



Optimization of number of blades per flange of a rotary puddler

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ABSTRACT

The experiment was conducted to evaluate the performance of different set of number of blades per flange of a rotary puddler under the controlled soil bin conditions. It was found that by using six number of blades (B2) per flange of rotary puddler, 84.43 per cent puddling index (PI), 110.90 Newton horizontal force (F_h), 35.60 Newton vertical force (F_v), 9.90 MJ/m × 10^{-0.3} specific energy (Es) and 8.49 percent performance index (PEI) were achieved under controlled soil bin. This was better than the four number (B1) and Eight number (B3) of blades per flange of rotary puddler.

Puddling is one of the most important operation of the paddy cultivation. Many researchers (Beeny et al., 1970; Hendric, 1975; Hendric and Gill, 1980; Sharma, 1990 and Tiwari and Singh, 1985) studied the effect of different size, shape, orientation and speed of rotary puddler in the flooded soil conditions for the optimization of blade parameters under field as well as controlled soil bin conditions. But no systematic study was made for the performance of different number of blades per flange of a bullock drawn rotary puddler in terms of quality and quantity of work under controlled soil bin conditions. Therefore, the work presented in this paper was intended to investigate the effect of number of rectangular blades per row of rotary puddler on the puddling quality and its over all performance.

METHODS AND MATERIALS

Experiments were conducted in a sandy clay loam containing 35.40% of coarse sand, 27.80% fine sand, 19.90% slit, 16.50% clay and 0.40% organic matter in a laboratory soil-bin at Indian Institute of Technology, Kharagpur. The optimum size, shape and orientation of the rectangular blades (15 cm x 75 cm x 30 degree) were used in this study as per Shrivastava [1995]. The soil conditions were simulated as field conditions with the help of processing trolley and maintained at an average cone index value of 220 ± 10 kPa at 0-152 mm depth. Before testing the blades, the soil bin was filled up with water and this flooded condition was maintained for 48 to 72 hours. The level of submergence was maint-

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ained at 30 mm throughout the experiments. The speed of operation (1.36 kmph) and depth of puddling (7.5 cm) was used for all these set of blades. Soil was puddled twice by each set of number of blades per flange. The blades were operated with the help of an electric motor. Octagonal ring transducer specially designed and fabricated on the basis of Cook, (1954) and Godwin (1975) were used for measuring the horizontal and vertical forces. The time and distance traveled were recorded simultaneously on two strip recorder for each set of blades per flange. The statistical randomized block design was used in the experiments. Fig.1 shows a schematic diagram of the experimental set up.

Puddling index was also measured soon after

the puddling operation with the help of a specially designed pounded soil sampler (Shrivastava, 1995). For determining the puddling index, soil samples were taken from the puddled soft top soil. These samples were allowed to settle for 48 h and then the puddling index was calculated by using the following formula (Pandey and Ojha, 1973) and Shrivastava (1995).

$$PI = [V_s - V_c] / V_s] \times 100 \quad \dots (1)$$

Where,

PI = Puddling index, %

V_s = Volume of soil sample, and

V_c = Volume of clean water on top after setting for 48 hours.

The specific energy also computed with the help of following relationship (Pandey and Ojha, 1973).

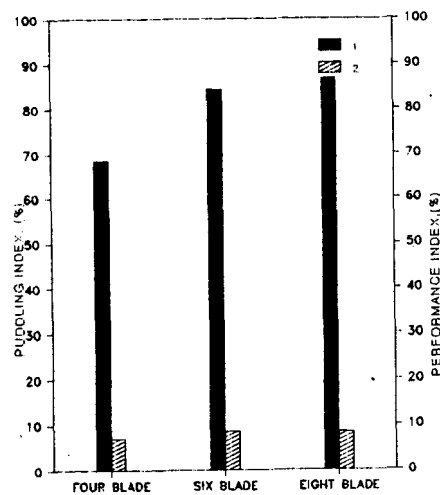


Fig. 1 Effect of number of blades per flange of a rotary on puddling and performance index

$$\text{Specific energy (Es)} = [F_n \times V_t] / V_s \quad \dots(2)$$

Where

- Es = Specific energy requirements, MJ/m³
 F_n = Draft force, N
 V_t = Forward velocity of implements, m/s
 V_s = Volume of soil puddle per unit time, m³/s
 = [D x W cos θ x V_t]
 D = Depth of cut, m
 W = Width of cut, m; and
 θ = Angle of blade w.r.t. shaft rotar

Therefore,

Specific energy (Es)

$$= [(F_n \times V_t) / W \times D \cos \theta \times V_t] \quad \dots (3)$$

The Performance Index (PEI) was computed on the basis of puddling index and specific energy requirements, the following relationship is given below :

$$\text{Performance Index (PEI)} = \text{PI} / \text{Es} \quad \dots (4)$$

Where

- PEI = Performance index,
 PI = Puddling index, and
 Es = Specific energy requirement

From the results, the optimum value of number of blades per flange of rotary puddler for achieving the best possible quality of puddling was ascertained.

RESULTS AND DISCUSSIONS

Quality of puddling

Quality of puddling determined by comparing the average values of puddling index (PI) of three different set of number of blades per flange of rotary puddler. Puddling index values were statistically analyzed and found that the different set of number of blades per flange of rotary puddler i.e. four blade/flange (B1), six blades/ flange (B2) and eight blades/flange

(B3) had a significant effect on the puddling index (PI) at 1% level of significance. Whereas, the values of critical difference (i.e. CD) of B2 and B3 were found to be not significant. It means that PI values of B2 and B3 was at par. Average values of PI are presented in Table 1.

It appears from Table 1 that the maximum values of PI was 86.72% achieved with B3; which was 2.3% and 18.29% more than B2 and B1 respectively. It was observed during the experiments that the large portion of uncut soil were left in the case of B1. With B3 on the other hand two blades act on the soil simultaneously and thus use excess energy with out any advantage on the PI. Sohene (1957) and Hendrik (1971) also had similar findings, that two blades should not strike the soil at the same time. Therefore, the six number of blades per flange (B2) was selected.

Force requirement

Horizontal force (F_h) and vertical force (F_v)
 The values of horizontal and vertical forces acting on the different set of number of blades per flange (B1, B2 and B3) were statistically analyzed and it was found that the all three sets had a significant effect on the horizontal and vertical forces at 1% level of significance. Whereas, the data of horizontal force based on CD value revealed that the B1 and B2 were not found to be significant, but B2 and B3 were significantly different at one per cent level. It means B1 and B2 had same horizontal forces. The CD values of vertical forces were however, found to be significantly different in all three different set of number of blades Table 1.

Table 1 Average values of PI, FH, Fv, Es and PEI for three different sets of blades comprising of 4,6 and 8 number in one row of a rotary puddler.

Sl. No	Number of blades	Puddling Index, PI, %	Horizontal Force F_h , N	Vertical Force F_v , N	Specific Energy ES, $MJ/m^3 \times 10^{-0.3}$	Performance Index, PEI
1	Four	68.43	109.20	32.57	9.747	7.00
2	Six	84.43	110.90	35.60	9.992	8.49
3	Eight	86.72	114.18	38.72	10.362	8.45

Specific energy (Es)

Computed values of the specific energy were statistically analyzed and it was found that the specific energy (Es) requirement of B1, B2 and B3 are significantly different at one per cent level of significance (Table 1).

The specific energy (Es) increased with increase in the number of blades per flange. The specific energy was computed minimum in the case of B1.

Performance index (PEI)

Computed values of performance index were statistically analyzed and it was found that the performance index for all the sets were significantly different at 1% level of significance.

Table 1 shows that the maximum value of the PEI was obtained in the case of B2.

CONCLUSION

The six number of blades per flange of an animal drawn rotary puddler gave better performance than four number of blades per flange and eight number of blades per flange in terms of performance index.

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