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Indexing Type Of Drill Jig For An Aerospace Component For Optimizing Productivity With Elevating Standards In Design And Analysis

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Abstract:
In the present scenario of the advanced industrial technology engineers and scientists have visualized and conceptualized many designs. The success of their designs and concepts is the materialization of their designs. Thus, the industry which gives shape to a theoretical design is a very potential and influential element in the technological development. The main objective of using jigs and fixtures in an industry is to achieve the Interchangeable Part Concept, and these are mainly used where production of goods is on large scale. The basic elements in the design of indexing type of drill jig is the component model, location, orientation and clamping. The scope of the research paper is to design an indexing type of drill jig for a component having angular holes at 25 deg such the designis validated and verified. The present paper entitled "Design and Analysis of Indexing type of Drill Jig" is the work done for the design and analysis of Jig. Jigs are mainly used for mass production and for interchangeable parts concept, for a long period in the manufacturing of Jigs. Modeling is done using SOLIDWORKS Software and Analysis by using ANSYS.

Keywords: *Design, Interchangeable Part Concept, Jigs, Mass Production*

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I. Introduction

The Over the past century, manufacturing has made considerable progress. New machine tools, high-performance cutting tools, and modern manufacturing processes enable today's industries to make parts faster and better than ever before. Although work holding methods have also advanced considerably, the basic principles of clamping and locating are still the same. Jigs and fixtures form an important category of equipmentthat goes a long way in achieving productivity. A jig, however, guides the cutting tool. A fixture references the cutting tool. The differentiation between these types of work holders is in their relation to the

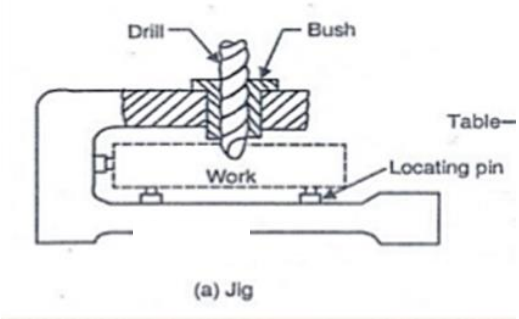


Figure1: A jig guides the cutting tool, in this case with a bushing

cutting tool. As shown in Figure 1, jigs use drill bushings to support and guide the tool. Fixtures, Figure 1, use set blocks and thickness, or feeler, gages to locate the tool relative to the work piece.

In the shop, drill jigs are the most-widely used form of jig. Drill jigs are used for drilling, tapping, reaming, chamfering, counter boring, countersinking, and similar operations.

Jigs are further identified by their basic construction. The two common forms of jigs are open and closed. Open jigs carry out operations on only one, or sometimes two, sides of a work piece.

Closed jigs, on the other hand, operate on two or more sides. The most-common open jigs are template jigs, plate jigs, table jigs, sandwich jigs, and angle plate jigs. Typical examples of closed jigs include box jigs, channel jigs, and leaf jigs.

Tooling Details

Tooling details are the overall construction characteristics and special features incorporated into the jig or fixture. Permanent work holders are designed and built to last longer than temporary work holders. So, permanent jigs and fixtures usually contain more-elaborate parts and features than temporary work holders.

Tooling Operation

The performance of any work holder is critical to the complete usefulness of the tool. If the work holder cannot perform the functions desired in the manner intended, it is completely useless, regardless of the cost or the extent of the detail.

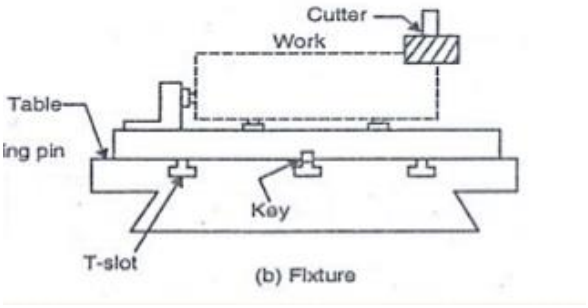


Figure 2 A combination drill jig/milling fixture

Essential Features Of Jigs And Fixtures

The jigs and fixture must satisfy the following conditions :

Reduction Of Idle Time:

The design of jigs and fixtures should be such that the process of loading and unloading the component takes the minimum possible time and enables on easy loading and clamping should be such that idle time is reduce to minimum.

Provision For Coolant:

The jigs and fixtures must have adequate arrangement for the cutting edges of the tools so that the tool is cooled and at the same time the swarf or chips produced are washed away, so that the operator does not have to waste time in adjusting the coolant flows and cleaning of the swarf or chips.

Hardened Surfaces:

All locating and supporting surfaces such as faces of locating pins should be hardened materials as far as conditions permit, so that they are not quickly worn out and their accuracy is retained for a longer time.

Safety:

The design of jigs and fixtures should be such that it should not constitute a danger to operator.

Fool Proof

Since the use of jigs and fixtures allows for the employment of unskilled workmen, the design of such equipment should be such that it would not permit the work piece or the tool to be inserted in any position other than the correct one.

Indexing Type Of Jig

These types of jigs are used to drill a series of holes in a circle, on the face of a work piece. The work piece is indexed and the next place the hole is to be drilled, comes under the jig bush, with the component clamp in one position of the jig, after each hole has been drilled there the single bush, etc. The work is indexed there 60 degree and the previously drilled hole located by the angular pin.

II. Methodology

Design Procedure Of Indexing Type of Drill Jig

Initially the component was deigned, modeled and edited to get the necessary details for designed of the jig. Secondly the individual parts such as Base Plate, Locator, Clamping Devices Bushes Jig Plate, and Indexing Mechanism has been developed. All these parts have been designed, Modeled, Drafting has been done individually.

The whole Design Procedure was completed with the help of CAD software by which the software helps for Designing, Drafting Assembly and Analysis which may be useful for customized applications and manipulations.

Component Description: The component for which the jig is deigned is a Casted Component which is having angular holes inclined at 25 deg equi-spaced.

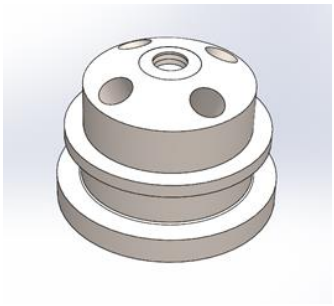


Figure 3: 3D Model of the Component

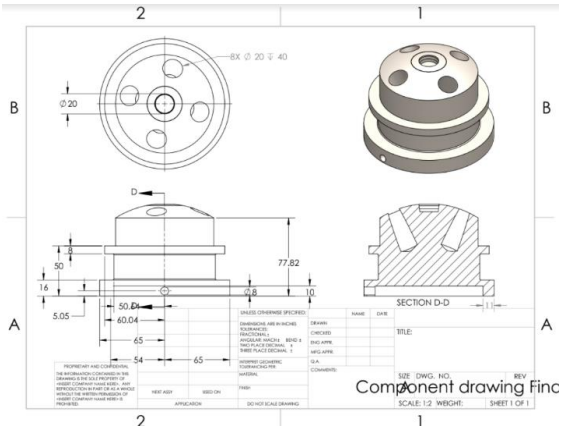


Figure 4 : 2D Detailing of the Component

Design Of Base Plate:

The Base Plate is one of the vital parts in the design of jigs. Base is generally taken as a support for the other parts .In general base are in the form of vertical, inclined, and horizontal plates. The base plate in the design is developed according to the dimensions of the work piece, so that during the machining and non- machining the structure is not distorted.

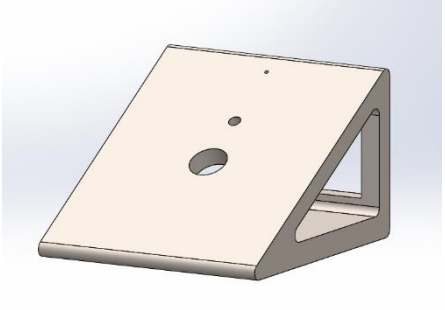


Figure 5: 3D Model of Base Plate

Design Of Locator

A minimum of three locators are used to locate the work piece.

The type of locator used in this design is locator for circular surfaces in which the inner diameter is taken as the locating surface of the component. The locating diameter for the component is 108(+/- 0.15) mm. From this locating surface clamping and other mechanisms are developed.

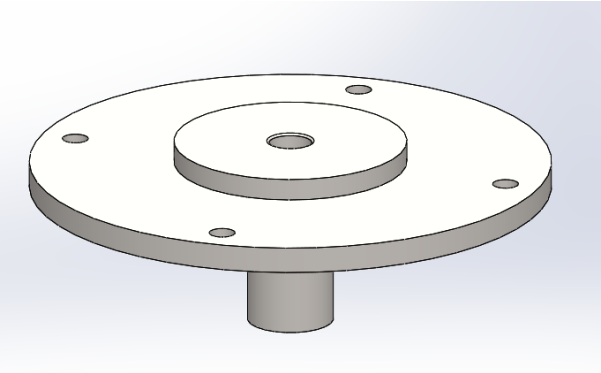


Figure 6: 3D Model of Locator

Design Of Clamping Device

While performing a manufacturing operation it is necessary to provide some kind of CLAMPING mechanisms to hold the work piece in the desired position and to resist the effects of gravity and operational forces.

Clamp From the calculation it is found the clamping force is greater than the drilling force (machining force) hence the jig design is safe, and the clamp chosen is also satisfied by its per formability.

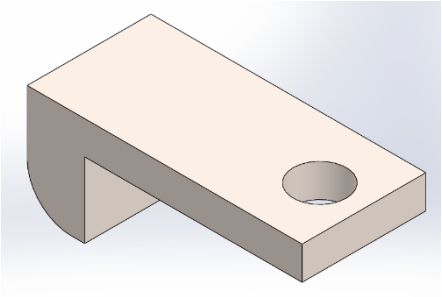


Figure 7: 3D Model of Strap Clamp

Design Of Bushes

Bushings are used to guide drills, reamers, and other cutting tools into proper position on the work piece. In the design of indexing type of drill jig the type of bushes used are;

- □ Liner Bushes
- □ Renewable Bushes
- □ Taper Bushes

Liner Bushes: These are taken from standards IS 666 according to the dimensions of the drilled hole the linerbushes used here are

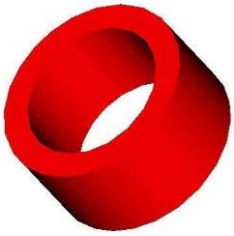
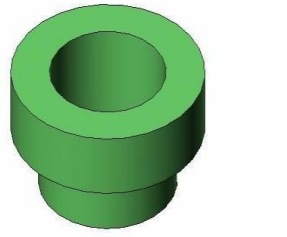


Figure 8: 3D Model of Linear Bush

Renewable Bush

In this design the renewable bush used is a lock and screw type in which the bushes can e replaced easily .For the diameter of the drilled hole three renewable bushes are used which are taken from IS 666.

Figure 9: 3D Model of Renewable Bush



Indexing Mechanism

For indexing, the mechanism adopted is "Spring and Plunger arrangement" which is explained as follows. When the handle is pulled down the spring disengages and the locator with bracket is rotated such the next position of the hole is pointed by the taper bush and the pin sits in the exact position of the hole, in that way the indexing is achieved.

This is one of the common methods of indexing which can be operated easily and here the operating type is alsominimum.

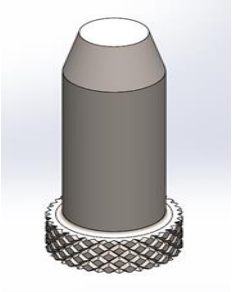


Figure 10 : Locator Pin

Assembly of the Indexing Drill Jig

After the modelling of the parts of the jig the assembly of the jig is completed using CAD software.

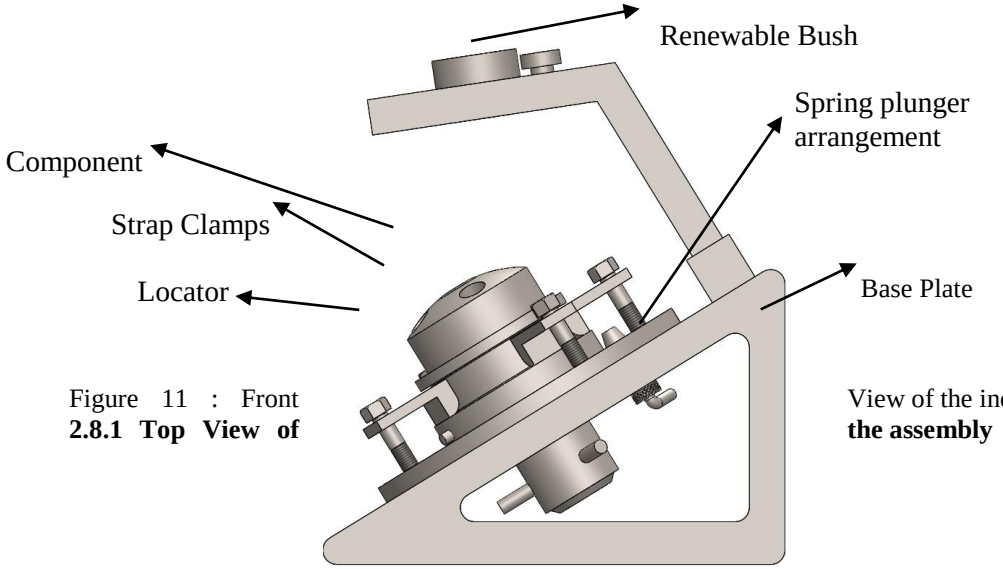


Figure 11 : Front View of the indexing drill jig

2.8.1 Top View of the assembly

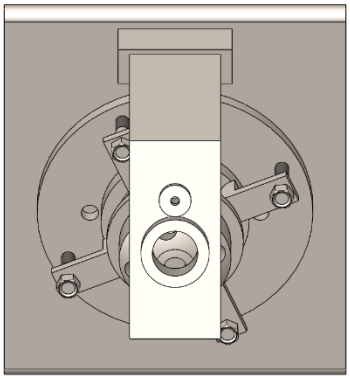


Figure 12 : Top View of the indexing drill jig

Here it is clearly observed that the drill axis coincides with the hole axis hence the design is satisfied for hole positioning in which the hole are inclined at 25deg with base.

In the design of drill jig the most vital part is the locator pin, because it is very much important that how the relationship is maintained hence for this a locator pin is used and in this design the locator pin is inclined at 25deg from the base of the component.

The concept of Fool Proof design is also satisfied, it means that any unskilled operator can easily operator the jig since the component is arrested in the desired position and there is no other chance for any positional errors.

Isometric View of the assembly

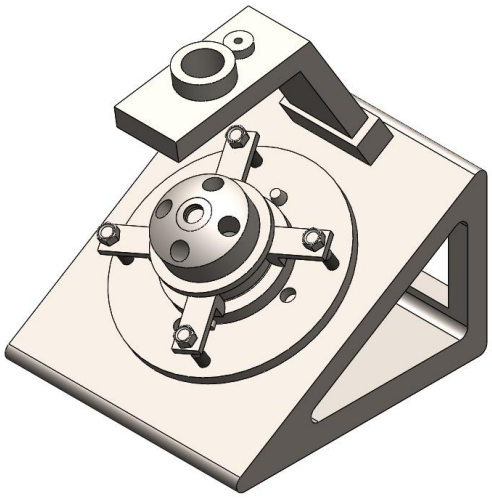


Figure 13 : Isometric View of the indexing drill jig

Calculation of the drilling and clamping forces

Calculation of the drilling forces

One of the primary objectives for the design of indexing type of drill jig is the calculation for the drilling forces. The following equations by Shaw and Oxford can be used for the computation of theTorque and Thrust

Calculation of Torque

$$\frac{M}{d^3} = 0.03\left[\frac{s^{0.8}}{d^{1.2}}\right]\left[\frac{1-k^2}{1+k^{0.2}} + 3.2k^{1.8}\right] \longrightarrow 1$$

Calculation of Thrust

$$\frac{P_x}{d^2 H_B} = 0.05\left[\frac{s^{0.8}}{d^{1.2}}\right]\left[\frac{1-k^2}{1+k^{0.2}} + 2.2k^{0.8}\right] + 0.07k^2 \longrightarrow 2$$

Where;

M = torque, kgf cm

Px = thrust, kgf

d = diameter of drill, mm

HB : Hardness of the material, Brinell hardness

s : feed, mm/rev
k=c/d=ratio of chisel edge length 'c'to drill diameter 'd'
Therefore substituting the values of diameter, Brinell hardness no., feed, k,
From Tables the values are taken as ;
HB=Brinell Hardness no. = 80
d= Diameter of the drill = 24mm
s= Feed per rev = 0.22-0.33mm/rev
k= Ratio of chisel edge length to drill diameter =0.55
Therefore substituting the values in the above equation 1 & 2 ,
The value of Torque =M=329.4 Kgf.cm
Thrust=Px=321.27 Kgf.
2.9.2 Calculation of power and thrust

Drill Power = $\frac{1.25d^2K_l\,n(0.056+1.5s)}{10^5}$

Where Kl=material factor as per tables (standards)= 0.35
d=diameter of the drill, =24mm
s=feed, mm/rev = 0.22 mm/rev
n=rpm of the drill= 35m/min
After subsituting the values ,
Power = 2.238 KW.
Drill Thrust, kgf
Drill Thrust, kgf =1.16K1d
Where K1 = material factor as per tables (standards)
d = diameter of the drill, mm
s = feed mm/rev
After subsituting the values
T = 176.567 Kgf.
2.9.3 Calculations of the clamping forces ;
Required Clamping Force = Cutting force (Factor Of Safety)/ Static Friction Coefficient
= [(300)/0.3] *2
= 2000 lbs
= 907.23 Kgf . [since 1 lbf = 0.4536 Kgf]
The Calculated Clamping Force for the Jig is found to be 907.23 Kgf.
Safe Design ,As the Clamping Forces Should always be greater than the drilling forces .

III. Results and Discussion

To measure the deformation and to determine the stress in the indexing jig Ansys is carried out for the assembly Meshed Model of the indexing jig

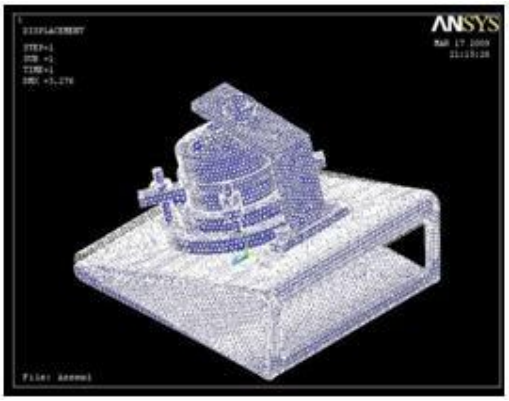


Figure 14 : Meshed Model of the indexing Jig

Stress

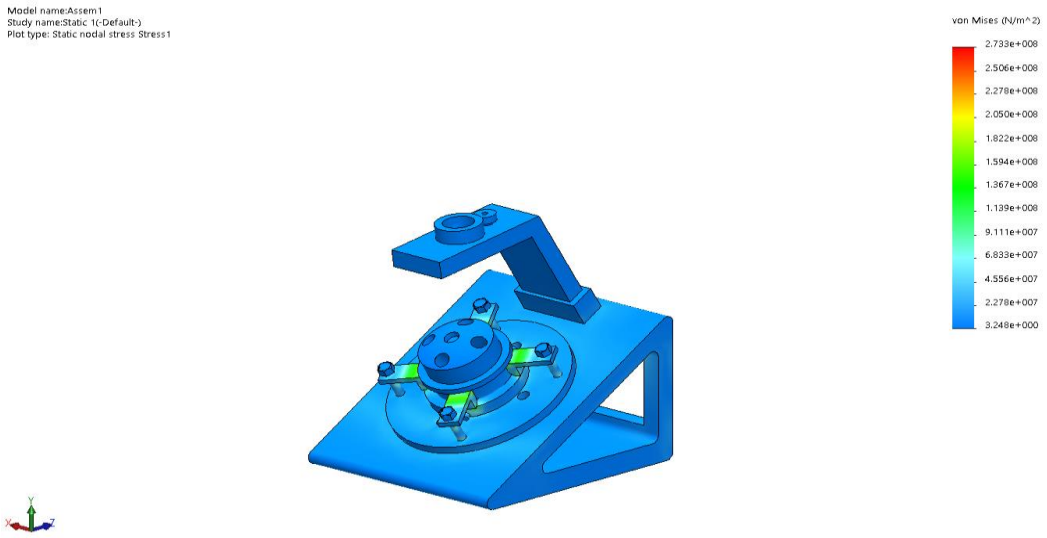


Figure 15 : Stress plot of the indexing Jig

Strain Plot

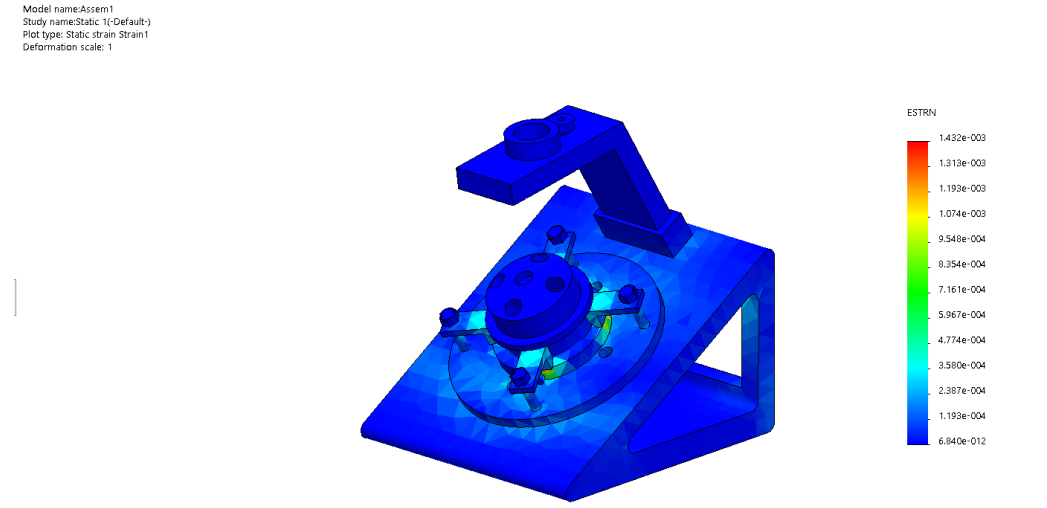


Figure 16 : Strain plot of the indexing Jig

Displacement Plot

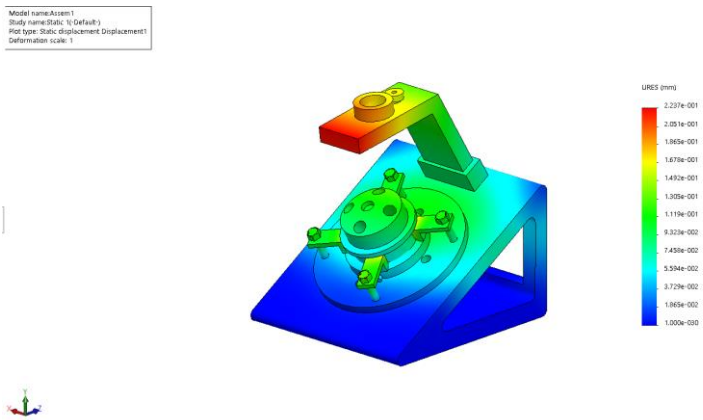


Figure 17 : Deformation plot of the indexing Jig

While designing for selecting the required parts of the Indexing Type Of Drill Jig the following calculations are done and compared with allowable limits for individual parameters like rpm, thrust and clamping force.

Table 1: Calculated Results

S.No.	Parameters	Calculated values
1	Torque (m) kgf cm	329.4 kgf.cm.
2	Thrust (*px*) kgf.	321.27 kgf.
3	Power drilling kw	2.238 kw
4	Drill thrust kgf	176.567 kgf.
5	Clamping force kgf	907.23 kgf.

From the above table it can be clearly understood that the Clamping Force is more than drilling forces therefore the design is safe for machining Hence the design made satisfies the interchangeable part concept, and the design is fool proof and the design is validated.

IV. Conclusions

- The design of indexing type of drill jig involved about 287mm x 203 mm dimensions.
- The material of the component is Mild Steel
- The Clamping force is more than the drilling force (calculated)
- The assembly of the Indexing Type of Drill Jig is found satisfactory.
- The results obtained after drilling like bore, surface finish etc. are found to be within the limit.
- The Stresses in the Nodal Solution indicate that the component as well as the assembly are reliable and safe under working conditions.

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