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Modeling of Economic Cost and Technological Control in Motor Housing Punch

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Abstract: *- With regards to the assembly line of cost control of motor housing process will be necessarily respected. The control of equipment includes to structure wheel, conveyor and motor for benefit which also needs to be controlled in detail. Only in this way can we fundamentally resolve the main problem of high cost process in manufacturer. When the produce Q increases AC&AFC decreases with nonlinear. When L is 2, 4 and 6 Meantime TC&VC increase with non-linearity. Among them the TC increases highest and VC increases lightly. AC, AVC & AFC decline with non-linearity. It expresses that the cost has been down with the many Q. When K is 25, 30 and 35 the AC, AVC and AFC decline meantime. The TC, FC and VC is larger than former. It expresses that the cost will increase under this condition. The volume is 6*E03cm3 that is value at thickness of 3mm. There is 2 times force decline and save that's about thickness ratio too. With the increase of 70r/m rotational speed, and the torque force increases to 20KNm with the increase of diameter to 60mm. The first punch of the process is the key. At this point, the deformation is 2.4 times which is the largest, which needs to be paid attention in the design, and the deformation check. When the width increases to 6mm, the volume becomes 12*E03cm3 that is said that gravity attains 84Kg which is the maximum mass value in motor drawing. When the d=0.5m the force will become 0.3tons at m=0.05tons & 90r/m, it saves 53 times than the biggest one of 16tons. The volume becomes about 3500cm3 that is said that gravity attains 20tons which is the maximum mass value in feed steel strip at the initial stage.*

Keywords:*- automatic production line；flywheel; motor; motor housing size；modeling control; AVC; TC&VC; L; K； Q*

1. Introduction

The flow line need modeling control for the purpose of high cost in manufacturer shop. Because the highest price equipment and material is used and specially the automatic flow line consumes the equipment price many years. Firstly the engineering model for flow line in every respects of its process is needed to building. Secondly, the account cost control is needed simultaneously. For instance, the Toyota motor company engineer adopts their scientific modeling results and compares with before and after the control is done in lines, so the a low deviated ie high accuracy can be gained by Engineers. Then they can ensure machine lifespan, not only excessive wearied, but also so fast that we don't make machine equipment breakdown for maintenance in time. [1~4]On the other hand they have to spend a lot of money, apply the original factory personnel for coming and fixing. This is because the load and frequency of the machine is too over it has not kept up, and do not reach the designated engineering demand on raw material. In this way they will produce a lot of waste materials and over used machines. The mould economic efficiency is important factor in automatic industry

so that we discuss this factor for the modules' benefit. [5~7]

2 Steel band

According to the parameters in table 1 it is calculated that kinematic relation about steel band for feeding material in motor housing process as below.

Table 1 some parameters of the steel strip.

Parameters	Width(mm)	Thickness(mm)	Radius of out(mm)	Radius of inner(mm)
value	130-200	3~6	900	100

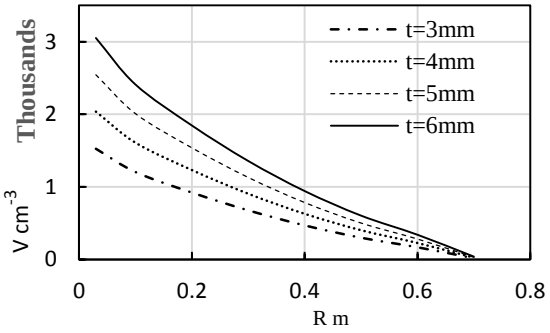


Figure 1 relationship between parameters volume-Radius in the receiving of the steel strap.

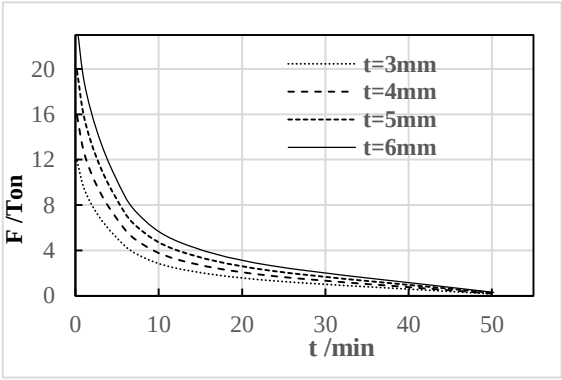
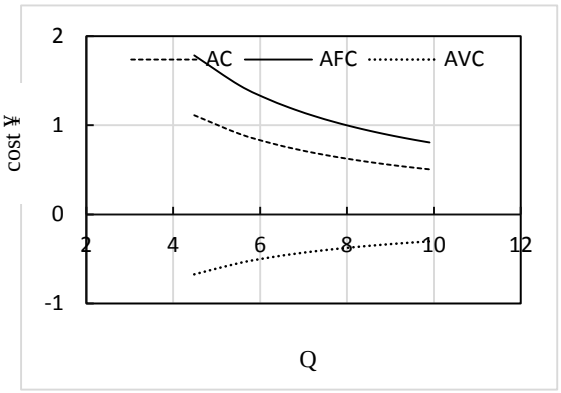


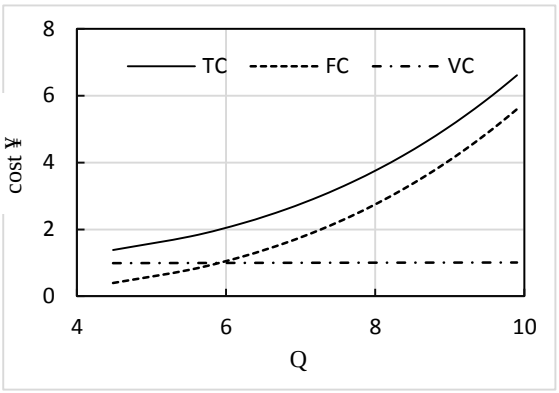
Figure 2 relationship between parameters force-time in the receiving of the steel strap.

As shown in Figure 1, with the increase of the radius of the steel strip of 0.1~0.8m, the housing volume decreases with the thickness from 3 to 6mm as well. Here the width steel strip is supposed to 20cm. When the thickness is increased to 6mm, the volume becomes about 3500cm3 that is said that gravity attains 20tons which is the maximum mass value in feed steel strip at the initial stage. Meantime, the volume is 1600cm3 that is value at thickness of 3mm at the beginning feed. There is 2 times force decline and save feeding force as well with the thickness decreasing from 6mm to 3mm. Total time is about 50min from feed beginning to end. Meantime the force decreases from 12~23tons to 0 and with strip radius from 0.7m to 0.

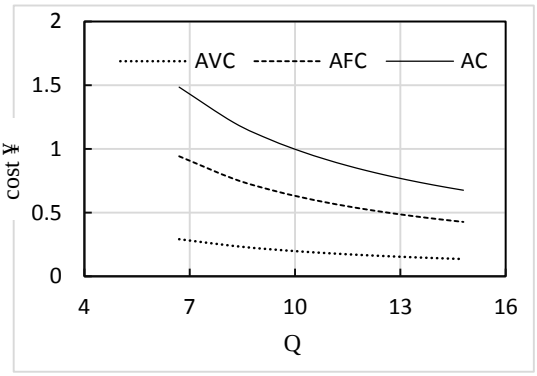
3 The cost control of economics modeling



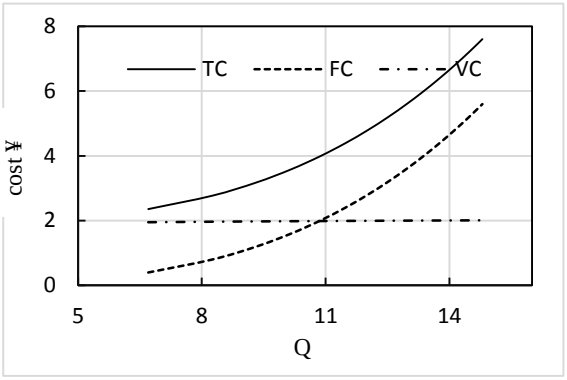
(a) L= 2



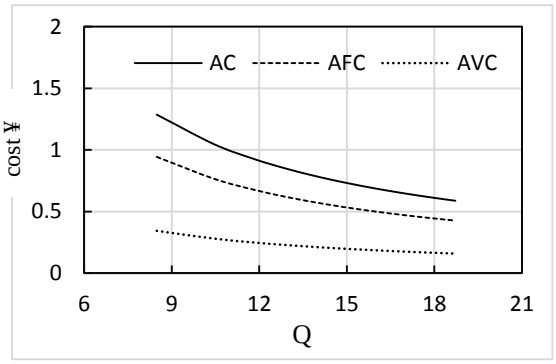
(b) L= 2



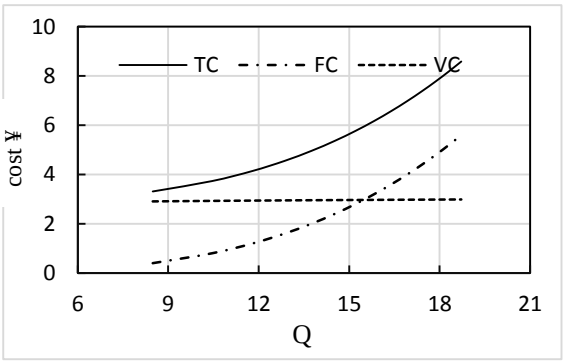
(c) L= 4



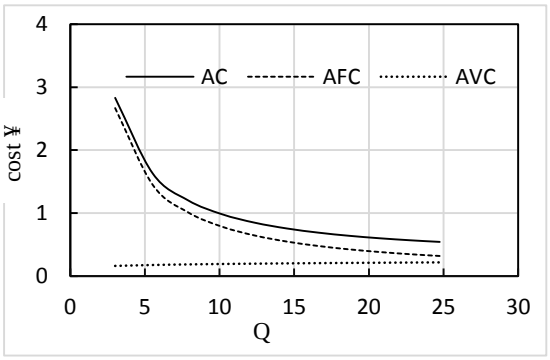
(d) L= 4



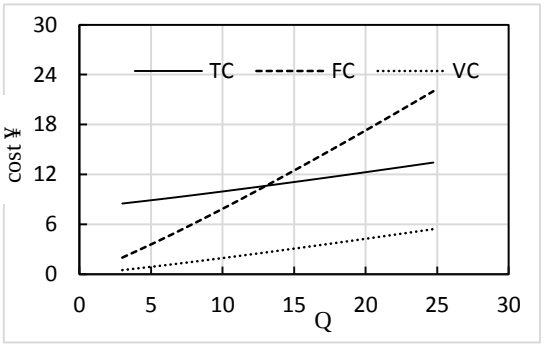
(e) L=6



(f) L= 6



(g) L=1,2⋯,14; K=1,2⋯,14



(h) L=1,2⋯,14; K=1,2⋯,14

Figure3 Relations between cost-Q with L in process

Here, TC is total cost; FC is fixed cost;VC is variable cost. AC is average cost; AVC is average variable cost; AFC is average fixed cost; L is labor; K is capital.

When the product amount Q increases TC&VC increase near in proportion to Q from Figure 3 (a~b)meantime AC, AVC& AFC decreases too with nonlinear. From Figure 3(a) if Q is 9 the AFC is

¥ 0.8, meanwhile it is ¥ 6 if Q is 1.3. The AFC is slope degree with Q=1/5=0.2 that is the lowest slope degree totally when we use two side point to analyze. The biggest Q difference is used to calculate the biggest venture will be formed, It's said that the much products need to less AFC. If it uses trend to analyze its slope as above, by comparing the primary is steep, while the latter is sluggish. The cost is more expensive generally so that we adopt AFC trend is good which is lower. The ¥6 of AFC has been used for investment to define 1.3 pieces, which is one investment. In Figure 3(a) with the increasing Q the AC and AFC decreases. Furthermore AC is bigger than AFC. They decline steep first and then sluggish when Q is 6. It expresses that the cost has been down with the many Q. From Figure 2(a) the TC increases lightly and then FC increases highly while VC is a certain. Generally the Figure reflects the three parameters. VC is ¥2 while TC is ¥4 at Q being 11 in Figure 3(c). To decrease total cost the VC and TC it is needed to calculate and analyzed further. When L is independent variable in Figure 3（c）the TC and VC are main parameters for evaluating total cost. For instance when Q is 10 pieces the TC and VC are ¥4 and ¥2 respectively as above. The values are good ones for investment, because this is optimum one according to this figure. With the increasing Q the total and variable cost will increase too high so that it is difficult to control them. Only if AC and AFC is middle position the TC and VC is not high relatively. It is observed that high VC shall be controlled upon a certain AFC. The turn TC>VC>FC is the effective trend from here so the wage in VC is more expensive than plant、equipment and molds. From Figure 3（a~f）it is found that with the increasing labors from 2 to 6 the total cost and variable cost will decrease upon increasing quantity. It means that when increasing L the TC and FC will decrease correspondingly which main reason for cost is down.

4 Dynamics of punching housing

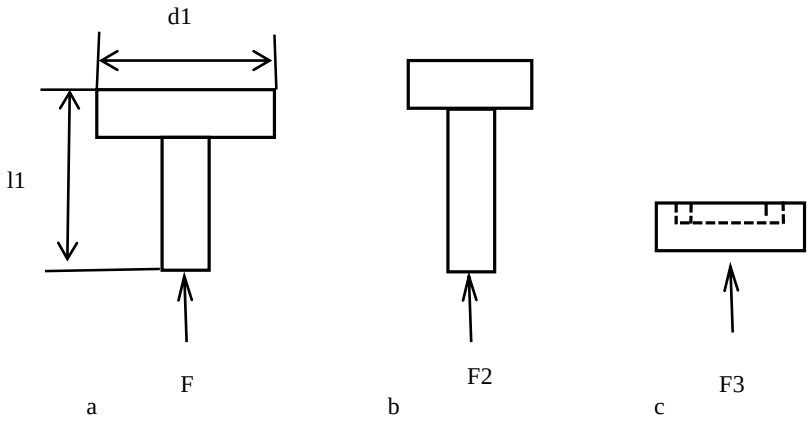


Figure 4 the schematic punching processes (a, b &c) for motor housing in course.

It is punching motor housing three power of process as shown in Figure 4(a-c). In the automatic flow product line for forming motor housing the three processes are needed: the first (a) is big diameter and short length; the second (b) is slim diameter and long length; the third is final slimmer and longer one, no drawing here; the fourth (c) is picking off the production. Because the first stamping is the biggest and difficult to produce it has been used as model to calculate and analysis mainly here.

The force is calculated from stress of steel plate which is supposed 300~500MPa. It must be beyond yield stress σs which is about 300~500MPa. In order to form plasticity of booking size process

above value is adopted to guarantee the stamping process proceeding smoothly. It is usually known that the low carbon steel has low stress so above higher value than yield stress is defined to fit in thin thickness steel

The parameters of motor housing processes is listed in Table 2. Here v mm/s is velocity of rotation in wheel as discussed above; n r/min is rotation; T is torque NKm. F1 is the force by punch in the first punching; σ1 is punching stress MPa.

Table 2 the parameters of the first motor housing process.

parameters	d_1, mm	l_1, mm	t1,mm	t,s	σ1,MPa	remarks
Value	50	30	0.8	1	200-500	C steel

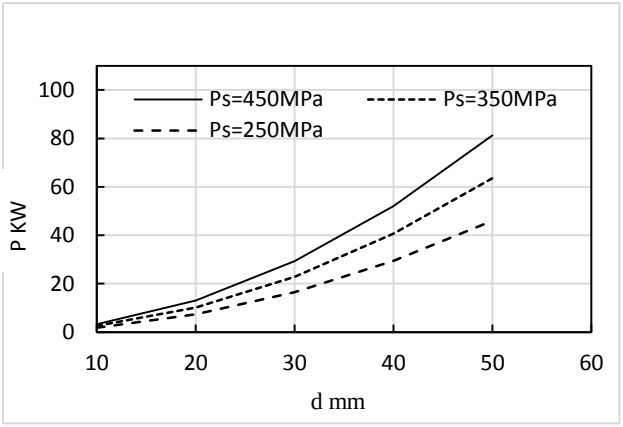
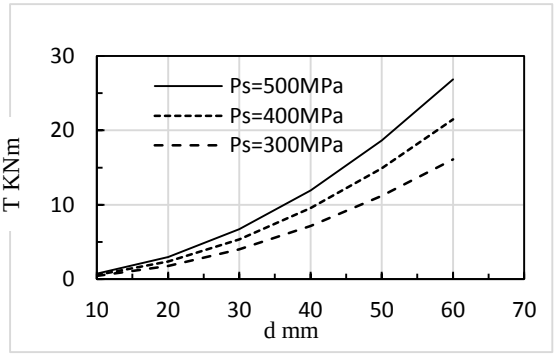
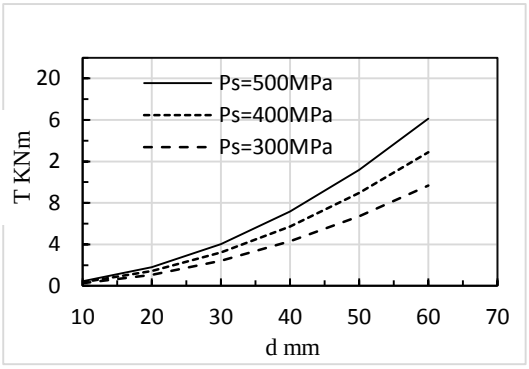


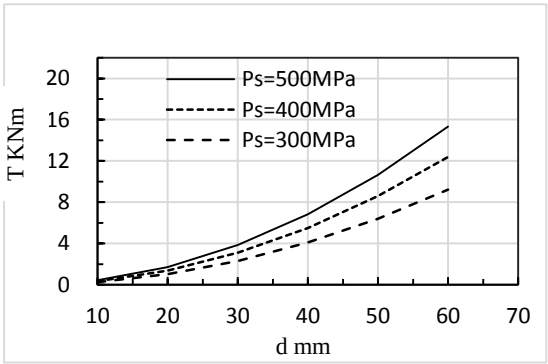
Figure 5 when the length L is 45mm the relation between powers and housing diameters with 250MPa~450MPa forces in the first punches.



(a) 20r/m

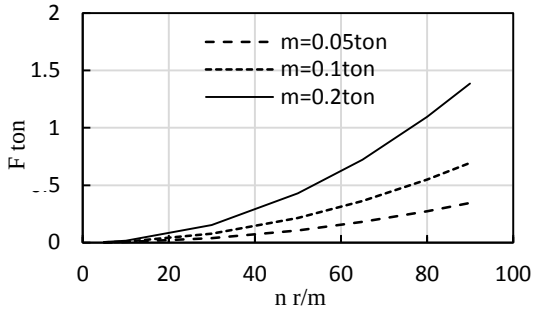


(b) 50r/m

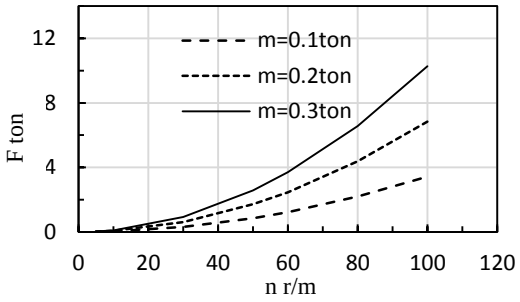


(c) 70r/m

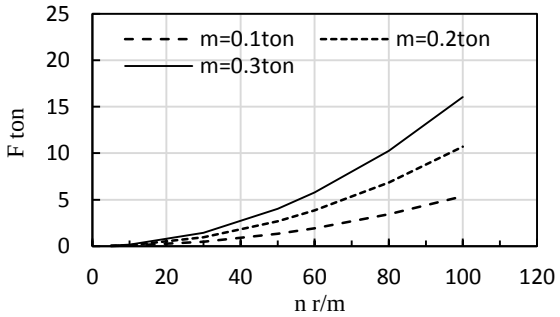
Figure 6 When the shaft rotary n is 20r/m、50r/m and 70r/m the relation between torque and diameters with 300MPa~500MPa forces in housing punches.



(a) 0.5m



(b) 1m



(c) 1.5m

Figure 7 when the flywheel diameter d is 0.5m, 1m and 1.2m the relation between force and rotary speed n in housing punches.

Detailed torque data are shown in Figure 5. Under the conditions of 60mm (500MPa) and 10mm (300MPa), the maximum torque moment is about 35KNm and the minimum is 8KNm. In Figure 6(a,b,c), with the increase of rotational speed, the torque decreases with the increase of 70r/m rotational speed, and the torque force increases to 20KNm with the increase of diameter to 60mm. Meanwhile, with the increase of diameter, the torque increases to 16KNm at the speed of 70r/m. The flywheel force increases with the increase of n. In Figure 7 (a,b,c), the flywheel force decreases with the increase of n. Meanwhile, as the flywheel diameter increases to 1.25m, the force will increase to 16tons at a speed of 100r/m. With the increase of rotational speed, the torque also decreases. When the d=0.5m the force will become 0.3tons at m=0.05tons & 90r/m, it saves 53 times than the biggest one of 16tons.

5 The economics nonlinear modeling

Production quantity Q is defined as below

$$f(L,K)=Q=\gamma L^{\alpha}K^{\beta} \text{ ----- (1)}$$

γ is technique coefficient;αis producing labor;βis capital elasticity. It has

$$LN\gamma = LNQ-\alpha LNL-\beta LNK \text{ ----- (2)}$$

Due to equation (8) it obtains

$$LN(Q_1/Q_2)=\alpha LN(L_1/L_2)+\beta LN(K_1/K_2) \text{ ---- (3)}$$

Here, subscript 1 and 2 is two coordinate.

$$LN(Q_2/Q_3)=\alpha LN(L_2/L_3)+\beta LN(K_2/K_3) \text{ ----- (4)}$$

α is solved in terms of (3) it can be gotten

$$\alpha=\frac{LN(Q_1/Q_2)}{LN(L_1/L_2)}-\beta LN(K_1/K_2) \text{ ----- (5)}$$

And $$\alpha=\frac{LN(Q_2/Q_3)}{LN(L_2/L_3)}-\beta LN(K_2/K_3) \text{ ----- (6)}$$

In terms of above equation it can be gotten

$$\beta = \frac{LN(Q_2/Q_3) - LN(Q_1/Q_2)LN(L_2/L_3)/LN(L_1/L_2)}{LN(K_2/K_3) - LN(L_2/L_3)LN(K_1/K_2)/LN(L_1/L_2)} \text{ -- (7)}$$

The cost increases steeply when labor is small then it becomes slow more than 10. At last the cost changes more sluggish when more than 20. The same situation has been observed in K with the 10 times. Meantime，the cost of K has been 1/10 to compare with one of L that explains K is cheaper than L the cost approximate 1/10. It is due to each L productivity occupying 10 times to compare with K. The labor is more expensive than capital. So the people in firm has been regulated according to fixed capital. Maybe the detail regulation is in terms of actual situation. Here in this paper k is equal to a constant in usual. The formulas for cost control are listed as below.

AC=TC′ ------- (8)

AFC=FC′ ------ (9)

AVC=VC′ ------ (10)

AC (Q) =AFC (Q) +AVC (Q) ----- (11)

MC=TC′ ------ (12)

$MP_L/P_L=MP_K/P_K$ ------ (13)

$Tc=KP_K+LP_L$ ------- (14)

$MP_K=dTP/dK$ ----- (15)

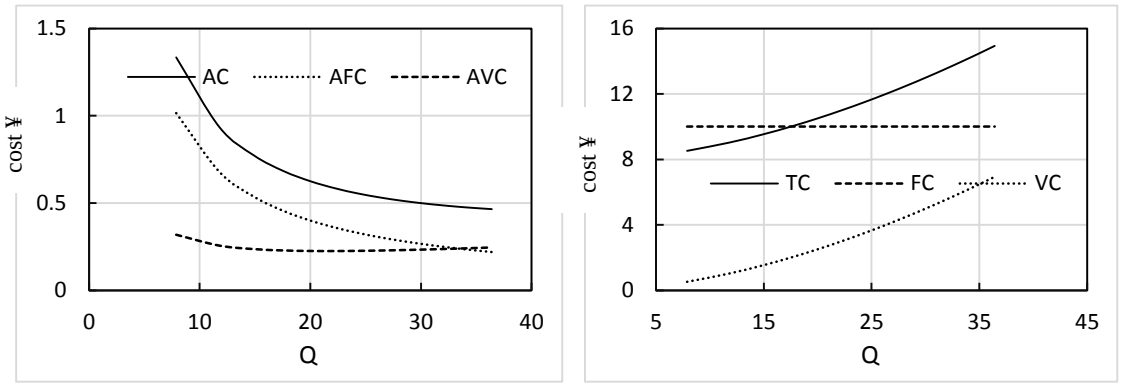
$MP_L=dTP/dL$ ----- (16)

AP=TP/L ----- (17)

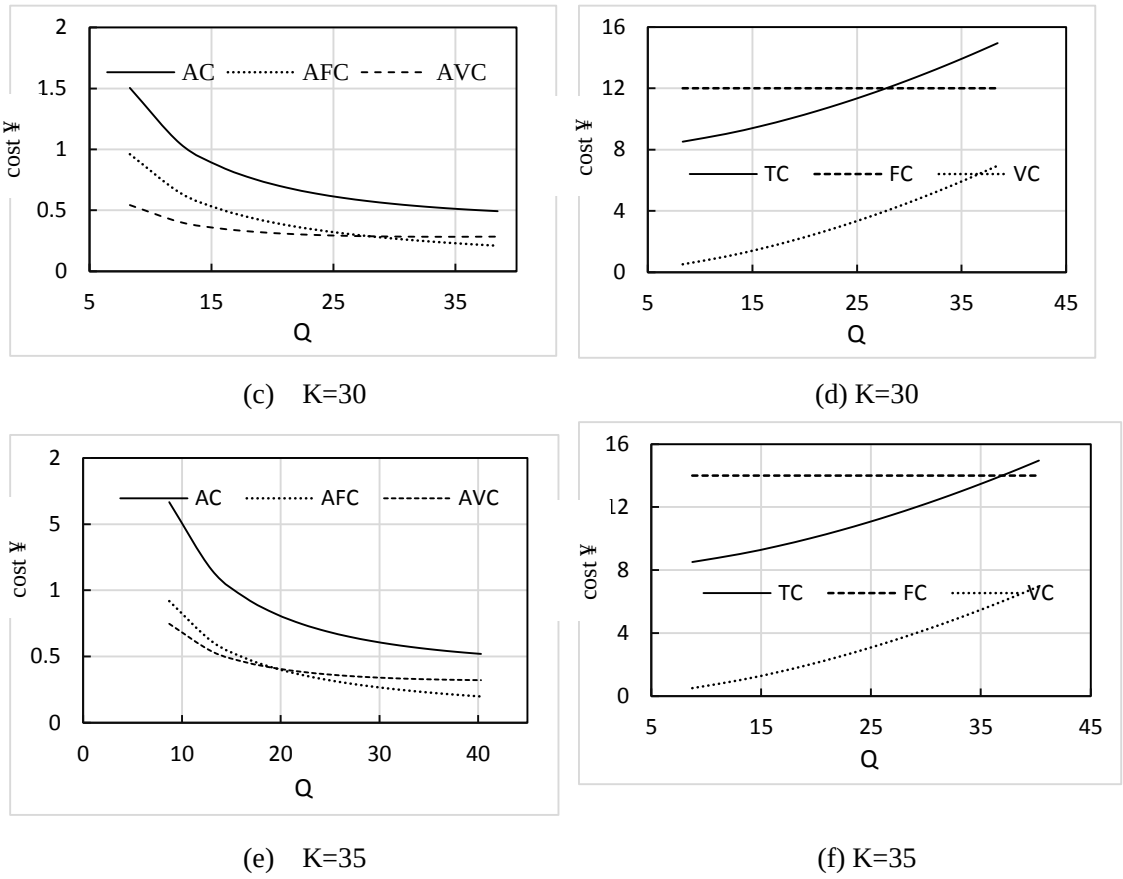
The parameters of which is formula of function Q which is products amount and L&K which is labor and capital respectively with coefficient α, β &γ. Here γ is technological coefficient; α, β are producing labor and capital elasticity respectively. The α, β & γ variance will be accurate. To use ten data and average them is numerical result with α=0.58, β=0.3 & γ=3.

5 Discussions

The steel band width is needed to regulate to small value which will save certain power of 36.8%. Besides that save too the light gravity to handle and assemble easily. It has saved the raw material which can save the money too. In terms of the simulation some big diameter also can be drawn by the power, meantime the high force will be regulated too. It must be put to a level pole with the central hole and draw regularly to avoid the band twist. Furthermore avoiding the big and heavy steel band will be used in order to guarantee the power life.



(a) K=25 (b) K=25



(c) K=30 (d) K=30

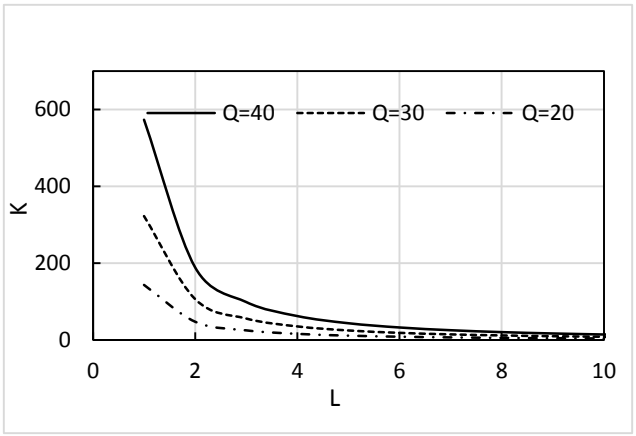
(e) K=35 (f) K=35

Figure 8 Relations between cost-Q with K (Pl=0.5 and Pk=0.4)

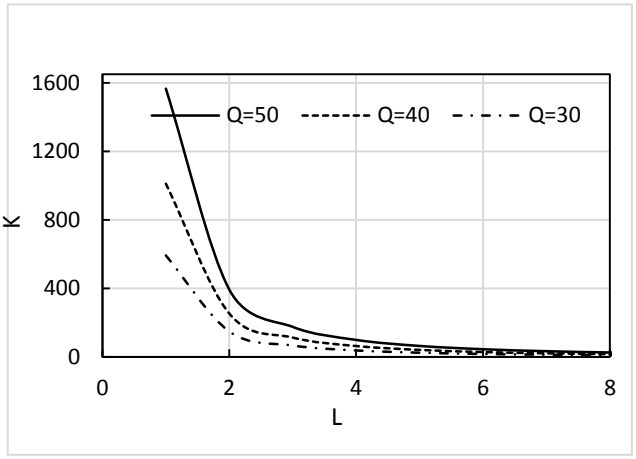
In Figure 8(a~f) are studying the cost control of production lines When K is 25, 30 and 35 AVC ,AC and AFC decline to increase meantime. The TC, FC and VC incline to decrease. It expresses that the cost will increase under this condition.

The financial account shows that relationship between cost and quantity for a worker in terms of production in a time. The time is less than 2s a little, so we should regulate the time to guarantee the product amount. When the capital price L increases AVC increases too with nonlinear which is easy to control. In terms of the curve it can be found that the cost increase point is to define the lowest price in order to save average cost. Because the nonlinear curve slope is different we may find the sluggish slope and define the exact value to application to corporation cost control.

The housing power can be saved in terms of the product sizes, rotary speed and fly wheel so that we can control the least energy save to gain the biggest benefit. Such as through decreasing the small size (d&h), small rotary and biggest diameter we attain to decrease process cost for motor housing. For instance at the conditions of 60mm (500MPa) and 10mm (300MPa), the maximum torque moment is about 35KNm and the minimum is 8KNm. In general the smaller size it is the smaller power is. For the purpose of saving power damage the power damage must be considered too. The bearing wearing damage is main cause to result in the certain power damage which is needed to numerical and experimental analysis is the main subject for us to decrease cost. For instance the over load and long load bearing need to be replaced in time to prohibit the machine stall and slow rotary to bring out unnecessary cost.



(a) motor housing



(b) threading

Figure 9 relationship between L and K

As Figure 8 When the product amount Q increases TC&VC increase near in proportion to Q from Figure 8 (a~b)meantime AC&AFC decreases too with nonlinear. From Figure 8 (a) if Q is 37 the AFC is ¥ 7, meanwhile it is ¥5 if Q is 30. From Figure 8（a~c）it is found that with the increasing capitals from 25 to 35 the total cost and variable cost will increase upon increasing quantity. In Figure 8(a) with the increasing Q the AC and AFC decreases. Furthermore AC is bigger than AFC. The turn TC>FC>VC is the effective trend from here so wage in VC is more expensive. From Figure 8（a~c）it is found that with the increasing capitals from 25 to 35 the total cost and variable cost will increase upon increasing quantity. It means that when K increases under constant L the TC and FC will increase correspondingly which main reason for cost is down. From Figure 9 it is observed that the K is lower in motor housing than screw threading. It is expressing that more labors are need in former due to its heavy capital. On the contrary the labors are increased to 8~10 is available and cost down in threading. They are decreasing steeply and then sluggish later in common.

6 Conclusions

1. The volume is 6*E03cm3 that is value at thickness of 3mm. There is 2 times force decline and save that's about thickness ratio too. With the increase of 70r/m rotational speed, and the torque force increases to 20KNm with the increase of diameter to 60mm. The first punch of the second process is the key. At this point, the deformation is the

largest, which needs to be paid attention to in the design, and the deformation check. The volume of 6*E03cm3 is value at thickness of 3mm so there is 2 times force decline. When the d=0.5m the force will become 0.3tons at m=0.05tons & 90r/m, it saves 53 times than the biggest one of 16tons. The volume becomes about 3500cm3 that is said that gravity attains 20tons which is the maximum mass value in feed steel strip at the initial stage.

2. It is observed that high VC shall be controlled upon a certain AFC with labor. The turn TC>VC>FC is the effective trend from here so wage in VC is more expensive than plant、equipment and molds. It is found that with the increasing labors from 2 to 6 the total cost and variable cost will increase to decrease upon increasing quantity. It means that when L &K increases the TC and FC will increase correspondingly. When the produce Q increases AC&AFC decreases with nonlinear. When L is 2, 4 and 6 Meantime TC&VC increase with non-linearity. Among them the TC increases highest and VC increases lightly. AC & AFC decline with non-linearity. It expresses that the cost has been down with the many Q. When K is 25, 30 and 35 AVC decreases the AC and AFC decline meantime. The TC, FC and VC is larger than former. It expresses that the cost will increase under this condition.

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