

Description

This invention is a gage by which to measure the quarter chord angle of the leading edge or trailing edge of each vane in a row of compressor vanes mounted in the vane assembly. This assembly includes inner and outer stator rings between which the vanes extend and within which they are securely mounted. The invention is particularly concerned with a device for successively measuring the individual angles of each of the vanes in the row of vanes.

The angle of leading and/or trailing edge of the vanes in a row of compressor vanes particularly in a multistage axial flow compressor is critical to the performance of the compressor and particularly to the efficiency of the compressor as a unit. The vanes are regularly permanently mounted in a row between inner and outer stator rings and it is routine to check either or both quarter chord angles of each ring after the row of vanes is assembled to assure that the quarter chord angle of all the vanes are within the design limits.

This had been done usually with a hand operated gage that is manually positioned on each vane individually and when several gage points on the gage are all in contact with the vane the angle is measured with respect to a leveling device forming a part of the gage. This is a time consuming process particularly in man hours merely in inspection of the vane assembly. It is desirable to determine the chord angle with several points lengthwise of each vane and thus the time involved is greatly increased. It will be understood that the chord angle routinely varies from the outer end to the inner end of each of the vanes so that inspection is routinely necessary at least at both ends and generally midway between the ends. Obviously, if the vane angles are not within the design limits, the vane assembly must be discarded or have the vanes reshaped to meet the required limits.

Reference is made to US-A-4 024 646 which discloses a vane gaging and bending apparatus having a gage device according to the precharacterizing portion of claim 1. The known machine has a table rotatable about a vertical axis and supporting a vane assembly and a pair of head units engageable with the leading edge and trailing edge of the vanes. The head units have jaws with a gage device being formed within one of the jaws. The gage device has a pivotably mounted rocker element having two vane contact points. A gaging block formed with the rocker element cooperates with a conduit to provide a pneumatic signal proportional to the alignment of the vanes. The head units are movable lengthwise of the vane but after measuring and possibly bending of one vane has been carried out the head units must be positively vertically retracted and moved away from the vane and thereafter again moved vertically to engage the next vane.

The object of the invention is to provide a quarter chord angle gage that will individually and successively inspect each vane in a vane

assembly to establish the precise quarter chord angle of each vane and reduce the time required for the inspection of the vane assembly.

According to the invention this is achieved by the features of the characterizing portion of claim 1.

With the gage device of the invention as the gage and the row of vanes move horizontally relative to one another the base and gage points therein are retracted from the vane being inspected by contact of the guide with the next vane so that the inspected vane may pass under the gage in order to place the next vane in a position for inspection. The transducer senses the position of the cam when the several gage points are all in contact with the vane, and this sensed position is electronically recorded to provide the desired record of the quarter chord angle. As the inspection continues the result is a record of the quarter chord angle for all of the vanes in the row of vanes after the inspection of the entire row is completed. The guide protects the gage points as the gage moves relatively to the successive vanes, and this guide serves to keep the gage points out of contact with the edge of each vane as it moves underneath the gage. It will be understood that the device is intended to inspect the vane during the continuous movement of the row of vanes underneath the guide and thereby significantly reduces the time needed for a full inspection of the entire row of vanes.

The gage device will now be described in greater detail with reference to the accompanying drawings, wherein:

Fig. 1 is an elevation of the gage device in starting position relative to the vane assembly and with parts broken away to show the operation better.

Fig. 2 is a diagrammatic view of the transducer and the associated recording mechanism.

Fig. 3 is a diagrammatic view of the gage and base in a position with all of the gage points in contact with the vane at which time the quarter chord angle is sensed by the device.

Fig. 4 is a view similar to Fig. 3 showing the device in the same position as Fig. 3 but on the trailing edge of the vane rather than on the leading edge as in Figs. 1-3 inclusive.

The invention is shown as being used to inspect a row of compressor vanes 10 positioned in a ring and with the vanes extending between inner and outer rings only one of which, the inner ring 12 is shown. It will be understood that the vanes extend between the two rings and are securely positioned in each so that the quarter chord angle 14 of the leading edge, or the angle 16 of the trailing edge, is fixed with respect to the axis of the vane assembly.

In the arrangement shown the vane assembly is positioned on a table 18 mounted to turn on a vertical axis 20. The vane assembly is mounted so that its axis coincides with the table axis. In this way rotation of the table underneath the gage will rotate the vane assembly on its axis.

The assembly is positioned under a gage

support 22. The rotary mounting of the table 18 provides means for relatively horizontally moving the table 18 and the gage support 22. Within the gage support 22 there is positioned a slide 24 movable on a vertical axis as shown and provided for by means of the linear bearing 26. The lower end of the slide has a horizontal pivotal support 28 which may be a bushing on which the gage base 30 is pivoted. This base carries three gage points for measuring the quarter chord angle at the leading edge 31 of the vane being inspected. The first gage point 32 is in the form of a pin that extends vertically when the gage base is in starting position and which moves with the base as the latter is rotated to bring the several points all into contact with the vane. This gage point 32 engages the vane or the leading edge. It will be understood that contact between the gage point 32 and the vane as the latter moves underneath the gage base causes the base to pivot on its axis in a counterclockwise direction.

The other two gage points 34 and 36 also extend from the base and are spaced away from the point 32 and spaced from each other to engage the convex side of the vane at points spaced from the edge and from one another chordwise of the vane. The starting position of these points and the base is shown in Fig. 1. The measuring point or position with all three points contacting the vane is shown in Fig. 3. It will be understood that the same device may operate in the same way on the trailing edge of the vane as shown in Fig. 4 where the gage point 32 engages the trailing edge 38 of the vane and the points 34 and 36 engage the concave side as points spaced chordwise from the trailing edge 38.

The gage base has an integral part, a cam 40, extending upwardly from the pivot and having an arcuate cam surface 42 gradually extending from a point 44 relatively close to the pivot at one end of the surface to a point 46 at the other end at a greater distance from the pivot point.

This cam engages the sensor 48 of a transducer 50 carried by the slide. With this cam and sensor in the arrangement shown, the transducer will accurately indicate the precise angle of the base when the three gage points are all in contact with the vane and thus will indicate the precise quarter chord angle of the leading edge of the vane. It is obvious that as the base rotates counterclockwise to position all three of the gage points in simultaneous contact of the vane that the cam 40 moves with the base carrying the surface 42 underneath the sensor 48 which follows the surface of the cam being vertically moved with respect to the transducer.

The device is intended to inspect each gage successively in a continuous process by a continuous movement of the row of vanes underneath the gage by a rotation of the table. To accomplish this the gage base is urged by a spring 52 into the starting of Fig. 1. One end of this spring is on pin 54 on the cam, the other end is on a pin 56 secured to a fixed guide 60. As the vane moves relative to the gage base it is caused to turn, carrying with it the cam 40 so that when the contacts all engage the

vane the cam will indicate the precise angle of the quarter chord.

The contacts 34 and 36 are prevented from accidental contact with the edge of the vanes as they move beneath the gage by the guide 60 secured to the slide and extending beyond the gage points when they are in the starting position as shown in Fig. 1. This guide engages with the leading edge of the vane and elevates the gage base adequately to keep the gage points out of contact with the vane as will be apparent.

In the operation of the mechanical part of the device the row of vanes is moved to the right beneath the gage as shown by the arrow 62 of Fig. 1. As this occurs, the leading edge 31 of the vane engages the gage point 32 as the guide 60 allows the gage to move lower onto the vane. As the vane continues its horizontal movement, engagement between the vane and the guide pin 32 causes the gage base to rotate counterclockwise and bring the gage points 34 and 36 toward the vane surface and ultimately into contact with the vane surface. When a point is reached as the base turns counterclockwise that all three gage points are simultaneously in contact with the vane at the three spaced inspection points, the cam is in a position to indicate the quarter chord angle being measured and the transducer sensor following the cam will indicate the angle.

After this particular position of the cam has been recorded, at the moment of the contact of all three gage points with the vane continued movement of the vane assembly under the gage turns each gage base further as a result of the gage point 32 riding over the edge of the vane until the tip of the gage point 32 clears the leading edge. Then spring 52 swings the base back into starting position in readiness for the inspection of the next vane. Continued movement of the vane ring carries the next vane into position to be engaged by gage pin 32. As the vane assembly moves beneath the gage structure, the guide 60 engages a forthcoming vane and lifts the gage base upwardly to prevent contact of the gage points 34 and 36 with the edge of the vane.

As the next vane to be inspected leaves the position of the vane in Fig. 1, a repetition of the operation continues. It is clear that this is a continuous operation and is carried out by a continuous uninterrupted forward movement of the row of vanes beneath the gage mechanism.

Referring now to Fig. 2 transducer 50 is connected by electrical leads 62 to the transducer electronic recording box and printer 64 which serves to record the particular position of the cam and thus the quarter chord angle for each vane. This occurs when the transducer is actuated by a signal from the gage contact detector box 65. The three gage points 32, 34 and 36 are connected by electrical leads 66, 68 and 70 and when contact is made between the vane and all three contacts at the time circuits within the detector box 65 are completed to signal to the transducer recording box to function to record the angle of the cam at that moment.

Immediately the contact among the gages is broken and the electronic mechanism will be set in readiness for the gaging operation on the next vane.

It will be understood that after the entire set of vanes has been checked for the quarter chord angle at one selected position lengthwise of each vane the mechanism may incorporate adjustments to move the entire gage head toward or away from the axis of the table and thus move it in respect to the axis of the vane assembly so that a second location of the chord angle measurements may be taken at another position lengthwise of each of the vanes.

Although the device is shown as applied directly to the gaging of the quarter chord angle of the leading edge of the vane it is equally operable. As above stated, the gaging of the trailing edge is indicated in Fig. 4 and as described above.

Claims

1. A gage device for measuring the quarter chord angle of compressor vanes (10) in a vane assembly having a row of vanes (10), comprising a table (18) for supporting the vane assembly with the axis thereof oriented vertically, a gage support (22) mounted above the table (18), means for relatively horizontally moving the table (18) and the gage support (22), means engageable with the leading edge (31) or trailing edge (38) of a vane (10) of the vane assembly, a pivotably mounted gage base (30) having two gage points (34, 36) engageable with a side of said vane (10) at points differently spaced from the leading edge (31) or trailing edge (38) of said vane (10), and a transducer (50) indicating the pivotal position of the base (30) when the two gage points (34, 36) are in engagement with said vane (10), characterized in that a slide (24) is freely vertically movable on the support (22) and has a guide (60) engageable with the vane leading or trailing edge (31, 38) to move the slide (24) vertically upon relative horizontal movement of the table (18) and gage support (22), that said base (30) is pivotably mounted about a horizontal axis on a lower portion of said slide (24), and said means engageable with the vane leading edge or trailing edge (31, 38) comprises a pin (32) on said gage base (30) for pivoting said gage base (30) to move said gage points (34, 36) into contact with said vane (10) responsive to contact of said pin (32) with said vane leading or trailing edge (31, 38) when the table (18) and gage support (22) are relatively moved horizontally, that a spring (52) is connected to said slide (24) and said gage base (30) to normally retain said base (30) in a starting position with the gage points (34, 36) spaced from said vane (10), that said base (30) has a cam (42) thereon and said transducer (50) has a movable sensor (48) engaging said cam (42), and that means are provided for sensing when the gage points (34, 36) and the pin (32) are all in contact with said vane (10) to activate the transducer (50).

2. A gage device according to claim 1, characterized by recording means to record the position of the cam (42) when the transducer (50) is activated.

3. A gage device according to claim 1 or 2, characterized in that said sensing means comprises electrical leads (66, 68, 70) from the two gage points (34, 36) and the pin (32) to a detector box (65) to activate the transducer (50) when the vane (10) establishes electrical contact among all of the two gage points (34, 36) and the pin (32).

4. A gage device according to any one of claims 1 to 3, characterized in that the table (18) is rotatable about a vertical axis (20).

Patentansprüche

1. Meßvorrichtung zum Messen des Viertelsehnenwinkels von Verdichterleitschaufeln (10) in einer Leitschaufelbaugruppe, die einen Kranz von Leitschaufeln (10) aufweist, mit einem Tisch (18) zum Tragen der Leitschaufelbaugruppe derart, daß ihre Achse vertikal ausgerichtet ist, einem Meßhalter (22), der oberhalb des Tisches (18) befestigt ist, einer Einrichtung zum relativen Horizontalbewegen des Tisches (18) und des Meßhalters (22), einer Einrichtung, die mit der Vorderkante (31) oder der Hinterkante (38) einer Leitschaufel (10) der Leitschaufelbaugruppe in Berührung bringbar ist, einer schwenkbar befestigten Meßbasis (30), die zwei Meßspitzen (34, 36) hat, welche mit einer Seite der Leitschaufel (10) in Punkten in Berührung bringbar sind, die unterschiedlichen Abstand von der Vorderkante (31) oder der Hinterkante (38) der Leitschaufel (10) haben, und einem Meßwandler (50), der die Schwenkposition der Basis (30) anzeigt, wenn die beiden Meßspitzen (34, 36) mit der Leitschaufel (10) in Berührung sind, dadurch gekennzeichnet, daß ein Schlitten (24) an dem Halter (22) frei vertikal bewegbar ist und eine Führung (60) hat, die mit der Leitschaufelvorder-oder-hinterkante (31, 38) in Berührung bringbar ist, um den Schlitten (24) bei relativer Horizontalbewegung des Tisches (18) und des Meßhalters (22) vertikal zu bewegen, daß die Basis (30) um eine horizontale Achse auf einem unteren Teil des Schlittens (24) schwenkbar befestigt ist und daß die Einrichtung, die mit der Leitschaufelvorderkante oder -hinterkante (31, 38) in Berührung bringbar ist, einen Stift (32) an der Meßbasis (30) zum Schwenken der Meßbasis (30) aufweist, um die Meßspitzen (34, 36) in Kontakt mit der Leitschaufel (10) aufgrund von Kontakt des Stifts (32) mit der Leitschaufelvorder- oder -hinterkante (31, 38) zu bewegen, wenn der Tisch (18) und der Meßhalter (22) horizontal relativbewegt werden, daß eine Feder (52) mit dem Schlitten (24) und der Meßbasis (30) verbunden ist, um die Basis (30) normalerweise in einer Ausgangsposition zu halten, in der die Meßspitzen (34, 36) Abstand von der Leitschaufel (10) haben, daß die Basis (30) einen Nocken (42) und der Meßwandler (50) einen beweglichen Meßfühler (48), der den Nocken (42) berührt, hat und daß Einrichtungen vorgesehen



Immediately the contact among the gages is broken and the electronic mechanism will be set in readiness for the gaging operation on the next vane.

It will be understood that after the entire set of vanes has been checked for the quarter chord angle at one selected position lengthwise of each vane the mechanism may incorporate adjustments to move the entire gage head toward or away from the axis of the table and thus move it in respect to the axis of the vane assembly so that a second location of the chord angle measurements may be taken at another position lengthwise of each of the vanes.

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2. A gage device according to claim 1, characterized by recording means to record the position of the cam (42) when the transducer (50) is activated.

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4. A gage device according to any one of claims 1 to 3, characterized in that the table (18) is rotatable about a vertical axis (20).

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sind zum Abfühlen, wann die Meßspitzen (34, 36) und der Stift (28) alle mit der Leitschaukel (10) in Kontakt sind, um den Meßwandler (50) zu betätigen.

2. Meßvorrichtung nach Anspruch 1, gekennzeichnet durch eine Aufzeichnungseinrichtung zum Aufzeichnen der Position des Nockens (42), wenn der Meßwandler (50) betätigt wird.

3. Meßvorrichtung nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß die Füleinrichtung elektrische Leitungen (66, 68, 70) aufweist, die von den beiden Meßspitzen (34, 36) und dem Stift (32) zu einem Detektorkasten (65) führen, um den Meßwandler (50) zu betätigen, wenn die Leitschaukel (10) elektrischen Kontakt insgesamt unter den beiden Meßspitzen (34, 36) und dem Stift (32) herstellt.

4. Meßvorrichtung nach einem der Ansprüche 1 bis 3, dadurch gekennzeichnet, daß der Tisch (18) um eine vertikale Achse (20) drehbar ist.

Revendications

1. Dispositif de mesure pour mesurer l'angle de la corde de profil d'aubes de compresseur (10) dans un ensemble d'aubes comprenant une succession d'aubes (10), comportant une table (18) pour supporter l'ensemble des aubes, l'axe de la table (18) étant orienté verticalement, un support de mesure (22) monté au-dessus de la table (18), des moyens pour déplacer horizontalement, l'un par rapport à l'autre, la table (18) et le support de mesure (22), des moyens pouvant venir en contact avec le bord d'attaque (31) ou le bord de fuite (38) d'une aube (10) de l'ensemble des aubes, une base de mesure (30), montée à pivotement, comportant deux points de mesure (34, 36) pouvant venir en contact avec une face de l'aube (10) en des points espacés différemment du bord d'attaque (31) ou du bord de fuite (38) de l'aube (10), et un transducteur (50) indiquant la position de pivotement de la base de mesure (30) lorsque les deux points de mesure (34, 36) sont en contact avec l'aube (10), caractérisé en ce qu'un coulisseau (24) est mobile librement, dans le sens vertical sur le support (22) et il comporte un guide (60) pouvant venir en contact le bord d'attaque ou

le bord de fuite (31, 38) de l'aube, afin de déplacer le coulisseau (24) verticalement lors du mouvement horizontal relatif de la table (18) et du support de mesure (22), la base de mesure (30) est montée à pivotement autour d'un axe horizontal sur une partie inférieure du coulisseau (24), les moyens pouvant venir en contact avec le bord d'attaque ou le bord de fuite (31, 38) de l'aube comprennent un doigt (32) sur la base de mesure (30) afin de faire pivoter la base de mesure (30) et de déplacer les points de mesure (34, 36) pour les mettre en contact avec l'aube (10), en réponse à la venue en contact du bord d'attaque ou de fuite (31, 38) de l'aube avec le doigt (32), lorsque la table (18) et le support de mesure (22) sont déplacés horizontalement l'un par rapport à l'autre, un ressort (52) est accroché au coulisseau (24) et à la base de mesure (30) de manière à rappeler normalement la base de mesure (30) dans une position de départ dans laquelle les points de mesure (34, 36) sont espacés de l'aube (10), la base de mesure (30) porte sur elle une came (42) et le transducteur (50) comporte un palpeur mobile (48) venant en contact avec la came (42), et des moyens sont prévus pour détecter le moment où les points de mesure (34, 36) et le doigt (28) sont tous en contact avec l'aube (10), afin de mettre en service le transducteur (50).

2. Dispositif de mesure suivant la revendication 1 caractérisé en ce qu'il comprend des moyens d'enregistrement pour enregistrer la position de la came (42) lorsque le transducteur (50) est mis en service.

3. Dispositif de mesure suivant l'une quelconque des revendications 1 ou 2 caractérisé en ce que les moyens de détection comprennent des conducteurs électriques (66, 68, 70) s'étendant à partir des deux points de mesure (34, 36) et du doigt (32) jusqu'à un boîtier détecteur (65), afin de mettre en service le transducteur (50) lorsque l'aube (10) établit un contact électrique entre la totalité des deux points de mesure (34, 36) et du doigt (32).

4. Dispositif de mesure suivant l'une quelconque des revendications 1 à 3 caractérisé en ce que la table (18) est montée à rotation autour d'un axe vertical (20).

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