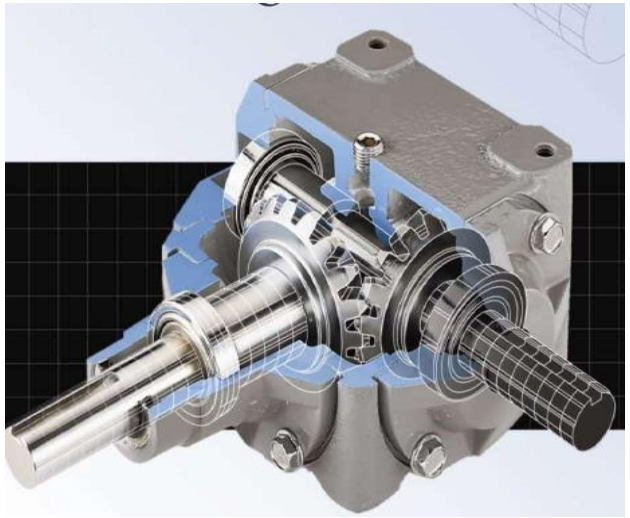
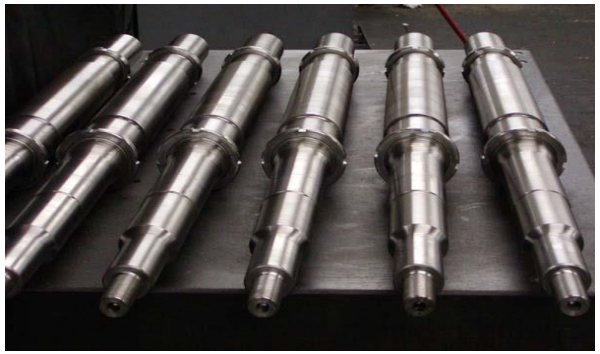
Shafts and Shaft Components



Shafts and Shaft Components

Introduction

- A **shaft** is a rotating member, usually of circular cross section, used to transmit power or motion and to support components like gears, cams, pulleys, sprockets, wheels, couplings etc



It provides the <u>axis of rotation</u>, or <u>oscillation</u>, of elements such as gears, pulleys, flywheels, cranks, sprockets, and the like and controls the geometry of their motion.

Components connected to drive shaft

gears

pulleys

flywheels

cranks,

sprockets,

bearings

Shafts and Shaft Components

- There are notches, keyways and fillets in shafts, so care must be taken to reduce stress concentration

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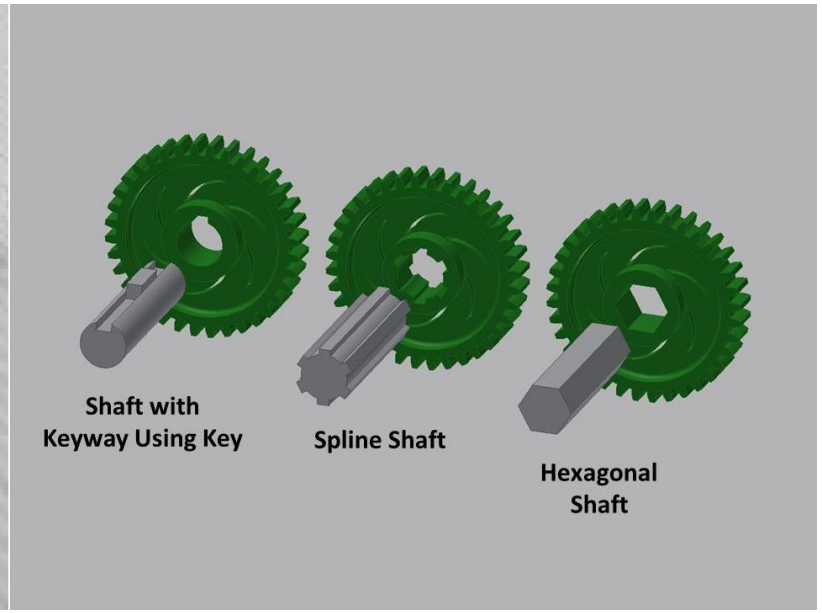

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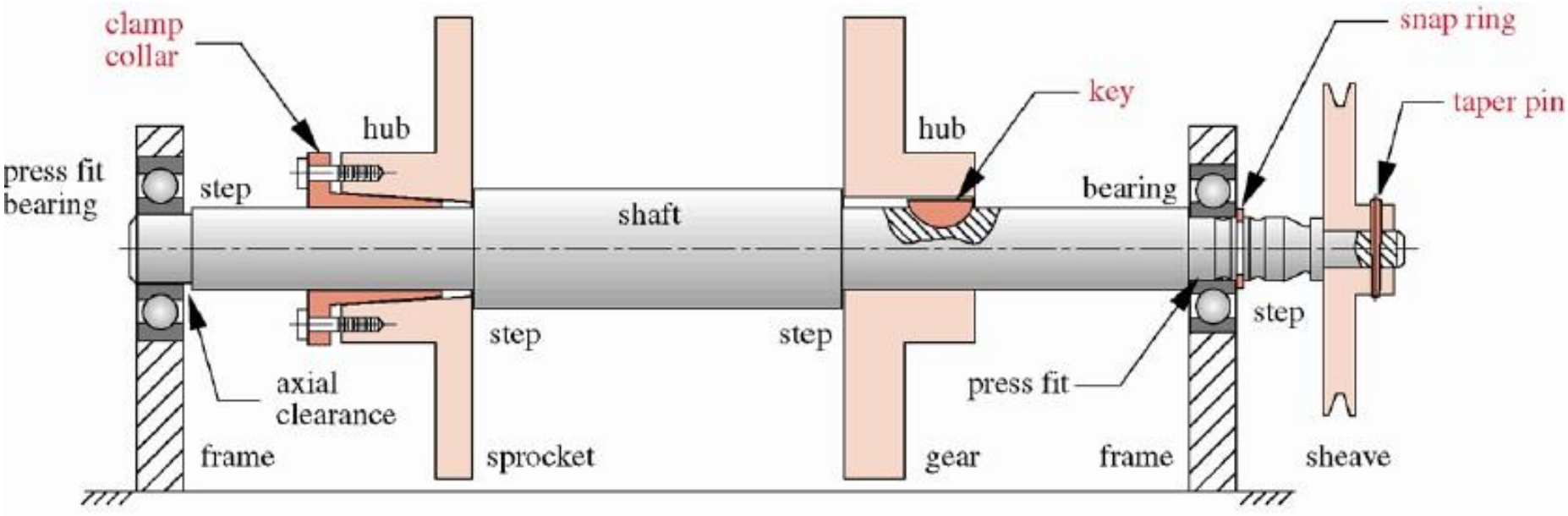
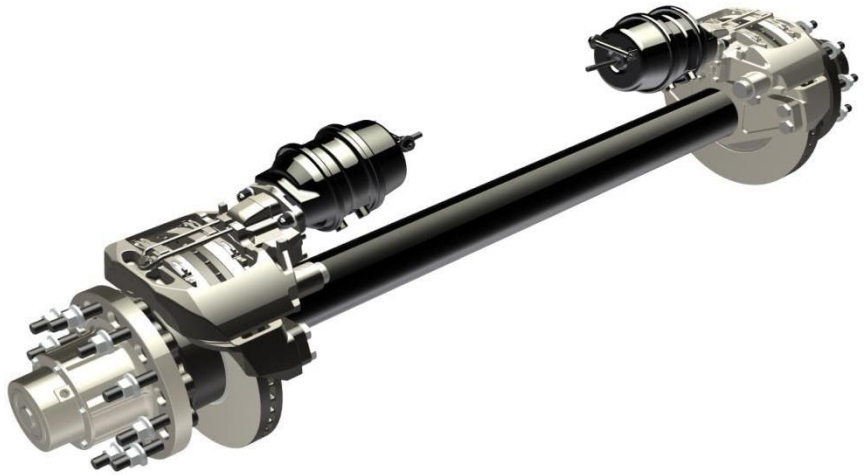


Various Methods to Attach Elements to Shafts.

- An **axle** is a non rotating member that carries no torque and is used to support rotating wheels, pulleys, and the like

* Member آي بيلف حوالين عليه Torque



A non-rotating axle can readily be designed and analyzed as a static beam, and will not warrant the special attention given in this chapter to the rotating shafts which are subject to fatigue loading.

Shaft Sizing

◆In deciding on an approach to shaft sizing, a stress analysis at a specific point on a shaft can be made using only the shaft geometry in the vicinity of that point. Thus the geometry of the entire shaft is not needed.

◆ In design it is usually possible to locate the critical areas, size these to meet the strength requirements, and then size the rest of the shaft to meet the requirements of the shaft-supported elements.

Shafts and Shaft Components

- Shaft Sizing

◆ The deflection and slope analyses cannot be made until the geometry of the entire shaft has been defined. Thus, deflection is a function of the geometry everywhere, whereas the stress at a section of interest is a function of local geometry.

↳ For this reason, shaft design allows a consideration of stress first. Then, after tentative values for the shaft dimensions have been established, the determination of the deflections and slopes can be made.

1) Stress Considerations.
2) Dimensions and Geometry of shaft.
3) Slope and deflection analysis.

Shafts and Shaft Components

Shaft Materials

- Necessary strength in shaft to resist loading stresses affects the choice of materials and their treatments

أقصى إجهاد تتحمله المادة

مقاومة المادة للتشكل (التغير في الشكل) في الحالم المرنة

E ↑ Stiffness ↑

Modulus of elasticity

- **Deflection is not affected by <u>strength</u>, but rather by <u>stiffness</u> as represented by the <u>modulus of elasticity</u>, which is essentially constant for all steels. For that reason, rigidity cannot be controlled by material decisions, but only by <u>geometric decisions</u>.**

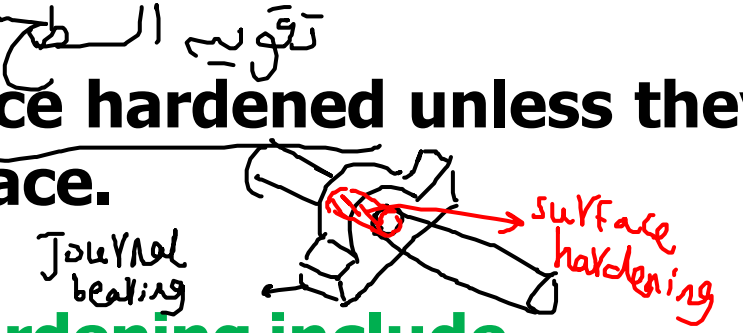
Deflection → Function of (stiffness of Material & geometry)

- A good practice for material selection:

  ⇒ **Start with an <u>inexpensive</u>, <u>low or medium carbon steel</u> for the first time through the design calculations. If <u>strength</u> considerations turn out to dominate over deflection, then a <u>higher strength</u> material should be <u>tried</u>, allowing the shaft sizes to be <u>reduced until excess deflection becomes an issue</u>.**

C.% ↑ Strength ↑ → in Steels

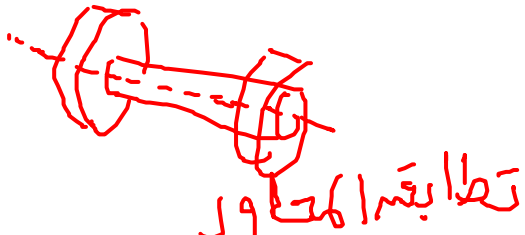
- **Shafts usually don't need to be surface hardened unless they serve as the actual journal of a bearing surface.**



↳ **Typical material choices for surface hardening include carburizing grades of ANSI 1020, 4320, 4820, and 8620.**

- **Cold drawn steel is usually used for diameters under about 3 inches. The nominal diameter of the bar can be left unmachined in areas that do not require fitting of components.**

- **Hot rolled steel should be machined all over. For large shafts requiring much material removal, the residual stresses may tend to cause warping.**



- **If concentricity is important, it may be necessary to rough machine, then heat treat to remove residual stresses and increase the strength, then finish machine to the final dimensions by the process called "cylindrical grinding".**

Manufacturing of Shafts

- For low production, turning is the usual primary shaping process. An economic viewpoint may require removing the least material.

- High production may permit a volume conservative shaping method (hot or cold forming, casting), and minimum material in the shaft can become a design goal