12,4	12,7	0,54	16 000	10 000	0,13	61813
	90	13	17,4	16	0,68	15 000	9 500	0,22	61913
	100	11	22,5	19,6	0,83	14 000	9 000	0,3	* 16013
	100	18	31,9	25	1,06	14 000	9 000	0,44	* 6013
	120	23	58,5	40,5	1,73	12 000	7 500	1	* 6213
	140	33	97,5	60	2,5	10 000	6 700	2,1	* 6313
	160	37	119	78	3,15	9 500	6 000	3,35	6413
70	90	10	12,4	13,2	0,56	15 000	9 000	0,14	61814
	100	16	23,8	21,2	0,9	14 000	8 500	0,35	61914
	110	13	29,1	25	1,06	13 000	8 000	0,44	* 16014
	110	20	39,7	31	1,32	13 000	8 000	0,61	* 6014
	125	24	63,7	45	1,9	11 000	7 000	1,1	* 6214
	150	35	111	68	2,75	9 500	6 300	2,55	* 6314
	180	42	143	104	3,9	8 500	5 300	4,95	6414
75	95	10	12,7	14,3	0,61	14 000	8 500	0,15	61815
	105	16	24,2	22,4	0,965	13 000	8 000	0,37	61915
	115	13	30,2	27	1,14	12 000	7 500	0,46	* 16015
	115	20	41,6	33,5	1,43	12 000	7 500	0,65	* 6015
	130	25	68,9	49	2,04	10 000	6 700	1,2	* 6215
	160	37	119	76,5	3	9 000	5 600	3,05	* 6315
	190	45	153	114	4,15	8 000	5 000	5,8	6415

Fig.6

As per the application load and space constraints , bearing 6314 is selected from the standard table provided by SKF Bearings.

Inner Diameter = 70 mm

Outer Diameter =150 mm

Static Load Bearing Capacity =68 KN

Dynamic Load Bearing Capacity = 111 KN

Number of Bearings used = 16

Load on each bearing = 12.26 KN (Static)

Number of bearings is taken 16 as per the proposed factor of safety. Thus the overall load is safely distributed.

4.4.1 CAM FOLLOWER

Cam Followers are bearings with a stud incorporating needle rollers in a thick walled outer ring. These bearings are designed for outer ring rotation, and have superior rotational performance with a small coefficient of friction. Also, they are designed to have minimal radial internal clearance to increase the loading zone, and thus reduce the effect of shock loads and ensure stable long life. As studs already have threads or steps, they are easy to mount. Cam Followers are follower bearings for cam mechanisms and linear motions and have high rigidity and high accuracy. They are, therefore, used widely for machine tools, industrial robots, electronic devices, and OA equipment. Stainless steel made Cam Followers are superior in corrosion resistance and suitable for applications in environments where oil cannot be used or water splashed, and in clean rooms.

A guide of material EN24 is used along with the cam follower mounted at the sides of a telescopic beam. This guide way provides the necessary path for the cam follower to roll. A sliding motion is thus provided in order to extend or retract the telescopic beam. The actuating motion provided by rack and pinion mechanism is further supported by this sliding mechanism. Use of guide way and cam follower ensures the jerk free and a smooth motion of a sliding.

EN24 Material properties:

Tensile strength=850-1000 N/mm²
Elongation =15%

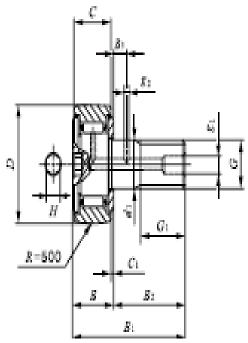


Fig.7

Stud dia. mm	Identification number: Shield type, With crowned outer ring	Shield type, With cylindrical outer ring	Sealed type, With crowned outer ring	Sealed type, With cylindrical outer ring	Mass (Ref.) g	D	C	d_1	G
3	CF 3 BR	CF 3 B	CF 3 BUUR	CF 3 BUU	4.3	10	7	3	M 3×0.5
4	CF 4 BR	CF 4 B	CF 4 BUUR	CF 4 BUU	7.4	12	8	4	M 4×0.7
5	CF 5 BR	CF 5 B	CF 5 BUUR	CF 5 BUU	10.3	13	9	5	M 5×0.8
6	CF 6 BR	CF 6 B	CF 6 BUUR	CF 6 BUU	18.5	16	11	6	M 6×1
8	CF 8 BR	CF 8 B	CF 8 BUUR	CF 8 BUU	28.5	19	11	8	M 8×1.25
	CF 8 BRM	CF 8 BM	CF 8 BUURM	CF 8 BUUM	28.5	19	11	8	M 8×1
10	CF 10 BR	CF 10 B	CF 10 BUUR	CF 10 BUU	45	22	12	10	M10×1.25
	CF 10 BRM	CF 10 BM	CF 10 BUURM	CF 10 BUUM	45	22	12	10	M10×1
	CF 10-1 BR	CF 10-1 B	CF 10-1 BUUR	CF 10-1 BUU	60	26	12	10	M10×1.25
	CF 10-1 BRM	CF 10-1 BM	CF 10-1 BUURM	CF 10-1 BUUM	60	26	12	10	M10×1
12	CF 12 BR	CF 12 B	CF 12 BUUR	CF 12 BUU	95	30	14	12	M12×1.5
	CF 12-1 BR	CF 12-1 B	CF 12-1 BUUR	CF 12-1 BUU	105	32	14	12	M12×1.5
16	CF 16 BR	CF 16 B	CF 16 BUUR	CF 16 BUU	170	35	18	16	M16×1.5
18	CF 18 BR	CF 18 B	CF 18 BUUR	CF 18 BUU	250	40	20	18	M18×1.5
20	CF 20 BR	CF 20 B	CF 20 BUUR	CF 20 BUU	460	52	24	20	M20×1.5
	CF 20-1 BR	CF 20-1 B	CF 20-1 BUUR	CF 20-1 BUU	385	47	24	20	M20×1.5
24	CF 24 BR	CF 24 B	CF 24 BUUR	CF 24 BUU	815	62	29	24	M24×1.5
	CF 24-1 BR	CF 24-1 B	CF 24-1 BUUR	CF 24-1 BUU	1 140	72	29	24	M24×1.5
30	CF 30 BR	CF 30 B	CF 30 BUUR	CF 30 BUU	1 870	80	35	30	M30×1.5
	CF 30-1 BR	CF 30-1 B	CF 30-1 BUUR	CF 30-1 BUU	2 030	85	35	30	M30×1.5
	CF 30-2 BR	CF 30-2 B	CF 30-2 BUUR	CF 30-2 BUU	2 220	90	35	30	M30×1.5

Boundary dimensions mm: G_1	B	B_1	B_2	B_3	C_1	g_1	g_2	H	$r_{s\,min}$ (1)	Mounting dimension f Min. mm	Maximum tightening torque N-m	Basic dynamic load rating C N	Basic static load rating C_0 N	Maximum allowable static load N
5	8	17	9	—	0.5	—	—	2	0.2	6.8	0.34	1 500	1 020	384
6	9	20	11	—	0.5	—	—	2.5	0.3	8.3	0.78	2 070	1 590	834
7.5	10	23	13	—	0.5	—	—	3	0.3	9.3	1.6	2 520	2 140	1 260
8	12.2max	28.2max	16	—	0.6	—	—	3	0.3	11	2.7	3 660	3 650	1 950
10	12.2max	32.2max	20	—	0.6	—	—	4	0.3	13	6.5	4 250	4 740	4 620
10	12.2max	32.2max	20	—	0.6	—	—	4	0.3	13	7.1	4 250	4 740	4 620
12	13.2max	36.2max	23	—	0.6	—	—	4	0.3	16	13.8	5 430	6 890	6 890
12	13.2max	36.2max	23	—	0.6	—	—	4	0.3	16	14.7	5 430	6 890	6 890
12	13.2max	36.2max	23	—	0.6	—	—	4	0.3	16	13.8	5 430	6 890	6 890
12	13.2max	36.2max	23	—	0.6	—	—	4	0.3	16	14.7	5 430	6 890	6 890
13	15.2max	40.2max	25	6	0.6	6	3	6	0.6	21	21.9	7 910	9 790	9 790
13	15.2max	40.2max	25	6	0.6	6	3	6	0.6	21	21.9	7 910	9 790	9 790
17	19.6max	52.1max	32.5	8	0.8	6	3	6	0.6	26	58.5	12 000	18 300	18 300
19	21.6max	58.1max	36.5	8	0.8	6	3	8	1	29	86.2	14 800	25 200	25 200
21	25.6max	66.1max	40.5	9	0.8	8	4	8	1	34	119	20 700	34 600	34 600
21	25.6max	66.1max	40.5	9	0.8	8	4	8	1	34	119	20 700	34 600	34 600
25	30.6max	80.1max	49.5	11	0.8	8	4	12	1	40	215	30 500	52 600	52 000
25	30.6max	80.1max	49.5	11	0.8	8	4	12	1	40	215	30 500	52 600	52 000
32	37 max	100 max	63	15	1	8	4	17	1	49	438	45 400	85 100	85 100
32	37 max	100 max	63	15	1	8	4	17	1	49	438	45 400	85 100	85 100
32	37 max	100 max	63	15	1	8	4	17	1	49	438	45 400	85 100	85 100

Fig.8

For the respective external load CF BUU20 Cam is selected.

5. ACTUATION MECHANISM

Actuation mechanism is most important part of spreader beam. An actuator is a type of motor that is responsible for moving or controlling a mechanism or system. It is operated by a source of energy, typically electric current, hydraulic fluid pressure, or pneumatic pressure, and converts that energy into motion. There are two main actuation mechanism taken in consideration while designing spreader system. First is hydraulics and second is electrical, every actuation mechanism has its own pros and cons. In hydraulics no mechanical parts are used therefore no wear and tear but on the other hand in electrical less power consumption and less bulky. It was a tough call, which mechanism is most compatible for not only in design perspective but also in costing and maintenance. Pros and cons for each mechanism given below.

1) Hydraulic actuators :

Advantages

- Hydraulic actuators are rugged and suited for high-force applications. They also operate in pressures of up to 4,000 psi.
- Hydraulic motors have high horsepower-to-weight ratio by 1 to 2 hp/lb.
- A hydraulic actuator can hold force and torque constant without the pump supplying more fluid or pressure due to the incompressibility of fluids
- Hydraulic actuators can have their pumps and motors located a considerable distance away with minimal loss of power.

Disadvantages

- Hydraulics will leak fluid. Like pneumatic actuators, loss of fluid leads to less efficiency. However, hydraulic fluid leaks lead to cleanliness problems and potential damage to surrounding components and areas.
- Hydraulic actuators require many companion parts, including a fluid reservoir, motors, pumps, release valves, and heat exchangers, along with noise-reduction equipment. This makes for linear motions systems that are large and difficult to accommodate.
- The initial unit cost of an electrical actuator is higher than that of pneumatic and hydraulic actuators.

2) Electrical Actuators:

Advantages

- Electrical actuators offer the highest precision-control positioning. An example of the range of accuracy is +/- 0.000315 in. and a repeatability of less than 0.0000394 in. Their setups are scalable for any purpose or force requirement, and are quiet, smooth, and repeatable.

- Electric actuators can be networked and reprogrammed quickly. They offer immediate feedback for diagnostics and maintenance.
- They provide complete control of motion profiles and can include encoders to control velocity, position, torque, and applied force.
- In terms of noise, they are quieter than pneumatic and hydraulic actuators
- Because there are no fluids leaks, environmental hazards are eliminated.

We selected electrical actuators because of its accuracy and its mobility which couldn't be possible in case of hydraulic actuators.

5.1 DESIGN OF RACK AND PINION

Use of rack and pinion is for linear actuation of a telescopic beam from the main beam. A rack is bolted at the top surface of telescopic beam and bolted exactly at the centre line. Rack and pinion arrangement transmits the power with almost 99% efficiency and the action is smooth.

Calculations
Mass to be moved (actuated):- [self weight of telescopic beam+ magnets weight+ metal cover+ spring and chains]

Weight to be moved= Mv =[200+212+84+15]kg= 511 kg

According to application velocity of moving beam should be 4cm per sec i.e. 0.04 m/sec

Force analysis:-

Fr= Force at rack.

Mass to move, M Kg
Linear Speed, V M/s
Acceleration time, ta
Acceleration due to gravity, g 9.8 M/s2
Coefficient of friction, μ
Pitch circle dia. of pinion, d mm.
External Force, F N
Service Factor, S.F.
CALCULATED DATA
Acceleration, a
Application force at rack Fr
Application Torque at pinion Tp.
Design Torque, Td .

Fr=[fc*Mv*g+Mv*a+Fext]........................[fc=frictional coefficient]

Fr=[0.15*511*9.81+0.04*511+0]

Fr=772.30 N

Torque of pinion= Fr*D/2000 N-m

Tp=46.338 N-m

Service factor=1.2......... Assumed

Design torque= 1.2*Tp= 55.60 N-m

Power at pinion-rack Assembly

P1=Td*wp= 55.60*(18/60)*2*π

P1=104.8035 watt

Power at worm Gear box

Assumed efficiency= 70%

P2=P1/ŋ

P2=166.35 watt

Power at work motor [efficiency 90%]

P3=P2/ŋm=184.83 watt

Torque At Rack= 98.05 N-m

Motor torque=Tm= P3*60/(2π*rpm)

Tm=49.02 N-m .... (rpm - 18)

Dimensions of driver and driven gears are as follows:

Driver gear (g1):

Module (m) - 3

Diameter (d) - 60 mm

No of teeth (z) – 20

Face width (t) – 28.3 mm

Driven gear (g2):

Module (m) - 3

Diameter (d) - 120 mm

No of teeth (z) – 40

Face width (t) – 38.3 mm

Dimensions of rack:

Module (m) - 3

Length (l) -2000mm

No of Teeth (T) – 212

Height (h) – 30mm

Width (b) – 30mm

As per required torque motor is selected.

5.2 SELECTION OF ELECTRIC MOTOR

An electrical motor is such an electromechanical device which converts electrical energy into a mechanical energy. In case of three phase AC operation, most widely used motor is Three phase induction motor as this type of motor does not require any starting device or we can say they are self starting induction motor.

Working of Three Phase Induction Motor

Production of Rotating Magnetic Field
The stator of the motor consists of overlapping winding offset by an electrical angle of 120°. When the primary winding or the stator is connected to a 3 phase AC source, it establishes a rotating magnetic field which rotates at the synchronous speed. Secrets behind the rotation: According to Faraday's law an emf induced in any circuit is due to the rate of change of magnetic flux linkage through the circuit. As the rotor winding in an induction motor are either closed through an external resistance or directly shorted by end ring, and cut the stator rotating magnetic field, an emf is

induced in the rotor copper bar and due to this emf a current flows through the rotor conductor. Here the relative velocity between the rotating flux and static rotor conductor is the cause of current generation; hence as per Lenz's law the rotor will rotate in the same direction to reduce the cause i.e. the relative velocity.
Thus from the working principle of three phase induction motor it may observed that the rotor speed should not reach the synchronous speed produced by the stator. If the speeds equals, there would be no such relative velocity, so no emf induction in the rotor, & no current would be flowing, and therefore no torque would be generated. Consequently the rotor can not reach at the synchronous speed. The difference between the stator (synchronous speed) and rotor speeds is called the slip. The rotation of the magnetic field in an induction motor has the advantage that no electrical connections need to be made to the rotor. Thus the three phase induction motor is: • Self-starting. • Less armature reaction and brush sparking because of the absence of commutators and brushes that may cause sparks. • Robust in construction. • Economical. • Easier to maintain.
Braking in induction motors refers to quickly bringing the speed of the motor to zero. Braking can be categorized into two broad categories viz. mechanical braking and electrical braking. Mechanical braking involves stopping the shaft by means of a braking shoe. When the braking is to be done, the supply to the motor is cut off and the brake is applied to bring the motor to a halt. Mechanical braking used in cranes and hoists. It is also used in elevators when the elevator has to stop at a specific floor of the building .Electrical braking involves stopping the motor using electrical means. Most electrical braking systems have a mechanical brake to hold the shaft in position once the machine has been stopped.

DC injection braking

In DC injection braking, a separate rectifier circuit produces a dc supply. When the brake is to be applied, the ac supply to the stator is disconnected and a dc supply is given to two of the phases. The dc voltage in the stator sets up its own magnetic field. The conductors of the rotor which is rotating will cut the magnetic field. As the conductors are short circuited, a high current is produced. This causes a braking torque to be produced in the rotor. The current produced in the rotor is dissipated as heat. This system can be used only when the rotor can withstand the heat which will be produced when the brake is applied.

Motor specification and dimensions:

Make - Indian
Mounting - Foot mounting
Power - 1 H.P
Torque - 40 N-m
Input r.p.m - 1700
Output r.p.m - 36
Gearbox - Worm and worm wheel
Reduction ratio - 47:1
Braking system - DC braking system
No of poles - 4 poles
Phase - 3 phase
Voltage - 440 volt A.C.

Fig.9

6. 3D CAD MODEL

The 3D model of the Lifting beam assembly is created using CREO PARAMETERIC software from the design calculations.

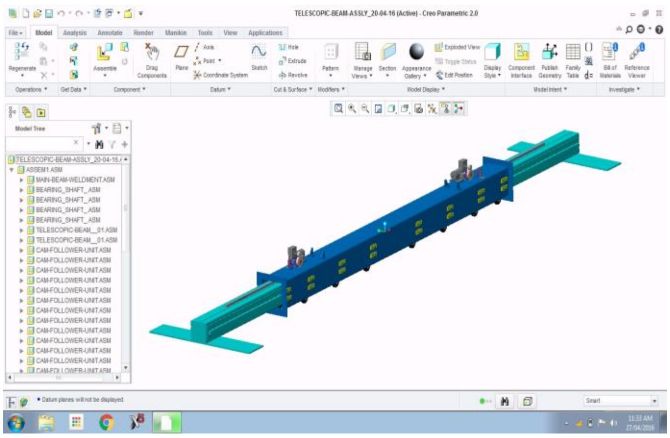


Fig.10

7. STRESS AND DEFORMATION ANALYSIS (FEA-ANALYSIS)

Finite Element Modeling (FEM) and Finite Element Analysis (FEA) are two most popular mechanical engineering applications offered by existing CAE systems. Finite element analysis (FEA) is a computerized method for predicting how a product reacts to real-world forces, vibration, heat, fluid flow, and other physical effects. Finite element analysis shows whether a product will break, wear out, or work the way it was designed. It is called analysis, but in the product development process, it is used to predict what is going to happen when the product is used. So for the analysis of the whole telescopic beam we have used ANSYS 16. All the analysis is done in the static structural mode.

Deflection:

From the static analysis, total maximum deflection is observed to be 15mm.The range of deflection is between 0 to15mm

Stress:

From the static structural analysis VonMises stresses are obtained. Maximum VonMises stress is 525MPa.

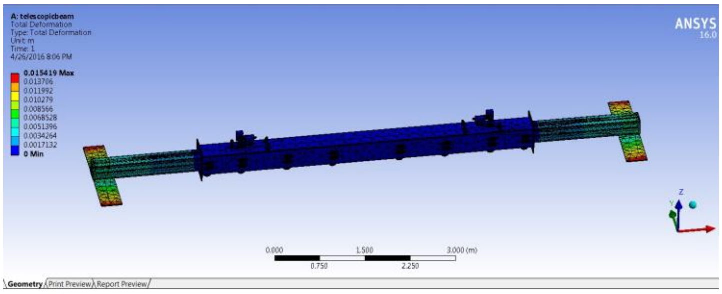


Fig.9

Figure shows deformation analysis of a whole assembly. It can be seen that the maximum deformation is within the limits and it occurs at the end of plate.

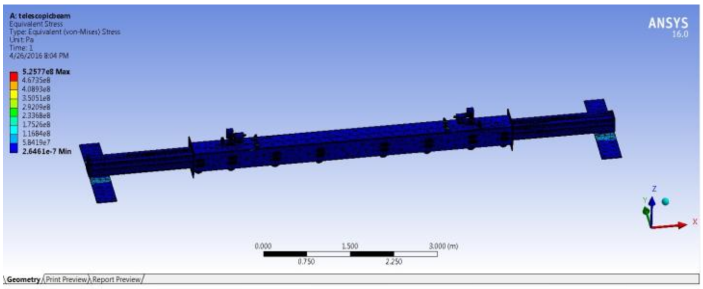


Fig.10

As we can see in the image that stress distributed is at minimum level. Thus design is safe for loading conditions.

6. CONCLUSION AND FUTURE SCOPE

The Optimum design with analysis is achieved. Use of electrical actuation has considerably reduced the cost of overall production. An efficient and a failsafe device with high working capability is achieved after the proposed modifications in a conventional EPM Lifter Beam. Selection of readymade material has reduced time of production and reduced many manufacturing process which included to built a square tube. Mobility is achieved due to telescopic action. This device has major future scope in material handling industries, shipping industries , building industries and heavy duty goods transportation industry.

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