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DETECTION OF FLAWS IN RIGID ARTICLES

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This invention relates to the production of shaped articles or components, i. e. articles or components produced by moulding, casting, forging, rolling, drawing, or other mechanical operation, during the course of which the said articles or components may undergo some strain which may result in the development of flaws often so minute that detection is difficult. The invention is more particularly concerned with and will be described in relation to the production of metallic articles and components but it will be apparent that it is equally applicable in the production of non-metallic bodies such as plastics and ceramics and metal-containing powders—"ceramels," and furthermore to the servicing of these various kinds of equipment.

It is an essential part of the production of many articles and components to be able to detect if and when faults however minute appear. Thus, it has been found necessary to develop processes for use in the production of the highly stressed components in use e. g. in modern aircraft, by which minute material faults become easily apparent on examination because although such faults for most purposes would not be prohibitive, for the purposes under consideration they would render the component unserviceable. Morevore, the producers of many forms of equipment for modern industry, especially in the aircraft industry, find the periodical servicing of equipment and components a very necessary part of their business in order to detect faults which may only develop during service.

The present invention provides a simple treatment whereby it may be readily determined at as early a stage as possible in the production of the component whether any minute cracks or porous places exist in the component so that as far as possible expense in machining and finishing the component may be avoided. The invention also facilitates the detection of flaws in the surfaces of components so that premature failure or breakdown during service shall be avoided and any flaws developing in service may be readily detected without in any way affecting the component under examination so that in the event of its being found to be sound it may be returned to service.

It is already well known in the examination of such componets to detect flaws by soaking the components in an oil bath at 80° C. for about 10 minutes. The oil enters any surface porosity or cracks by capillary action and on removal from the bath any surplus oil is wiped from the surface, and while still warm the component is

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dusted with French chalk. After standing for some time defective areas are shown up by the staining of the chalk film due to the seepage of retained oil. An oil which has been employed for this purpose consisted of 25% lard oil and 75% kerosene.

While this technique has served satisfactorily for the examination and control of smaller simpler components, it has proved difficult to carry out in the case of larger and more intricate components. It proved impracticable to wipe the surplus oil from intricate sections in the time taken for the component to cool to room temperature. As a result the smaller defects were not easily observable and there was considerable masking of effects due to the spontaneous staining of the chalk on areas from the surface of which the oil had not been sufficiently removed. Moreover, the flaw indication which at best appears as a dark grey stain on a light grey background was not sufficiently defined to make the detection of small defects infallible, particularly when dark components such as chromated magnesium alloys were being inspected.

The steps which constitute the present invention comprise treating the article after the said mechanical operation with a composition consisting essentially of a water-emulsifiable oil and rinsing the oil from the surface of the component with water, rapidly drying the said article and dusting thereon a finely-divided powder.

The expression "emulsifiable oil" as used herein and in the appended claims is intended to be construed quite broadly as not defining its chemical characteristics but its physical properties as being capable of penetrating into minute fissures and being either inherently or as a result of an added emulsifying agent capable of being washed away from a surface by emulsification with water but sufficiently water repellent to resist peneration of the wash water into the fissures into which it has penetrated.

In making up the oil composition according to the invention a variety of oils may be employed, light mineral oils and kerosene having been found satisfactory. It is to be understood that I do not intend to be limited to the use of mineral oils as the main non-water soluble constituent of the emulsifiable oil. Suitable emulsifiable oils may be prepared by those skilled in the art from vegetable products such as pine oil or arachis oil; from animal oils such as sperm oil or lard oil, or from synthetic products such as nitrobenzene, or from suitable mixtures of these in-

gredients, the main consideration being relative non-miscibility with water, viscosity, stability and lack of action of the final mix on the articles to be examined.

A suitable emulsifying agent where mineral oils are employed is a soap or a mixture of soaps such as potassium oleate and triethanolamine oleate, which may be conveniently incorporated with the oil by first mixing the free fatty acid and triethanolamine with the oil and then adding an aqueous solution of the alkali. Other higher fatty acid salts (i. e. having 8 or more carbon atoms) with water-soluble organic or inorganic bases may be used.

A "coupling" or blending agent such as methyl cyclo-hexanol may also be incorporated in order further to clarify and stabilise the composition. Many other hydroxylated organic materials will serve this purpose, such as butyl and amyl alcohols, glycol mono-ethers, diacetin, diacetone alcohol and cyclohexanol.

The invention also includes a water-emulsifiable oil composition suitable for the above treatment consisting essentially of a water-insoluble oil together with an emulsifying agent with or without additives designed to impart desirable properties, for example, homogeneity, stability, increased or decreased viscosity, lowered surface tension and ready emulsification or miscibility with water. Such a composition may contain up to 25% of water and may comprise a true solution, a colloidal solution or a water in oil emulsion with the oil as the continuous phase.

In carrying out the process according to the invention, the component to be treated may be immersed in a bath containing the water-miscible oil composition which may conveniently be heated above room temperature as this assists the penetration of the oil but generally the bath is sufficiently effective at room temperature. The water rinse, which may conveniently be effected by dipping or preferably by spraying, causes the oil composition on the surface of the component to be dispersed and readily washed away before the oil in the cracks and porous places is affected, leaving the surface after drying clean and free from oil. Any flaws in the surface, however small, will be filled with the oil which has penetrated during the treatment and is not washed away in the rinsing, and after the surface is dry and has been dusted with a white or light coloured powder, this oil will seep out of the flaw and shows up as a stain on the light surface, the action being probably assisted by capillary attraction of the powder for the oil. The water rinse is preferably effected by spraying because it enables the component to be held in such a position that the water runs away rapidly from the surface affected.

The rapid drying may be conveniently carried out by directing an air jet on to the surface to be dried and if desired the air may be heated for this purpose.

Any powder which is white or contrasts in colour with the staining produced at flaws and which is finely-divided, is suitable for the purpose of the invention, and the powder dusting may be conveniently effected by means of a spray gun at 10 lbs. per square inch air pressure. French chalk has been found to give very satisfactory results in the even dusting of the surface.

An important feature of the invention is the incorporation with the powder of an oil soluble dyestuff which is practically imperceptible when mixed with the dry powder but which in coming into contact with the oil seeping from the flaw will cause an intense colouration at the location of any crack or other faulty part of the component. A suitable dyestuff for this purpose is one supplied by the Clayton Aniline Company Limited under the designation Oil Red "S," which gives a brilliant red stain at the defective areas. It is desirable to keep the powder dry in this instance because although this dyestuff is only readily soluble in oils, the presence of moisture increases the tendency for the powder to be coloured spontaneously and in addition renders even dispersion of the powder more difficult.

Any other dyestuff which is sufficiently soluble in the emulsifiable oil and gives a readily observable colour when in contact with the oil may be used instead of the above mentioned dyestuff.

The times required for soaking the component in the oil composition, washing and drying, and to allow the oil to seep out of the crack, are not critical and very little practice will soon show how in any particular instance these times should be arranged. It has been found that good results are obtained by soaking in the oil for 15 minutes at room temperature and allowing the component to drain. Raising the temperature of the oil composition may shorten the time required for these operations. The spraying with water should take about three minutes, and a period of about three minutes may be allowed after dusting with the powder before examination.

The following examples will further illustrate the nature of the invention and the manner in which it may be carried into effect:

Example 1

40 gallons of paraffin (boiling range 150–220° C.) were charged into a tank and heated to 60° C. by means of an electrical immersion heater. 4.8 gallons of oleic acid, 4.0 gallons of Sextol (methyl cyclohexanol) and 0.2 gallon of triethanolamine were added in succession and stirred in. Finally 1.8 gallons of caustic potash (38° Beaumé) were well stirred in, and the mixture allowed to stand at a temperature of 60° C. until clear.

The emulsifiable oil thus obtained was then allowed to cool to room temperature and a magnesium alloy crankcase, which had been previously degreased in a trichloroethylene vapour degreaser, was immersed in the liquid for 15 minutes, drained, and sprayed with water at 120 p. s. i. to emulsify and wash away the superficial film of oil. After drying with a compressed air jet, the component was dusted with a mixture of 95% French chalk with 5% of Oil Red "S" dye, and allowed to stand for 30 minutes. A crack which had developed in the crankcase wall during engine running was shown up by red staining. The emulsifiable oil prepared according to this formula was found to possess the following physical properties:

Kinematic viscosity at 70° F.=3.5 centistokes.
Surface tension=24.6 dy./cm. at 20° C.
Specific gravity at 20° C.=0.824.

Example 2

1900 ml. of light mineral oil (viscosity 15 centistokes at 100° F.) were mixed in a suitable container with 80 ml. of oleic acid and 20 ml. of "Lissapol NX," a synthetic non-ionic type of emulsifying agent. The mixture was heated to 50° C. and was then used to inspect connecting rods by the following sequence of operations.

The components were first degreased in a tri-

chloroethylene vapour degreaser, then transferred whilst still warm to the hot oil mixture, and allowed to remain in the oil for ten minutes, removed, shaken free of surplus oil, rinsed free of superficial oil by a water spray, dried in a warm air jet, and dusted with a French chalk/dye mixture containing 10% by weight of dye. Visual examination of the components after standing for 24 hours revealed small fatigue cracks, which had formed in one connecting rod during running of the engine from which it had been stripped, the cracks being indicated as thin red stains on the lighter chalk background.

The emulsifiable oil prepared according to this method was found to possess the following physical properties:

Kinematic viscosity at 60° F.=38 centistokes.
Kinematic viscosity at 160° F.=5.6 centistokes.
Surface tension at 60° F.=27.6 dy./cm.
Surface tension at 160° F.=26.7 dy./cm.
Specific gravity at 60° F.=0.872.

Example 3

To 28 litres of paraffin oil (boiling range 160–250° C.) contained in a glass tank were added with stirring 1,200 ml. of oleic acid and 300 ml. of "Lissapol NX." 120 ml. of water were then added and after thorough agitation a clear mixture having the following physical properties was obtained:

Kinematic viscosity at 60° F.=3.1 centistokes.
Surface tension at 60° F.=23.4 dy./cm.
Specific gravity at 60° F.=0.796.

Several aluminium alloy piston forgings were, after degreasing, immersed in turn in the mixture for a period of 10 minutes each, followed by draining, washing and drying as previously described. After dusting with French chalk containing 7.5% by weight of "Oil Red S" dye, intergranular forging cracks in the material were rendered visible as a sharply defined red network.

The present invention has certain advantages over the process previously referred to in which the article or component is soaked in an oil bath. The overall working time taken to carry out the process according to the invention is considerably less, and although the ultimate sensitivity of the process cannot be appreciably altered, it is easier for the operator to note the indications that defects give and the indications are more permanent.

I claim:

1. A process for the detection of flaws in articles which have been submitted to a mechanical operation, which process comprises treating the surface of the article after the said operation with a water-in-oil emulsion in which the continuous phase is a water-immiscible oil containing an emulsifying agent, rinsing the emulsion from the surface of the article with water, drying the surface, and dusting thereon a finely-divided light colored powder containing dispersed therein an oil-soluble water-insoluble dyestuff.

2. A process for the detection of flaws in articles which have been submitted to a mechanical operation, which process comprises treating the surface of the article after the said operation with a water-in-oil emulsion in which the continuous phase is a light mineral oil fraction containing a mixture of potassium and tri-ethanolamine oleate, rinsing the emulsion from the surface of the article with water, drying the surface, and dusting thereon a finely-divided light colored powder containing dispersed therein an oil-soluble water-insoluble dyestuff.

3. A process for the detection of flaws in articles which have been submitted to a mechanical operation, which process comprises treating the surface of the article after the said operation with a water-in-oil emulsion in which the continuous phase is a light mineral oil fraction and a mixture of potassium triethanolamine oleate together with a blending agent, rinsing the emulsion from the surface of the article with water, drying the surface, and dusting thereon a finely-divided light colored powder containing dispersed therein an oil-soluble water-insoluble dyestuff.

4. A process as claimed in claim 3, wherein the blending agent is methyl cyclohexanol.

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