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# Manufacturing of balanced inter-saw spacers

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**Abstract.** The article defibes the ways to manufacture statically balanced inter-saw spacers for fiber-cleaning and linting machines. In manufacturing steel spacers, a welded belt joint is used where the weld seam causes an imbalance of spacers. To achieve static balance in the inter-saw spacers, we create two holes of 13.2 mm diameter in single-belt spacers and 11.85 mm diameter in two-belt spacers. At that, the remaining 10 holes in both types of spacers are made with a diameter of 15 mm, which makes it possible to balance the imbalance of these inter-saw spacers. In addition, the single-belt spacer is recommended for shafts of saw blades with large diameters, and two-belt spacers - for shafts with smaller diameters.

## 1 Introduction

Unbalance or imbalance of rotating parts is one factor affecting machines' reliability during operation [1, 2]. The imbalance of parts causes variable loads on bearing supports and high wear of contacting surfaces accompanied by vibrations of rotating machine components [3].

The key drawbacks of saw cylinder in cotton ginning machines include the use of rare non-ferrous metals (such as aluminum), deformation of aluminum spacers, excessive weight, and high costs. The existing designs of the inter-saw spacer do not provide the technological requirements for saw blades, that is, precise coordination of saws in the inter-rib gaps of the grate and imparting the necessary rigidity to the saw blade [4-7].

Therefore, the most promising and meeting the technological requirements of the saw blade, in our opinion, is the use of new designs of inter-saw spacers for the saw gin and linter machine based on new manufacturing principles that meet the requirements of primary cotton-processing technology [8-9].

To eliminate the mentioned shortcomings in the manufacture of inter-saw spacers for saw blades of cotton ginning machines, a new single-belt design of the inter-saw spacer for fiber and linter separators is proposed for large diameters (radius $r$) of shafts (Fig. 1). In this case, a disk with a hole sized to fit a large radius shaft is constructed from durable sheet metal, with the disk's outer diameter shaped like a straight-sided slot. The concentrically positioned belt is designed as a ring with perimeter holes to secure the disk and ring together. [8]. Steel saw spacers are manufactured using welded belt joints, which results in unbalanced spacers. Therefore, there is a need to balance the inter-saw spacers statically.

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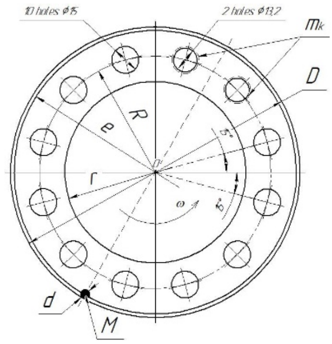


**Fig. 1.** Scheme of balanced of single-belt spacer.

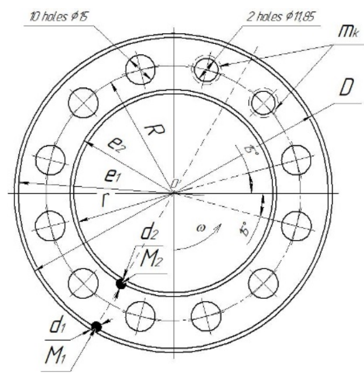


**Fig. 2.** Scheme of balanced of two-belt spacer.

The above design of the inter-saw spacer (Fig. 1) [8] is intended for shafts with large diameters, while for shafts with smaller diameters, another design is proposed (see Fig. 2) [9].

## 2 Materials and methods

*Static balancing of a single-belt spacer*. In the production of steel spacers, belts are connected using welding. Therefore, when a spacer with mass $M$ and weld diameter $d$ rotates (Fig. 1) relative to the axis with angular velocity $\omega$=76.44 s$^{-1}$ with the center of mass displaced by the eccentricity value $e$=0.078 m, a centrifugal force arises (Table 1):

Balancing a single-belt inter-saw spacer to achieve static stability

$$P = M \cdot e \cdot \omega^2. \quad (1)$$

**Table 1**. Calculation results of balanced single-belt spacer.

| Number of spacers | Welding mass *M*, kg | *e*, m | ω, rad/s | P, N | R, m | *e/R* | $m_k$, kg |
|---|---|---|---|---|---|---|---|
| 1 | 0.0005138 | 0.078 | 76.445 | 0.23419 | 0.064 | 1.21875 | 0.000626 |
| 129 | 0.0662778 | 0.078 | 76.445 | 30.21103 | 0.064 | 1.21875 | 0.080776 |

For balancing a single-belt inter-saw spacer statically (i.e. centrifugal force of inertia acting on the additionally introduced mass $M$ from welding), it is necessary to maintain the following equality:

$$m_\kappa \cdot R \cdot \omega^2 = M \cdot e \cdot \omega^2, \quad (2)$$

hence, we find

$$m_k = \frac{e \cdot M}{R} = 1.219 \cdot M \cdot \tag{3}$$

*Static balancing of two-belt inter-saw spacers.* To address the shortcomings in the production of spacers for cotton gin machines with smaller saw blade shafts (radius *r*), a new design for two-belt inter-saw spacers has been proposed (Fig. 2). This design features a disk with a hole to fit the smaller shaft size (radius *r*) and a concentric belt made of durable sheet metal. The outer diameter of the disk has a straight-sided slot, while the concentric belt is shaped like a ring with perimeter holes for connecting the disk and the ring. Additionally, a second belt with holes is added within the inner hole of the disk [8].

When two-belt spacers with masses of welds $M_1$ and $M_2$ (Fig. 2) rotate relative to the axis at an angular speed $\omega$=76.445 s-1 with a displaced center of mass at eccentricity values of $e_1 = 0.078$ m and $e_2 = 0.052$ m, centrifugal forces arise (Table 2).

**Table 2.** Calculation results of balanced two-belt spacers.

| Number of spacers | Welding mass $M_i$, kg | $e_i$, m | ω, rad/s | P, N | R, m | $e_i/R$ | $m_k$, kg Separately | $m_k$, kg Total |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.0005 | 0.078 | 76.445 | 0.234 | 0.064 | 1.219 | 0.00063 | 0.00104 |
| | 0.0005 | 0.052 | 76.445 | 0.156 | 0.064 | 0.813 | 0.00042 | |
| 129 | 0.1326 | | | 50.35 | | | 0.13463 | 0.13463 |

For the centrifugal force of inertia acting on the additionally introduced masses $M_1$ and $M_2$ from the welding seams to rotate the two-belt spacers, equality (3) must be met, from which we obtain:

$$m_{k_1} = \frac{e_1 \cdot M_1}{R} = 1.21875 \cdot M_1 \tag{4}$$

$$m_{k_2} = \frac{e_2 \cdot M_2}{R} = 1.8125 \cdot M_2 \tag{5}$$

## 3 Results and discussion

To counteract the impact of this force on the bearings, we adjust the mass by removing material from two holes in the spacer: 13.2 mm diameter holes for single-belt spacers (Fig. 1) and 11.85 mm for two-belt spacers (Fig. 2). Before welding, we measure the mass of the disk and sheet metal of the spacer ($m_{dsh}$), and after welding, we measure the mass of the completed spacer ($m_{gas}$). The difference in mass ($m_к = m_{gas} – m_{dsh}$) is calculated and recorded in Tables 3 and 4.

**Table 3.** Balancing hole diameters for single-belt spacers.

| Hole diameter, m | Mass of two holes, kg | Removed mass, kg For one spacer | Removed mass, kg For 129 spacers |
|---|---|---|---|
| 0.015 | 0.00277 | 0.00000 | 0.00000 |
| 0.0145 | 0.00259 | -0.00018 | -0.02346 |
| 0.014 | 0.00242 | -0.00036 | -0.04613 |
| 0.0135 | 0.00225 | -0.00053 | -0.06800 |
| 0.0132 | 0.00215 | -0.00063 | -0.08074 |
| 0.0125 | 0.00193 | -0.00085 | -0.10936 |
| 0.012 | 0.00178 | -0.00100 | -0.12884 |

**Table 4.** Balancing hole diameters for two-belt spacers.

| Hole diameter, m | Mass of two holes, kg | Removed mass, kg | |
|---|---|---|---|
| | | For one spacer | For129 spacers |
| 0.015 | 0.00277 | 0.000000 | 0.00000 |
| 0.014 | 0.00242 | -0.000358 | -0.04613 |
| 0.013 | 0.00208 | -0.000691 | -0.08908 |
| 0.0125 | 0.00193 | -0.000848 | -0.10936 |
| 0.012 | 0.00178 | -0.000999 | -0.12884 |
| 0.011847 | 0.00173 | -0.001044 | -0.13465 |

## 4 Conclusion

When manufacturing a single-belt intersaw spacer with a hole diameter of 15 mm in the amount of 10 pcs (Figure 1), it is necessary to reduce the diameter of the remaining two holes to 13.2 mm, which makes it possible to compensate for the imbalance of the spacer from the weld seam $m_k$ =-6.3·10$^{-4}$ kg; for 130 saw blades, it is $m_k$ =-80.78 g.

For the manufacture of two-belt spacers with a hole diameter of 15 mm in the amount of 10 pcs, it is necessary to reduce the diameter of the remaining two holes to 11.85 mm, which makes it possible to compensate for the imbalance of the spacer from the weld seam $m_k$=-1.044·10$^{-3}$ kg, which in total for 130 saw blades is $m_k$ =-134.63 g.

The calculation results allowed for the production of statically balanced steel spacers, both single-belt and two-belt, designed for shafts with various diameters.

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