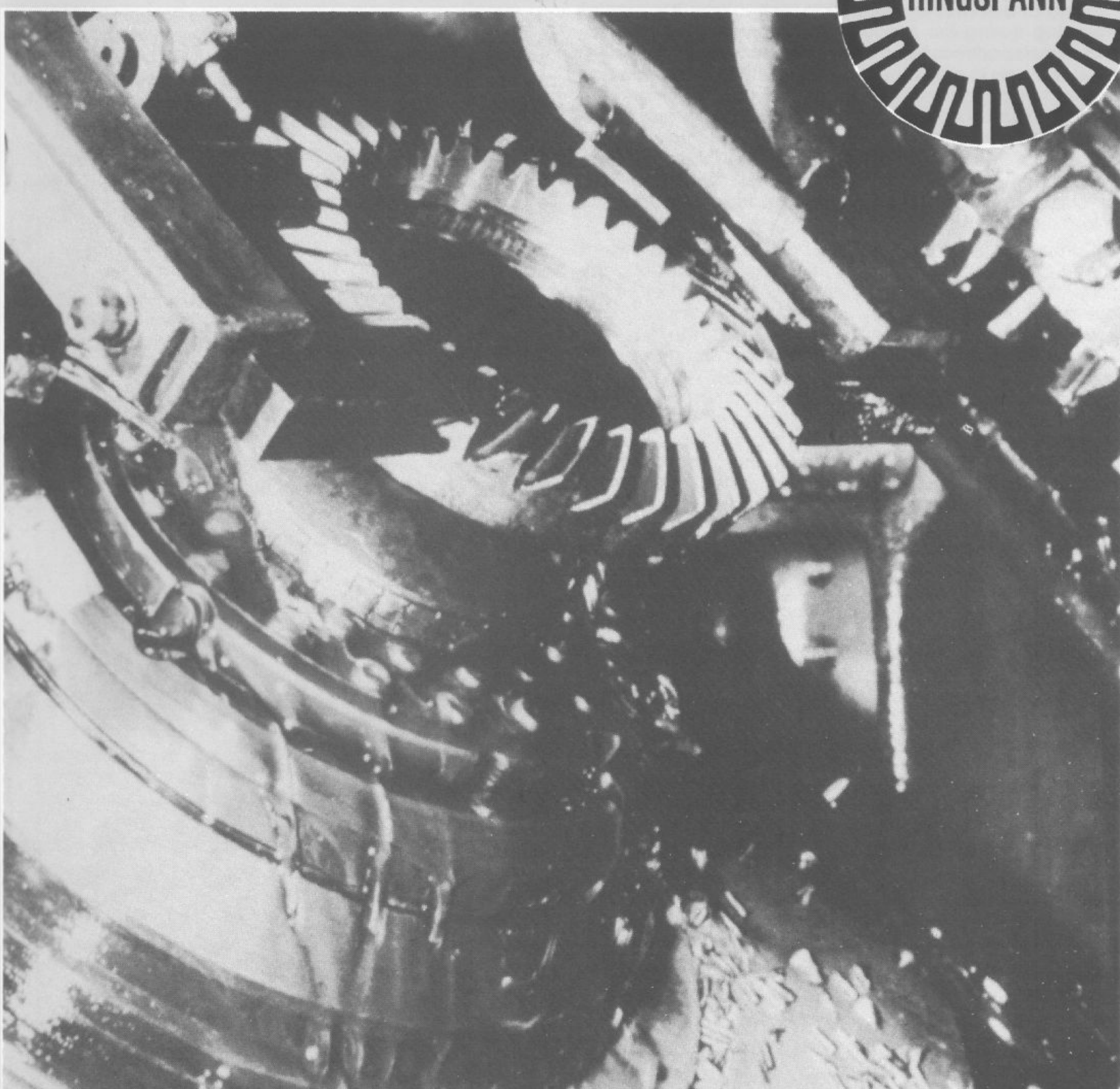
RINGSPANN



Precision Clamping Fixtures For the Automotive Industry

Precision Clamping Fixtures For the Automotive Industry

1. INTRODUCTION

In view of the progress achieved during the past decades in the field of automotive production technology, the precise clamping during the production of engine-, transmission- and chassis parts has been of major importance. Fortunately, developments in clamping technology have kept pace and ensure that capacity of the production machinery and the production techniques are increased to their present high standard. Highly-developed clamping systems have made it possible to reduce the machine down-time. Further requirements will have to be met to reduce setup time. Here, too, developments in the field of clamping fixtures will contribute to technical progress.

Component manufacturing has had to meet the demands of end product manufacture and a large number of components must feature diameter-, aligning- and centering tolerances measured in ten thousands of an inch. The reasons include an increasing output related to the reduction of the total cost of the vehicle. However, environmental pollution, i.e., reduction of noise and emissive material as well as the demands made on the traffic safety of the vehicles directly control the precision of the individual components.

Improving component tolerances will, of course, raise the prime cost of the components and it is important that this is considered for volume production. Exceptionally high responsibility therefore lies with development and design engineers, as it is for them to bear in mind the cost of achieving for example, a true running accuracy of 0.01mm for as many as a million components. Without full co-operation between production- and development engineers this level of manufacturing technology would be impossible to attain.

In the course of this paper, clamping principles featuring special advantages are examined, with a review of the increases of locating workpieces on cylindrical clamping surfaces. Thereafter, using practical examples, methods will be shown how to select the most suitable clamping device. Based on these illustrations, examples are shown of precision clamping fixtures from many areas of automobile manufacture. Finally, future trends in the development of precision clamping fixtures are discussed for new manufacturing technologies.

2. THE CLAMPING FIXTURES

With so many components in the automotive manufacture process – even when reduced to engine-, power transmission- and suspension components – it is necessary to define the different versions of clamping which are dealt with in this paper. The most significant are as follows:

2.1 THE VEHICLE PARTS

Here clamping fixtures are included which are functioning as parts within the driving equipment, such as engine and power transmission, the suspension, parts of the steering, brakes, and wheels. These parts are machined on high-volume equipment in large numbers.

2.2 THE SHAPE OF CLAMPING SURFACES

Clamping fixtures for cylindrical clamping surfaces are machined on the workpieces. It is where these cylinders are very short or if they can be reached only with much difficulty, are special fixtures used. Occasionally it will be necessary to use as clamping surfaces two coaxial cylinders with different diameters. In these situations the efficiency of highly-developed clamping fixtures is particularly important.

2.3 MANUFACTURING PROCEDURES

Clamping fixtures for the following manufacturing functions are included:

- ☐ Turning
- ☐ Grinding
- ☐ Drilling
- ☐ Milling
- ☐ Welding
- ☐ Balancing
- ☐ Centering
- ☐ Inspection

3. REVIEW OF CLAMPING FIXTURES FOR CYLINDRICAL CLAMPING SURFACES

High-capacity clamping elements which are currently available and their benefits as follows:-

3.1 DEMANDS MADE ON CLAMPING FIXTURES

- ☐ Cylindrical running accuracy to 0.0005" over long periods.
- ☐ Wear-resistance.
- ☐ Resistance to swarf.
- ☐ Resistance to lubricants and coolants.
- ☐ No workpiece damage.

To ensure a true-running accuracy it is vital that the workpiece is pulled to true surface by the clamping device. Relatively few clamping fixtures are available in standard versions to meet this requirement.

3.2 COMPARISON OF THE MOST COMMON CLAMPING FIXTURES FOR PARTS WITH CYLINDRICAL SURFACES

Figure 1 shows the various types or groups of clamping fixtures and their benefits. In figure 1 the five most common systems are in columns:

- ☐ jaw chucks
- ☐ taper clamping fixtures
- ☐ segment clamping fixtures
- ☐ lever element clamping fixtures
- ☐ expanding mandrels

SYSTEMATIC SURVEY OF CLAMPING FIXTURES FOR WORKPIECES WITH CYLINDRICAL CLAMPING SURFACES

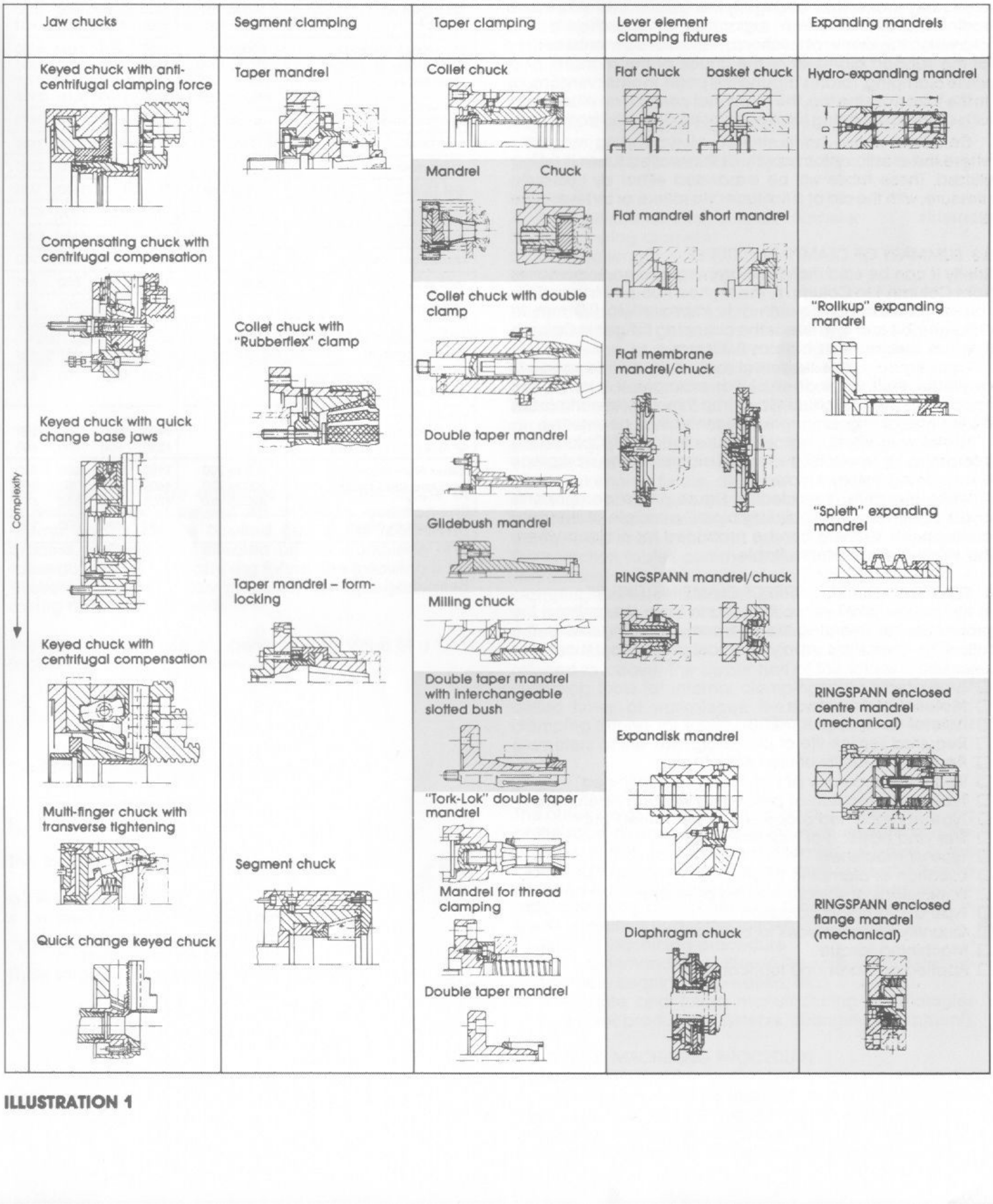


ILLUSTRATION 1

Column 1 is the most popular and widely known. The example given at the top shows a modern collet chuck with centrifugal force adjustment. The normal practice is to machine with turned-out clamping jaws. Various alternative chucks are shown below.

Column 3 taper clamping fixtures; for expanding or compressing a collet on its diameter by means of axial force. The principle is similar with the segment clamping fixture in Column 2 except that here the individual segments are subjected to radial displacement by a taper or wedges.

Column 4 shows the lever-element clamping fixtures. The clamping element is an ingeniously designed axial-symmetrical part performing rotational motions, as a result of the axial clamping stroke, thus changing the axial movement into a radial movement, or an expansion or reduction of the diameter. The center of rotation of the lever element is seated at the support diameter of the chuck or the mandrel and, while clamping, rotates around this point. In other versions, as in the third from the top, the rotational center is an elastic joint of a diaphragm being totally enclosed or slotted from inside.

Column 5 shows an illustration of expanding mandrels where the elastic deformability of thin-walled tubes is being utilized. These tubes will be expanded either by hydraulic pressure, with the aid of a flat taper via rollers, or by lever-type elements.

3.3 SUMMARY OF CLAMPING FIXTURES

Briefly it can be said that the clamping accuracy increases from Column 1 to Column 5. The highest true-running perfection of 0.015mm in Column 1 is improved to 0.01mm in Columns 2, 3 and 4, whereas the clamping fixtures in Column 5 reach precisions as high as 0.001mm.

From figure 1, it is apparent that while a wide range is available, limitations do exist. For example, it is very often impossible with jaw chucks to clamp thin-walled workpieces if after machining, accurate concentricity is necessary.

The lever-element clamping fixture, in figure 1, Column 4, is interesting as, in addition to radial clamping, the workpiece is also being axially located.

While the units illustrated in Figure 1 are components constructed from the "building block" principle of standard components specials can be produced for projects where the existing range is unsuitable.

4. SELECTION OF THE CORRECT CLAMPING FIXTURE

In the course of 20 years, Ringspann have streamlined the procedure for selecting the optimum clamping fixture. The following principals apply in most cases for successful selection.

- ☐ Type of workpiece
- ☐ Material of workpiece
- ☐ Type of workpiece loading
- ☐ Required service life of clamping tool
- ☐ Required quantity of clamping tools
- ☐ Required accuracy of surface to be machined
- ☐ Type and precision of preceding working operations
- ☐ Type of machined processes to be carried out
- ☐ Size and position of machining force
- ☐ Type of machinery
- ☐ Location of clamping fixture
- ☐ Dimensions of spindle flanges or tapers
- ☐ Type of clamping actuation
- ☐ Quantity of workpieces to be machined
- ☐ Machining torque
- ☐ Applied coolants and lubricants

TABLE 1
REFERENCE VALUES FOR SPECIFIC CUTTING FORCES

Material	Tensile strength resp. Brinell hardness N/mm^2	Specific cutting force in N/mm^2 at feed in mm/rev.			
		0.1	0.2	0.4	0.8
St 34, St 37, St 42	o B to 500	3600	2600	1900	1360
St 50	500 to 600	4000	2900	2100	1520
St 60	600 to 700	4200	3000	2200	1560
St 70	700 to 850	4400	3150	2300	1640
GS38, GS45	300 to 500	3200	2300	1700	1240
GS 52, GS 60	500 to 700	3600	2600	1900	1360
GS 70	over 700	3900	2850	2050	1500
Mn steel, Cr-Ni steel,	700 to 850	4700	3400	2450	1750
Cr-Mo steel and other	850 to 1000	5000	3600	2600	1850
steel alloys	1000 to 1400	5300	3800	2750	2000
	1400 to 1800	5700	4100	3000	2150
stainless steel	600 to 700	5200	3750	2700	1920
tool steel	1500 to 1800	5700	4100	3000	2150
manganese hard steel		6600	4800	3500	2520
GG 10, GG 15	HB to 200	1900	1360	1000	720
GG 20, GG 26	HB 200 to 250	2900	2080	1500	1080
cast iron, alloy	HB 250 to 400	3200	2300	1700	1200
malleable cast iron		2400	1750	1250	920
yellow brass	HB 80 to 120	1600	1150	850	600
red brass		1400	1000	700	520
cast bronze		3400	2450	1800	1280
pure aluminium		1050	760	550	400
aluminium alloy with high Si-content (11 . . . 13% Si)		1400	1000	700	520
piston alloy					
A1, Si (tough, 11 . . . 13.5% Si)		1400	1000	700	520
G Al-Si (11 . . . 13% Si)		1250	900	650	480
Other Aluminium-cast	o B to 300	1150	840	600	430
and kneaded alloys	300 to 420	1400	1000	700	520
	420 to 580	1700	1220	850	640
magnesium alloys		580	420	300	220

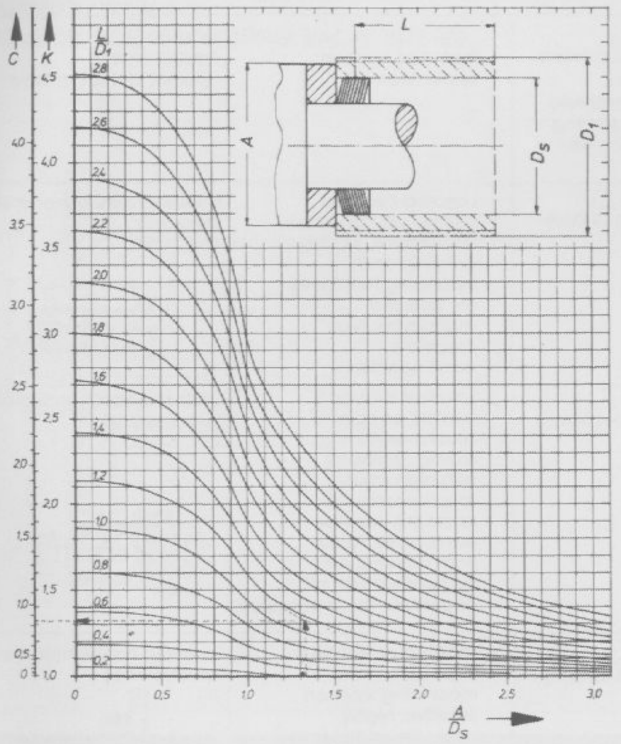


ILLUSTRATION 2
DIAGRAM FOR DETERMINATION OF FACTOR K FOR EQUIVALENT MACHINING TORQUE

The answers to these questions will limit the scope of potential clamping fixtures. An important question will always be the torque applied during the machining process or the forces effected on the workpiece and subsequently on the clamping fixture. The following is an illustration of an exemplary calculation of torque generated during machining of parts:

The machining torque M_a, generated by virtue of a turning tool, is calculated as follows:

$$M_a = \frac{F_h \cdot D_1}{2000} \quad \text{(Nm)}$$

The factors of this equation stand for:

F_h = main cutting force (N)
F_h = $a.s.k_s$ (N)

The factors of this equation stand for:

a = cutting depth (mm)
s = feed indexing/rotation (mm/U)
k_s = specific cutting force (N/mm^2) numerical values from Table 1
D_1 = largest machining diameter (mm)

It will be possible with this torque, depending on the functional principle and an additional safety margin for the clamping fixture, to dimension clamping elements and locating surfaces. This, however, frequently requires further consideration in addition to the mere machining torque. Therefore, as an example, a problem frequently occurring is illustrated as follows:

It often occurs that the actuation plane of the machining force is far apart from the clamping surface, thereby generating a degree of torque causing the workpiece to tilt, so that the maximum torque transmitted by the clamping element cannot be fully utilized as machining torque. In this case it would be appropriate to calculate an equivalent torque M_v which is to be determined as shown below. By including the machining torque M_a which is arrived at as already shown above, the equivalent torque M_v becomes:

$$M_v = K \cdot M_a \quad N_m$$

The factor K is found by calculating the values for A/D_s and L/D_1 and by taking the complementary value for K from Figure 2. The values stated in Figure 2 have the following meaning:

A = maximum locating surface diameter
D_s = clamping diameter
L = tilting length
D_1 = maximum machining diameter

This procedure applies to clamping fixtures having only one centering- or clamping point and one tool engaged. The influence of the auxiliary cutting forces has been disregarded, as this is usually insignificant.

By the aforementioned detailed descriptions of the calculation of torque transmitted by the clamping element, an example is given of the working method in the state of projecting. Based on the above, it would be possible to choose from a standard programme the most suitable type of clamping fixture, as shown in Figure 3.

The left half of Figure 3 is a selection from the standard programme of clamping fixtures, while the right half contains the most important special clamping designs. The selection tables commence with the column at the very left, indicating the range of clamping diameters and clamping diameter radii of length. The centre column has the preferred ranges of application. The results are indicated in each of the third columns showing the most suitable clamping tool meeting the principal criteria referred to above. The upper half of the tables illustrate clamping tools for internal clamping, e.g., clamping of drilled holes of workpieces; the bottom half refers to clamping fixtures for external clamping such as external diameters of the workpieces.

5. EXAMPLES OF APPLICATIONS

The objective of the above illustrations are the machining of the most diversified parts in the manufacture of automobiles. Further it has been demonstrated which of the clamping fixtures are most commonly used and how to proceed expediently in order to arrive at the most favourable clamping device. These will now be described in detail, classified under the following headings:

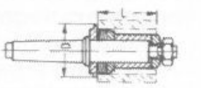
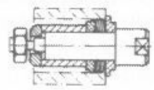
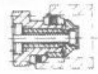
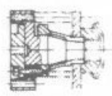
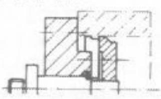
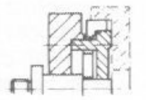
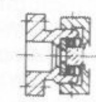
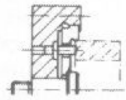
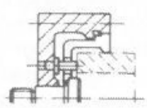
- ☐ Type of machining procedure
- ☐ Special demands in relation to the workpiece (deformation-free, aligning, thin-walled, etc.)
- ☐ Up-to-date and future manufacturing technologies (e.g., new production systems, changing equipment).

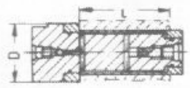
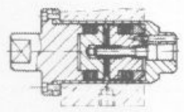
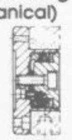
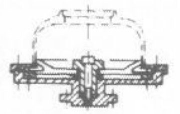
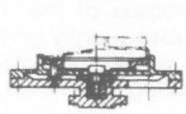
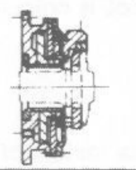
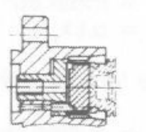
5.1 TYPE OF MACHINING PROCEDURE

☐ Turning

Figure 4 is a chuck to be inserted on a multiple-spindle automatic lathe for the machining of valve bodies for power steering components in passenger cars. A large number of similar parts are held by two different clamping

ILLUSTRATION 3 SELECTION DIAGRAM FOR DETERMINATION OF OPTIMAL CLAMPING FIXTURE

Workpiece D/L hardened clamping diameter	Preferred fields of application	RINGSPANN standard clamping tools
$D \geq L$ 18–80mm	Fitted in taper of milling, turning, grinding & balancing machines	Taper mandrel 
$D \geq L$ 18–80mm	Located between centres on controlling devices, turning, milling and grinding machines. Hand operated.	Centre mandrel 
$D \geq L$ 22–110mm	Located on flange of turning, milling, grinding & balancing machines. Hand or power operated.	Flange mounted mandrel 
$D \geq L$ 10–100mm	Located on a flange. Installed for high dynamic stresses, i.e. torques, and also for small clamping diameters. Power operated.	Tapered collet chuck 
$D \geq L$ 90–375mm	Short mandrel for turning, milling, grinding or balancing machines. Hand or power operated.	Flat mandrel 
$D \geq L$ 70–200mm	Clamping of workpieces with short clamping length for balancing, grinding and middle range machining.	Short mandrel 
$D \geq L$ 10–100mm	Mainly for grinding and for light turning operations. Hand operated.	Chuck 
$D \geq L$ 35–350mm	Narrow chucks for turning, milling, grinding and balancing machines. Hand or power operated.	Flat chuck 
$D \geq L$ 40–340mm	Narrow chucks for turning, milling, grinding and balancing machines. Larger clamping depth and machining of through bores possible. Hand or power operated.	Basket chuck 

Workpiece D/L hardened clamping diameter	Preferred fields of application	RINGSPANN special clamping tools
$D \leq L$ 20–300mm	Located between centres on inspection installations, turning, grinding and balancing machines. For sensitive workpieces: high precision. Hand operated.	Enclosed centre mandrel (hydraulic) 
$D \leq L$ 25–205mm	Located between centres on special machines (turning, milling, grinding) with high safety requirements (no leakage). Also for workpieces made from material not compatible with oil or grease. Hand operated.	Enclosed centre mandrel (mechanical) 
$D \geq L$ 25–205mm	Located on flange for inspection and machining work on sensitive, highly accurate workpieces. Hand or power operated.	Enclosed flange mandrel (mechanical) 
$D \geq L$ 50–550mm	Located on flange of vertical and horizontal balancing machines, grinding and turning machines and machining centres. Clamping via inherent spring tension. Hand or power operated.	Flat membrane mandrel 
$D \geq L$ 50–550mm	Located on flange of vertical and horizontal balancing machines, grinding and turning machines and machining centres. Clamping via inherent spring tension. Hand or power operated.	Flat membrane chuck 
$D \geq L$ 3–400mm	Located on flange, principally for installation in internal grinding machines, fine turning, precision drills and manufacturing centres. Clamping via inherent spring tension. Pneumatically operated.	Cup membrane chuck 
$D \geq L$ 8–150mm	Located on flange of turning and grinding machines. For high dynamic stresses, mass production manufacture and automatic workpiece feed.	Tapered collet chuck 

diameters. The different clamping diameters require merely an exchange of the collets located between RINGSPANN discs and workpiece. This can be done in a very short time.

Figure 5 is a photograph of the workpiece showing the chucks as Figure 4. The upper lining allows an identification of a workpiece, while no workpiece is contained by the chuck located on the left side.

Figure 6 shows a mandrel for the purpose of machining brake discs for passenger cars. The clamping is achieved in the very short cylindrical bore of the brake disc, resulting in a simultaneous action at the locating ring. The clamping is being effected by a disc spring pack and released mechanically by a move of the pullrod to the left. During clamping the attenuation pistons are pushed radially outward by means of springs and an axially aligned slide, thereby stabilizing the brake disc during machining against vibrations.

ILLUSTRATION 4
CHUCK FOR MACHINING VALVE BODIES

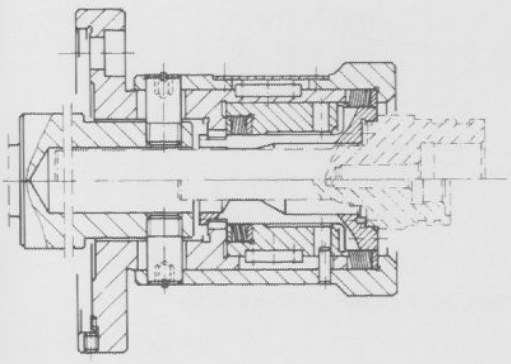
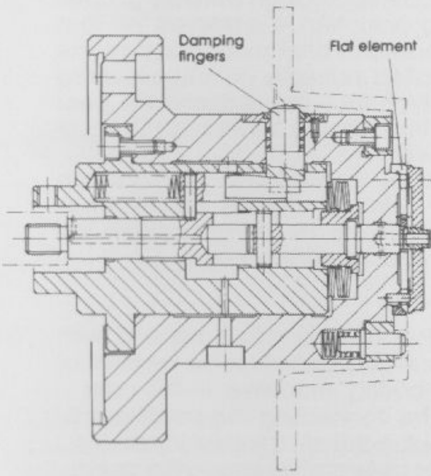


ILLUSTRATION 5
MACHINE ROOM OF MULTI-SPINDLE LATHE WITH CHUCKS FOR MACHINING VALVE BODIES

ILLUSTRATION 6
MANDREL FOR MACHINING CAR BRAKE DISCS WITH DAMPENING ATTACHMENT



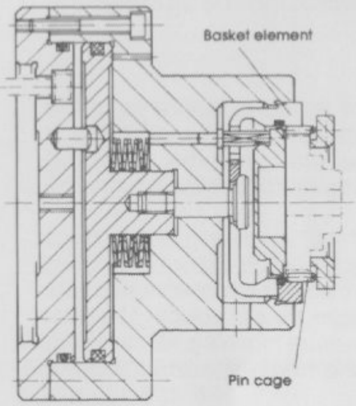


ILLUSTRATION 7
PNEUMATICALLY OPERATED CHUCK FOR MACHINING GEARS

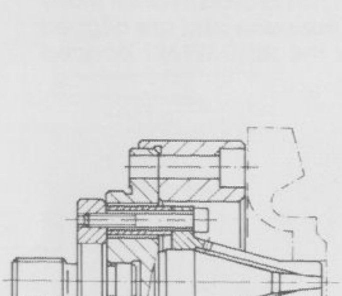


ILLUSTRATION 8
TAPERED MANDREL FOR HOLDING PUMP IMPELLERS

☐ Grinding
Figure 7 is an illustration of a pneumatically actuated chuck with basket chuck clamping element for the location of gear-wheels during operation of an internal grinder. Here, too, the clamping actuation is achieved via disc springs which will be released by pneumatic pressure. The clamping is being controlled indirectly via rollers located within a cage inside which they are slid into the gear openings, thus securing true running between pitch circle and bore to be machined.

Figure 8 is a taper chuck for the location of a pump impeller on a surface grinder. In spite of the small clamping diameter in the bore of the pump impeller, this chuck is a very rugged and compact design.

☐ Fine Boring
Figure 9 is an illustration of a parallel mandrel with RINGSPANN bonded discs and a collet for the location of piston rods on a fine-boring machine; in this case operation is by hand. The connecting-rod small end is being machined and subsequently placed inside the piston. In order to prevent deformation due to the rough flat surface of the big connecting-rod end, the mandrel is equipped with a cardan ring to function as a backstopping ring.

Figure 10 shows a penumatically operated conical chuck for holding a flywheel for the purpose of drilling the connecting holes. Here it can be easily recognized how short the available clamping recess may be on this type of clamping fixture.

☐ Balancing
Figure 11 illustrates how a flat mandrel operates in the process of balancing a flywheel. Here the problem is similar to that in Figure 10, as also here the clamping position is very short and the required precision is high. The chuck is hand-operated.

Figure 12 shows a mandrel for balancing brake discs on a horizontal balancing machine. The actual clamping body is a diaphragm mandrel centering the workpiece by the spring force of the diaphragm, thus producing torque. Release is actuated via a pressure bushing, a cross-pin and a pushrod with the aid of a hand-operated screw.

☐ Inspection
Figure 13 is an inspection mandrel with a precision radial and axial bearing for the control of circular and transverse stop defects of flanges.

Figure 14 illustrates a design of a mandrel for the testing of noise intensity in gears which has proved itself for many years. The gears are faced on the cone and are aligned by a transverse movement of the RINGSPANN bonded disc.

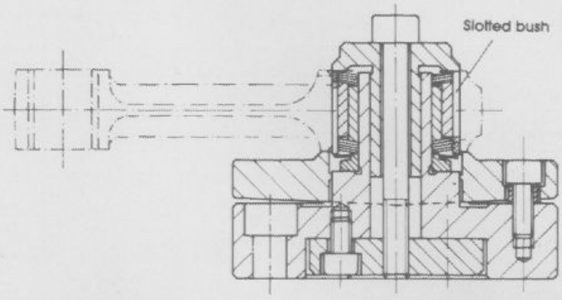


ILLUSTRATION 9
PARALLEL MANDREL FOR CONNECTING ROD

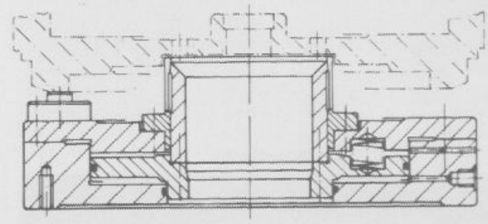


ILLUSTRATION 10
PNEUMATICALLY OPERATED TAPERED MANDREL FOR FLYWHEEL

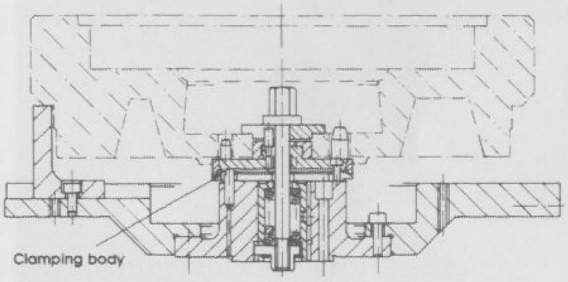


ILLUSTRATION 11
SHORT MANDREL FOR BALANCING FLYWHEELS

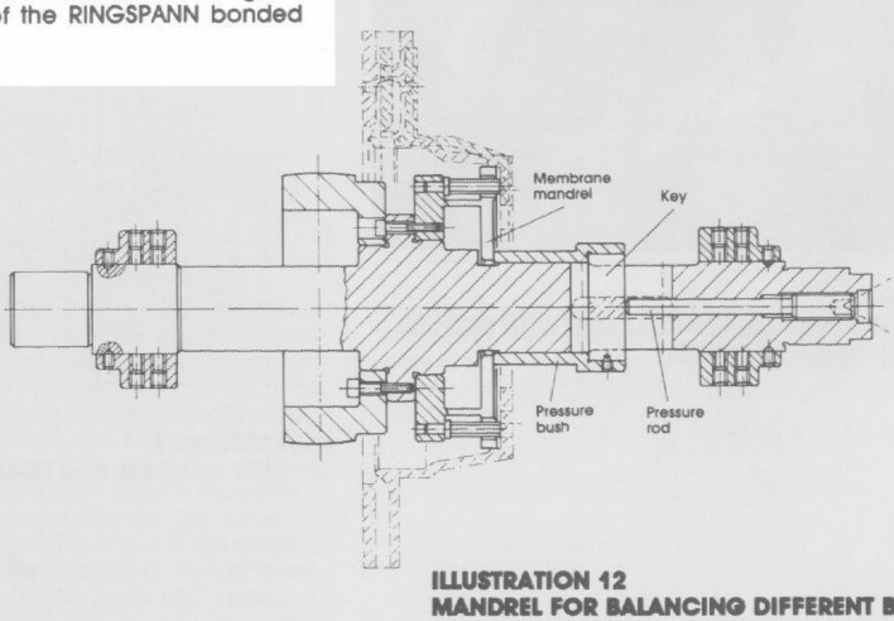


ILLUSTRATION 12
MANDREL FOR BALANCING DIFFERENT BRAKE DISCS

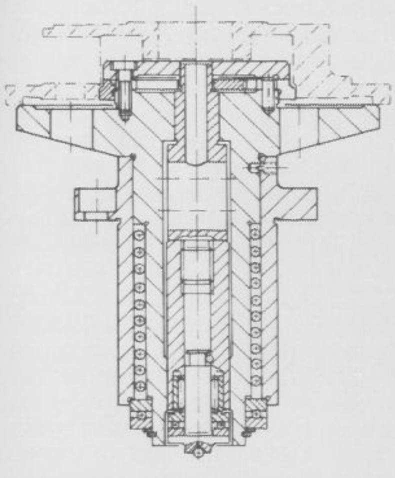


ILLUSTRATION 13
CONTROL MANDREL WITH RADIAL AND AXIAL BEARINGS FOR FLANGE

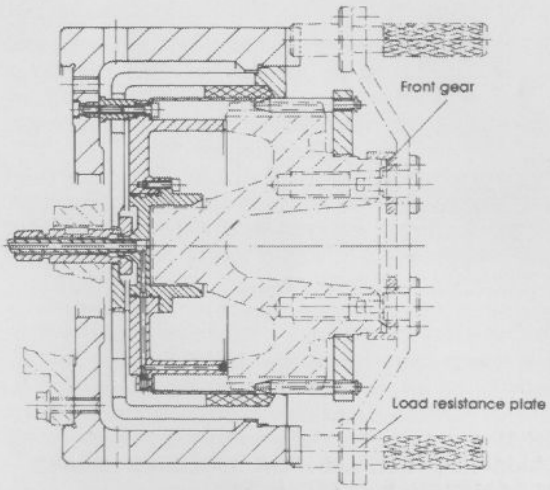


ILLUSTRATION 16
BASKET-TYPE CHUCK FOR HOLDING GEARWHEEL MACHINING OF SPUR GEARS WITH DEFINED POSITIONING TO IMPELLER GEARS

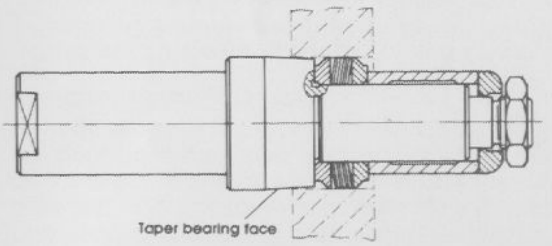


ILLUSTRATION 14
MANDREL FOR NOISE TESTING OF GEARWHEELS

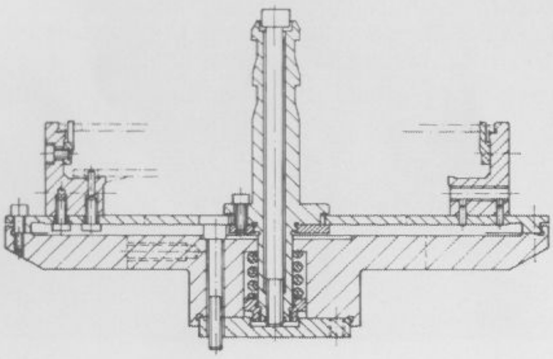


ILLUSTRATION 17
DIAPHRAGM CHUCK FOR HOLDING THIN-WALLED CLUTCH PRESSURE PLATES

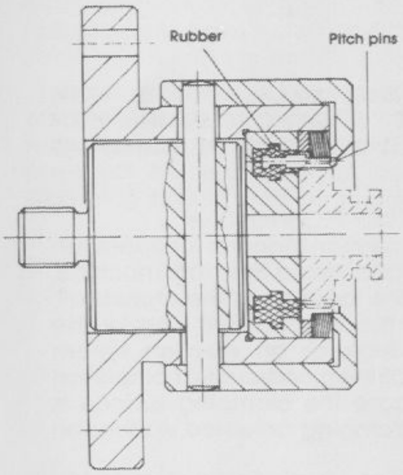


ILLUSTRATION 15
CHUCK FOR STARTER PINION

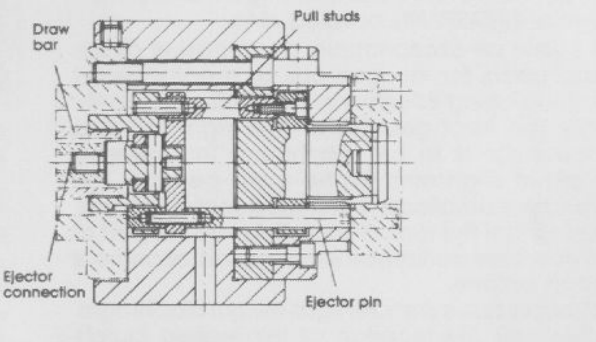


ILLUSTRATION 18
TAPERED MANDREL WITH EJECTOR DEVICE FOR HOLDING CRANKSHAFT

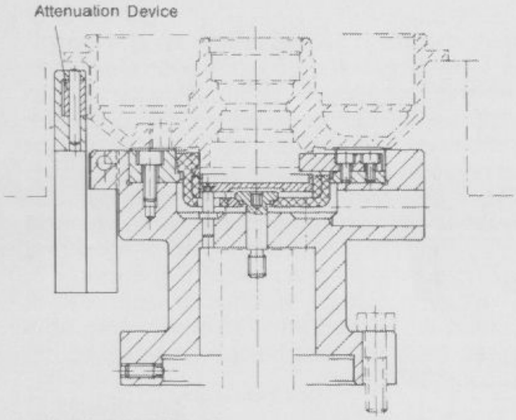


ILLUSTRATION 19
CUP-TYPE CLAMPING FIXTURE FOR HOLDING BRAKE DRUMS WITH DAMPENING ATTACHMENT

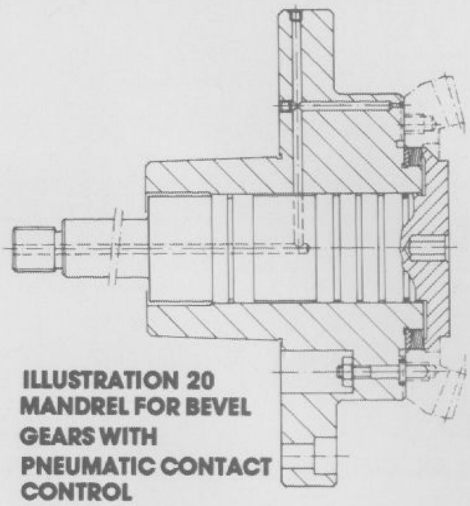


ILLUSTRATION 20
MANDREL FOR BEVEL GEARS WITH PNEUMATIC CONTACT CONTROL

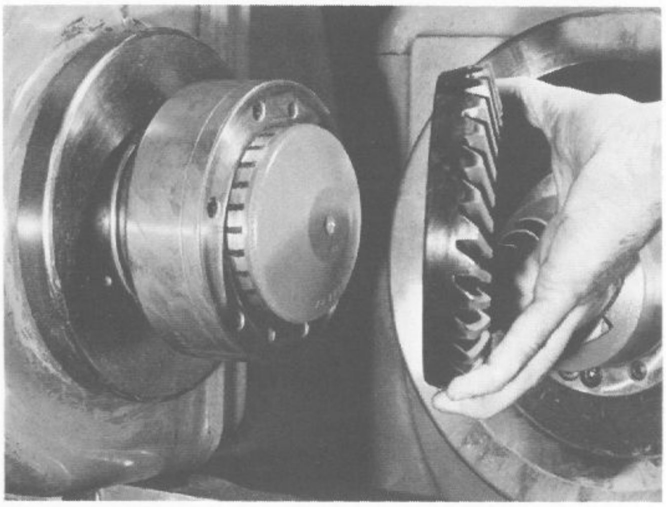


ILLUSTRATION 21
PHOTOGRAPH OF A MANDREL FOR CUTTING MACHINE IN FIGURE 20

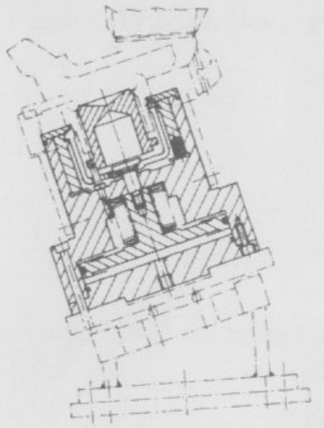


ILLUSTRATION 22
BASKET-TYPE CLAMPING FIXTURE FOR AUTOMATIC WELDING UNIT FOR JOINING STUB AXLE PARTS

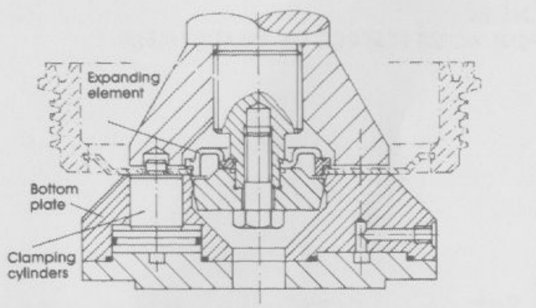


ILLUSTRATION 23
MANDREL FOR MACHINING BRAKE DRUMS WITH AUTOMATIC WORKPIECE FEED, CENTERING WITH MANDREL AND CHUCKING BY MEANS OF CLAMPING PISTONS

5.2 WORKPIECE WITH SPECIAL REQUIREMENTS

Figure 15 is an illustration of a clamping chuck for drilling the bearing bushings of a starter gear on an automatic lathe. The centering is achieved by flexibly-seated precision pins fitted between the teeth of the gearing of the workpiece. The pins feature rubber bearings and, due to axial movement of the outer bushing, the clamping is achieved via a RINGSPANN bonded disc.

Figure 16 shows an exceptionally deep basket chuck locating large gears for the gearbox of a commercial vehicle; clamping being effected in the outer gearing via a roller cage. The front gearing on the right locating surface of the gear is to be machined. This gearing requires an exact alignment to the main gearing. The chuck features a pneumatically-controlled seating device, thereby ensuring that the tool will not slide into the part of clamping device, if the workpiece is not in exact alignment to the backstop surface.

Figure 17 illustrates an extremely light-weight diaphragm clamping chuck for the location of thin-walled clutch pressure plates. The clamping chuck is located on a vertical balancing machine and can be applied to two different workpieces without prior changeover. The centering of the workpiece is by the spring force of the diaphragm, augmented by compression springs arranged in the lower section of the device. The long central release screw effects disengagement.

5.3 MODERN MANUFACTURING TECHNOLOGY

Figure 18 shows a taper expansion mandrel for operation on an automatically-charged micro-finishing machine. The mandrel functions in the location of the crankshaft; Figure 18 only revealing the extreme left end of the crankshaft. The mandrel features an ejection system which thrusts the crankshaft off the mandrel after completion of the operation. In this case the clamping surface is relatively short, the taper clamping actuated via tension bolts and tube.

Figure 19 is an illustration of a basket clamping device for the location of brake drums on a vertical multispindle turning machine. In comparison to Figure 6, this clamping fixture features a cushioning device by which it is possible to largely eliminate vibrations in the bell-shaped part, due to the machining with ceramic tools.

Figure 20 shows a mandrel for the location of pinion gears on tooth-cutting machines. Here charging is effected by an automatic mechanism. The mandrel features a pneumatic control system, ensuring that the machining process is not started prior to the workpiece being properly located.

Figure 21 is a photograph of the mandrel shown in Figure 20. This is to demonstrate how the pinion gear is manually mounted on the mandrel via the automatic charging installation.

Figure 22 shows an angular mounted basket chuck in an automatic welding mechanism for an axle journal. The chuck is clamped by the disc spring pack and released by air pressure. Also here the proper locating procedure of the workpiece to the chuck base is pneumatically controlled. In addition, by means of a lever system and micro switch a test is made to verify whether the clamping operation has been effected.

Finally, Figure 23 shows a mandrel for the machining of brake drums. By way of an automatically expanded clamping mandrel, the brake drum is placed on the bottom face of the clamping block, then the clamping mandrel travels to the position indicated upon which the workpiece is lifted by several clamping pistons located in the lower part until it is in the seat of the clamping unit. During this process the workpiece is centered by the U-shaped clamping element. The special shape of the clamping element provides it with the required degree of flexibility necessry in bridging the large work tolerance.

6. FUTURE DEVELOPMENTS

As in all areas of technology, precision clamping fixtures will change in the future to comply with the requirements and projects. It can be assumed that the level of precision reached will improve and even higher standards of centering and aligning precision will be expected. In the future, automatic changing installations will more frequently be coupled with machining devices, so that special consideration will have to be given to the design of clamping fixtures. This trend is already recognizable in a series of examples given in section 5.

Due to further developments in the field of automation, more and more clamping fixtures will have to be equipped with safety devices for the purpose of testing the positioning and subsequent clamping actuation of the workpiece. Other safety- and positioning mechanisms on the clamping fixture will also be required. A standardization of the monitoring contacts – of either an electric or pneumatic nature – will have to be examined in due course in conjunction with the machine tool industry.

In order to achieve a further reduction of setup cost, the present system of tool stocks might in future be extended to the stocking of clamping fixtures as well, or exchange parts will be kept in stock. The design engineers of clamping fixtures must be prepared for this situation!

SUMMARY

The present production methods of the automotive industry have set high standards of efficiency. This applies in particular to engine-, power transmission- and suspension components where tolerances are usually limited to ± 0.0005". These requirements can only be met if the clamping fixture for locating components during the machining process operate with high precision and have a long service life. Furthermore, they must be constructed in a manner to effect quick change without any problem during operation. The precision chucks greatly contribute to the reduction of the setup time in machining equipment. In the future, clamping fixtures will have to meet all the above requirements, with the trends towards automatic changing. An equal trend can be observed where in order to effect a reduction in setup cost, clamping fixtures will be stored much like other cutting tools in magazines.