Design and Fabrication of TMT bar bundle Bending Machine-A case study on TMT Bending Machine

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Abstract-*Thermo mechanically treated bars are preferred over conventional mild steel bars because of their superior tensile properties. But increased strength and toughness of thermo mechanically treated bars create problem during subsequent manual bending operation. Hence, there felt a need of adoption of machine bending operation. In this paper the problems associated with the manual bending operation and subsequent adoption of the machine bending are discussed. A systematic study reveals that there is a substantial improvement in the quality of the bending. More uniform bend products are produced. Productivity is also improved because of reduction intime of bending. Along with the quality of the bending there are saving in terms of the floor space area and labor cost.*

Keywords-Bending Machine, Manual bending, TMT bars, Uniform bending etc.

I. INTRODUCTION

Thermo mechanically treated (TMT) bars are nowadays afundamental requirement for construction in India and abroad. TMT bars have improved properties such as yield strength, ductility and toughness and corrosion resistance over Torsional bars. The multilayered microstructure having soft ferrite-pearlite core of TMT bars enables them to bear dynamic and seismic loads. TMT bars have high fatigue resistance to Dynamic/ Seismic loads due to its higher ductility. This makes them most suitable for use in earthquake prone areas . With the above properties, TMT steel is also highly economical and safe for use and hence finds wide application in the areas of construction of roads, buildings bridges etc.

TMT bars are most preferred because of their flexible nature and fine welding features. TMT bars (having low carbon content) can be used for welded joints without reduction in strength at the weld. External ribs running across the entire length of the TMT bar give superior bonding strength between the bar and the concrete and fulfils Bond requirements as per IS: 456/78 and IS: 1786/85.

Due to very high elongation values and consistent properties through out the length of the bar, TMT bars have excellent workability and bendability. TMT bars provide better safety of structures because of higher Strength combined with higher ductility and Bendability. Unlike cold twisted deformed (CTD) Reinforcement bars, TMT bars have high thermal stability. They are the preferred choice in the application areas such as construction of Chimney fires as they sustain elevated temperatures of 400-6000 C.

II. NATURE OF THE PROBLEM

TMT bars are moved from the manufacturing unit to the dealers and construction sites by means of surface transportation. For ease of transportation and subsequent storage at the dealers site uniform bending of 12 meter long TMT bars is usually required so as to acquire minimum floor space and ease in handling. As the TMT bars have very high yield strength, it become difficult to bend them manually and uniformly. The non-uniform bending results in 8-9% wastage of material, A lot additional floor space was required to store the TMT bars and also leads to the difficulty of in loading and unloading. This results in excessive labour costs, poor packaging and gradual loss in the good will of the company.

III. SCOPE OF THE PROBLEM

Thermo mechanically treated bars are preferred over conventional mild steel bars because of their superior tensile properties. But increased strength and toughness of thermo mechanically treated bars create problem during subsequent manual bending operation. Hence there felt a need of adoption of machine bending operation.

IV. DESIGN AND CALCULATION FOR TMT BENDING MACHINE

(A) DESIGN OF PULLEY

MATERIAL = Cast Iron …………………..Table XV-(7)
As diameter of Pulley is above 150mm (D= 700.1 mm)
TYPE OF CONSTRUCTION = Arm Construction…….Table XV-(7)

(B) DESIGN OF SHAFT

$P_d = 2\pi\ N_2\ T_d / 60$ …………………….(1)
Where ,
P_d = Design Power = $P_R \times K_l \times K_\theta$ …………………Table XV-(1)

Where,
P_R = Rated Power = 22 KW

$K_l = 1.1$ [For driver shaft electric Motor & driven line]……...Table XV-(2)

$K_\theta = 1$ [Angle with Horizontal 0]……………..Table XV-(3)
Now
$P_d = 22 \times 1.1 \times 1 = 24.2$ KW
N_2 = Rpm of driven = 24 rpm

Now put all above values in equation (1)

$24.2 \times 10^3 = 2\pi \times 24 \times T_d / 60$
$T_d = 1452 \times 10^3 / 24 \times 2 \times \pi$
$T_d = 9628.87$ Nm $= 9628.87 \times 10^3$Nmm
But
$T_d = \pi/16 \times f_s \times d^3$
Where,
$F_s = S_{ys}$ / F.S = 271 /3 = 90.33 [SI Grade-20]…………..Table II-(3)

$9628.87 \times 10^3 = \pi/16 \times 90.33 \times d^3$
d =81.57 mm

Apart from the twisting moment shaft is also subjected to bending moment

$D_s = 1.5 \times d = 1.5 \times 81.57 = 122.35$ mm

Hence Standard D_s = 120 mm ……………………Table XI-(4)

(C) DESIGN OF HUB
$D_h = 1.5\ D_s + 25$ ……………………Table XV- (7)
$D_h = 1.5\ (120) + 25$
$D_h = 205$ mm
Length,
$L_h = 1.5\ D_s = 1.5\ (120) = 180$ mm

(D) DESIGN OF KEYWAY
MATERIAL – SAE 1030
Key width b = 36 mm Key height h = 18 mm … Table VII-(5)
$L = L_h = 1.5\ D_s$
$L = 1.5\ (120)$
L = 180 mm

(E) ALLOWABLE BENDING STRESS
$\sigma_b = M / Z$
$90.33 = 300.25 \times 10^3 / Z$
$Z = 3.324 \times 10^3\ mm^4$
But,
$Z = \pi\ h^3 / 64$
Where h is bending length or circumfrcial length
$3.324 \times 10^3 = \pi\ h^3 / 64$
$h^3 = 67715.97$
h =40.75 mm

(F) DESIGN FOR ROTATING PLATE

01- Treat circular plate as supporting element subjected to bending and may deflect.
02- Considering simply supported h of the disc and load of TMT rod as uniformly
Distributed over the surface area.

(G) LOAD AND SUPPORT ………………. Table I-(3)

$F = \pi.\ R^2.\ P$
Where,
R = D/2 = 1500/2 = 750 mm = 0.750 m
P = Load (Consider 32 mm TMT bar and 1.2 m length)
P = 7.57 Kg = 7.57 x 9.81 = 74.26 N
Now,
$F = \pi \times (0.750)^2 \times 74.26$
F = 131.228 N

$A = F / t^2$
Where,
T = 25 mm Flat plate
$A = 131.228 / (0.025)^2$
$A = 209.96 \times 10^3\ N / m^2$

(H) MAXIMUM STRESS AND SUPPORT DEFLECTION

$\sigma_{rmax} = \sigma_{tmax} = -0.4\ A$ at centre
$\sigma_{rmax} = \sigma_{tmax} = -0.4\ (209.96 \times 10^3)$
$\sigma_{rmax} = \sigma_{tmax} = -83.985 \times 10^3$

Now,
$C = F / E.\ t^3$

Where,
E = Modulus of Elasticity = 204×10^3[I.S. C-30 SAE 1030] ……Table II-(7)
$C = 131.228 \times 10^6 / 204 \times 10^3 \times 25^3$(All values in mm)
C = 0.0412

(I) DEFLECTION

$\delta_{max} = 0.24 \times C \times R^2$
$\delta_{max} = 0.24 \times 0.0412 \times (0.750)^2$
$\delta_{max} = 5.562 \times 10^{-3}$
$\delta_{max} = 0.00556$ mm

DESIGN FOR PIVOT PIN

Consider both shear and bending Stress in the Pin.

BENDING FORCE REQUIRED

$\sigma_b = 32 . M / 5 . d^3$
Where,
M = Final Torque on the disc
$M = 29.21$ KW $= 29.21 \times 10^3$ W ……………..(From Chapter 5)
Now,
$\sigma_b = 32 \times 29.21 \times 10^3 / 5 \times (32)^3$ ………….(Considering for 32 mm TMT)
$\sigma_b = 5.705$

CONSIDERING SHEAR FAILURE ON PIN

$T = \text{Bending Force} \times 4 / \pi \times d_p^2$
Considering I.S C-50 Annealed SAE 1050
$T = S_{ys} / F.S$

T = 246 / 3
T = 82
Now,
$82 = 5.705 \times 4 / \pi \times d_p^2$
$d_p = 0.088$ m
$d_p = 88$ mm

(1) TORQUE CALCULATION ON THE GEAR BY THE MOTOR

Motor Specification= SQ CAGE TEFC 3 PHASE
Power = 22 KW = 22000 Watt
N = 1440 Rpm (S4 Duty)
Torque (T) = (Px60) / (2ΠxN)
Torque (T) = (22000x60) / (2x3.14x1440)

Torque (T) = 145.892 Nm

(2) FORCE REQUIRED TO BEND THE BAR

2.1 Bending Equation
M / I = σb / Y
Where
2.1.1 I = Moment of Inertia
$I = \Pi / 64 \text{ X } d^4$ (For Solid Circular Shaft)
$I = \Pi / 64 \text{ X } (32)^4$
$I = 51471.85 \text{ Kgmm}^4$

2.1.2 Y = Distance from Neutral Axis
Y = d/ 2
Y = 32 / 2
Y = 16 mm

2.1.3 σb = Bending Stress
σb = Syt / Fos (SI Grade 20)
σb = 271 / 3 (IJIRAE, ISSUE 4, VOLUME 2, ISSN: 2349-2163)
$\sigma b = 93.333 \text{ N / mm}^2$

Now put the Values of I , Y , σb in the bending equation
M / 51471.85 = 93.33 / 16
M = (93.333x51471.85) / 16
M = 300251.386 Nmm
M = 300.251 Nm

2.2 GEAR BOX (PREMIUM U1000) OUTPUT RPM
G/B rpm = Motor Rpm/ Gear ratio (Gear ratio = 60 :1)
= 1440 / 60
G/B rpm = 24 rpm.

2.3 FINAL TORQUE ON ROTATING DISC

I/P Torque = O/P Torque x Winch overall efficiency
(" SINGLE DRUM WINCH DESIGN " By Michael Markey Third edition Chapter 10)
Where
I/p torque = 21.91 KW (U Premium 1000 60:1 Gear box)
Winch efficiency =70 to 75 % (For Worm Gearbox)

21.91 = O/p torque x 0.75
O/p torque = 21.91/ 0.75
O/p torque = 29.21 KW

(3) TIME REQUIRED FOR BENDING " 1" BUNDLE

Target = 500 Ton / day
In 1 Hour = 500 / 20
= 25 Ton/day

In 1 Minute = 25 / 60
= 0.416 Ton/day

1 minute $\Rightarrow$ 416 kg

X $\Rightarrow$ 13 kg (for 8 mm)

Time required to bend = 33.13 x 60 /416
1 bundle (in second) = 4.778 sec
= 5 sec
Similarly
Time required to bend = 88.74 x 60/416
(20 mm x 12 m) = 12.79 sec
= 13 sec (approx.)

Weight Calculation Of 8 Mm To 32 Mm Tmt

SR.NO.	TMT SIZE (MM)	QTY IN BUNDLE	WEIGHT (KG)
01	08	7	33.13
02	10	6	44.37
03	12	5	53.24
04	16	4	75.72
05	20	3	88.74
06	25	2	92.43
07	32	2	151.44

Table 5.7 Weight Calculation of 8mm to 32 mm TMT

V. CONCLUSION

1. TMT bar bending machine save floor space area.

The commissioning of the automatic bending machine led to a saving of about 77% in terms of floor space area. There is a reduction of the span by about 57% by adopting „U" bent TMT bars over V bent TMT bars which ensure the safe loading operation.

2. TMT bar bending machine save bending time.

The time required for the machine bending is drastically reduced by 33% as compare to the manual bending which enhances the productivity.

3. TMT bar bending machine reduce man power.

With adoption of machine bending of TMT bars, man power saving of about 66% was achieved as compared to manual bending.

4. TMT bar bending machine save cost of labour.

The machine bending of TMT bars saves upto 28% cost over the manual bending operation. Further the machine and installation cost can be recovered within four to five months from the date of operation.

5. TMT bar bending machine gives more uniform bend bar over manual bending

With the adoption of machine bending the uniform product quality was achieved which further increased the efficiency of the packaging and quicker dispatch. The commissioning of the machine has imparted a better and safe environment during bending

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