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Production of V-Belt Pulley Using Segmented Pattern

[1]Dauda, M. and [2]Okechukwu, C.
[1,2]*Advanced Manufacturing Technology Programme, Jalingo, Nigeria.*

ABSTRACT
Towards reduction of machining steps and improvising V-belt pulleys where there is no lathe machine for turning blanks, a V-belt pulley has been developed using segmented pattern and three flask mould. This project is aimed at reducing the machining time, energy and cost by providing an already grooved blank for turning of pulleys and improvising same in remote areas where there is no lathe machine. Also, large diameter pulleys can be produced via this method. The chamfered top and bottom segments of the pattern have dowels, while the centre disc segment has holes for positioning of the dowels. Sand moulding was achieved by moulding the wooden pattern segments in the cheek, followed by the drag and lastly, the cope, when the drag-cheek subassembly is turned upside down. Cores made of dry sand and sodium silicate were moulded in plastic pipes, dried and positioned in the core print cavities to form holes and reduce weight after casting. Aluminium scraps were melted in a charcoal furnace to achieve the casting. Visual inspection of the pulley groove with a B64 V-belt after fettling, showed good fitting.

KEYWORDS: *V-belt pulley, Segmented pattern, Machining, Sand casting, Three flask mould*

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I. INTRODUCTION

Pulleys as machine elements have played important role in power transmission in machineries. Power transmission between shafts is achieved either through gear or belt drives. In the case of belt drives, pulleys are mounted on shafts over which a belt runs, transmitting the power [10]. A pulley can be cast in one piece or may be built up from separate parts [2]. The manufacture of V-belt pulleys usually involves many operations such as casting or forging of metal blanks with many subsequent machining operations or by forming from sheet with at least one final spinning operation wherein one or more V-belt seating grooves are formed in all metal pulleys [6].

Summary of proven methods of production of pulleys are outlined as follows: (a) Press forming of a sheet metal for the production of a V-belt pulley [1, 7]; (b) Production of multi-stage pulley using a groove forming roller [3, 8, 11]; (c) Making of composite pulley using a pre-configured mould [6, 12]; (d) Moulding of a resin pulley in an enclosed mould [13]; (e) Production of toothed belt pulley with annular flanges [9]; (f) Production of plastic pulley by moulding a plastic annular body about a metal insert [4]. Despite the availability of these pulley production methods, production of metal pulleys is often achieved by casting of pulley blanks and subsequent turning in a lathe machine. The process of taper-turning the pulley groove by adjusting the compound rest of conventional lathe has been the major task consuming much energy and man-hours. Elimination of this groove making operation will obviously reduce the cost of machining pulleys via a decrease in machining time, energy consumption and an increase in tool life.

The objectives of this project include: (a) To eliminate the groove-making operation in machining pulleys; (b) To provide an alternative method of producing V-belt pulleys in places where there is no lathe machine; (c) To provide an alternative method of producing large diameter pulleys that cannot be accommodated by available lathe machines.

II. MATERIALS AND METHODS

2.1. Materials

The materials used in making pattern segments, moulding boxes or flasks, cores, moulding sand and casting are listed in table1 below:

Table 1: List of materials used in making V-belt pulley casting

S/N	Materials	Uses
1	"Agba" wood	Making of moulding boxes, riser and sprue
2	Plywood	Making of pattern segments
3	Nails	Fastening moulding boxes' parts
4	Plastic pipes	Making of cores' boxes
5	Abrasive papers	Sanding of pattern segments to specification
6	Top bond glue	Bonding plywood parts to form pattern segments
7	Hardener + Auto-body filler	Used to achieve the chamfered portions of the pattern segments
8	Dry silica sand + Sodium silicate	Making of cores
9	River bank sand + Water + Bentonite	Used as backing sand in the cope, cheek and drag
10	Sieved dry silica sand	Used as facing sand
11	Aluminium scrap	Used in casting the V-belt pulley

2.2. Geometric modeling of the pattern segments

Prior to the development of the wooden pattern segments, the geometric modeling of the pattern was done using Pro-Engineer software and the exploded view and detailed drawing of the segments assembly are as shown in fig.1 and fig.2 respectively.

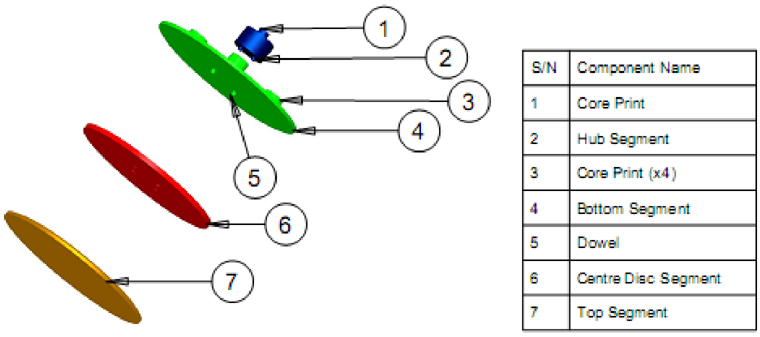


Figure 1: Exploded view of the pulley pattern assembly

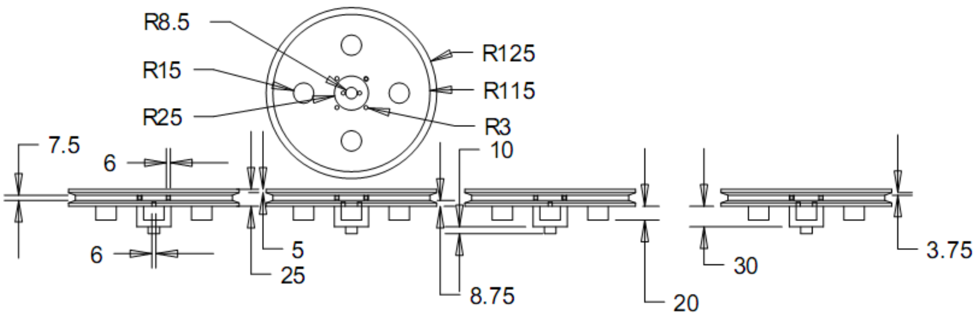


Fig. 2: Third angle orthographic projection of the pulley pattern assembly

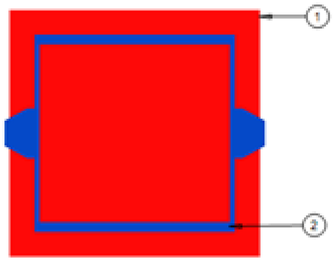
2.3. Production of the pulley pattern segments

Plywood was used in the making of the top, bottom, centre disc and hub segments of the pulley pattern. The core print and the dowels were made of "Agba", a local wood that is commonly available in Taraba State, Nigeria. Cutting of different parts based on 2D drawing of the different shapes was achieved using a jigsaw. Thicknessing and smoothening of shapes were carried out using rough (P60) and smooth (P150) abrasive papers. The chamfered portions of the top and bottom segments of the pattern were achieved by gluing two discs of diameters 250mm and 230mm, with top bond glue and filling the offset between their perimeters with body filler made of a mixture of auto-body filler and hardener. The filled portions were sanded to remove the excess and achieve the chamfered surfaces. Holes in the centre disc were drilled with an electric hand drill. The picture of the pattern is as shown in fig.3.

Fig. 3: Picture of the pulley pattern

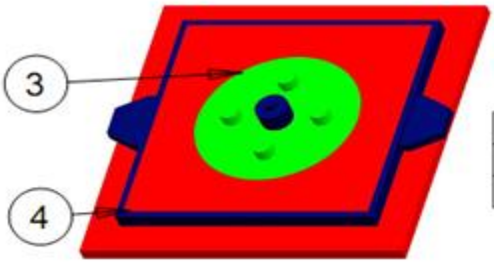
2.4. Sand moulding of the segmented pattern

Preceding the sand moulding process are the productions of the cores and moulding boxes. The sand cores were produced by moulding a mixture of dry silica sand and sodium silicate in plastic pipes, while the moulding boxes or flasks were made of "Agba" wood. The height of the cheek was made to be equal to the sum of the thicknesses of the top, bottom and centre disc segments of the pulley. The stages involved in the sand moulding of the segmented pattern are shown from fig.4 to fig.11 below:



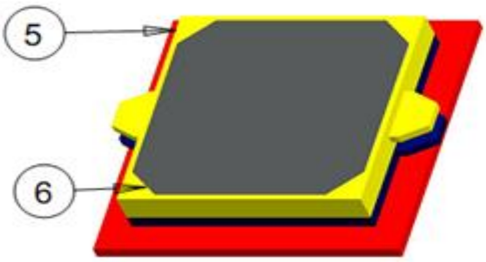
S/N	Component Name
1	Moulding Board
2	Cheek Box

Fig. 4: Place the cheek box on the moulding board



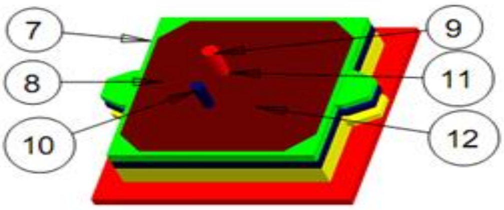
S/N	Component Name
3	Pattern
4	Backing Sand

Fig. 5: Position the top, centre disc and bottom segments of the pattern; pour and ram the backing sand



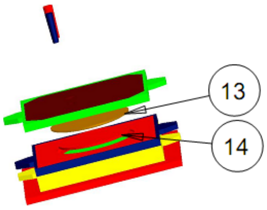
S/N	Component Name
5	Drag Box
6	Facing/Backing Sands

Fig. 6: Place the drag box on the cheek; pour and ram facing and backing sands consecutively



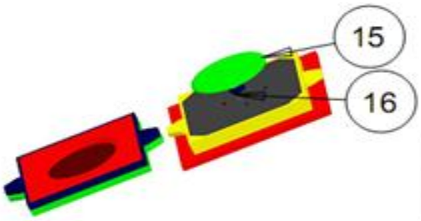
S/N	Component Name
7	Cope Box
8	Facing/Backing Sands
9	Sprue
10	Riser
11	Sprue Basin
12	Vent

Fig. 7: Turn the drag-cheek subassembly upside-down and place the cope on the cheek; position the riser and sprue; pour and ram the facing and backing sands consecutively; vent the cope and make the sprue or pouring basin



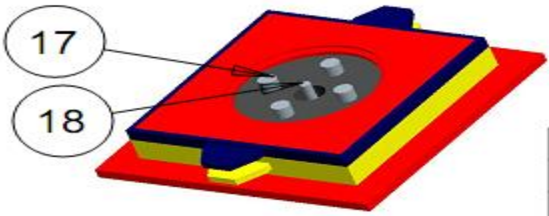
S/N	Component Name
13	Top Segment
14	Centre Disc

Fig. 8: Rap and remove the riser and sprue; remove the cope; remove the top and centre disc segments from the top part of the cheek



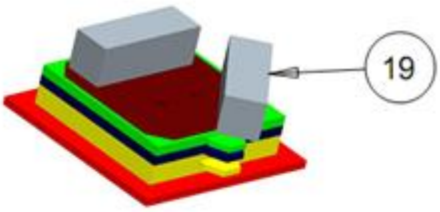
S/N	Component Name
15	Bottom Segment
16	Hub Segment

Fig. 9: Place the cheek on the cope; remove the bottom and hub segments from the drag



S/N	Component Name
17	Core(x4)
18	Centre Core

Fig. 10: Place the cheek on the drag and allow the subassembly to dry; position the centre core and core(x4) for weight reduction



S/N	Component Name
19	Load(x2)

Fig. 11: Place the cope on the cheek; position heavy load(s) on the cope to act against metallostatic pressure; the mould is ready for casting

Fig. 12: Picture of the cheek and drag subassembly showing dried cores in the core print cavities prior to casting

2.5. Determination of the mass of the pulley model

Prior to the melting of the aluminium scrap, the mass property of the V-belt pulley was generated in Pro-Engineer software using the analysis tool. The analysis steps include: Draw the pulley model as shown in fig. 13 - click analysis icon – scroll to model – click mass properties – change density value to 0.0000000027 – click compute current analysis for preview – highlight and copy volume to mass – paste in MS word. Note: Density of Aluminium = 2700kg/m^3 = 0.0000000027tonne/mm^3[5].

Fig. 13: Pulley model

The result of the pulley model analysis includes:

VOLUME = 1.1177041e+06 MM^3 **SURFACE AREA = 1.3851880e+05 MM^2**

III RESULT AND DISCUSSION

3.1. Result of the casting process

The casting operation was preceded by the melting of aluminium scraps in a charcoal fired furnace and heavy steel part positioned on the cope to counter metallostatic pressure of the molten aluminium. Molten aluminium with good fluidity was poured into the sand mould as shown in fig.14. Pictorial view of the casting after knock out is shown in fig.15. After fettling, the pulley groove was weighed on a scale and visual inspection of the groove was carried out using B64 V-belt as shown in fig. 16 and fig. 17 respectively.

Fig. 14: Pouring of molten aluminium into the sand mould

Fig. 15: Pulley casting after knock out

Fig. 16: Cast pulley being weighed on a scale after fettling

Fig.17: Inspection of the pulley groove with a B64 V-belt

Table 2: Mass of pulley before and after casting

Pulley stages	Mass of pulley (kg)
Model in Pro-E software	3.0178
Cast after knock out	3.2000
Cast after fettling	3.0000

3.2. Discussion

During the removal of the pattern segments, it was observed that the bottom segment was retained in the drag when the cheek was removed from the drag. This is due to the high ramming pressure and the length of the core prints attached to the bottom segment, which are embedded in the drag after ramming. Hence, removal of the top and centre disc segments frees the cheek as the thickness (8.75mm) of the bottom segment is far less than the length (20mm) of the core prints. The difference in mass between the pulley model and the cast can be attributed to shrinkage and low density inclusions in the cast. Error in the weighing scale can be a contributing factor, also. Dimension of the B64 V-belt pulley was used in the geometric modeling of the pulley pattern segments and visual inspection of the cast pulley groove with same showed good fitting.

IV CONCLUSIONS AND RECOMMENDATIONS

4.1. Conclusions

Problems encountered during the trial sand moulding revealed that for success to be achieved in using the segmented pattern and three flask mould, moulding must commence with the cheek, followed by the drag and lastly the cope. Also, it is pertinent to position the cheek on the drag immediately the pattern segments are removed, to avoid the collapsing of the moulding sand in the cheek. Visual inspection of the pulley groove showed that the method adopted can produce already grooved pulley blanks that need no taper turning in the lathe. Obviously, the method used in this research can be used to improvise metal pulleys in remote areas where there are no lathe machine for turning metal pulleys and for the production of grooved pulley blanks; hence, this offers the advantage of lowering the machining cost via reduction in machining steps, time and energy. More so, the tool life will be increased if the taper turning of the pulley groove is eliminated.

4.2 Recommendations

- Collapsing of the moulding sand in the cheek may be avoided using plaster of paris around the pulley pattern or reinforcing the mould with wire mesh.
- Production of V-belt pulleys with many grooves can be achieved by ensuring that the number of cheeks equals the number of grooves.

- To achieve better cavity accuracy and stronger ramming, the pattern segments and dowels should be made of metal.

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REFERENCES

[1] Assai, T., Isono, T. and Funahashi, N. (1996). Pulley. U. S. Patent No. 5,527,227.
[2] Bhatt, N. D. and Panchal V. M. (2009). Machine drawing. (44th ed.). Gujarat-India: Charotar Publishing House
[3] Bytzek, K. K. (1981). Method of pulley manufacture and product. U. S. Patent No. 4,273,547.
[4] Emett, K. J. (2001). Method of producing a plastic pulley with a metal insert. U. S. Patent No. 6,200,513B1.
[5] Geick, K. (1971). Engineering Formulas. West Germany: McGraw-Hill.
[6] Gobeille, W. P. (1973). Composite V-belt pulley and method. U. S. Patent No. 3,772,928.
[7] Kanemitsu, T., Harada, K. and Fujii, N. (2000). Method of producing a sheet metal pulley for V-belt. U. S. Patent. No. 6,012,318.
[8] Kanemitsu, Y. (1984). Method of making poly-V pulleys. U. S.
[9] Krull, L. (1981). Toothed belt pulley. U. S. Patent No. 4,244,206.
[10] Narayana, K. L., Kannaiah, P. and Reddy, K. V. (2006). Machine drawing. (3rd ed.). New Delhi: New Age. International Publishers Ltd.
[11] Shohara, H., Adachi, M., Suzuki, H., Kasuya, Y., Ohno, T., Tabuchi, Y. and Kinoshita M. (2002). Multi-stage. Pulley and production method thereof. U. S. Patent No. 6,463,659B2.
[12] Speer, B. L. (1983). Composite pulley and method for making. U. S. Patent No. 4,366,609.
[13] Ueno, H. (1998). Method of moulding a resin pulley. U. S. Patent No. 5,728,343.