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(54) Title: A BROACHING OIL OR HEAVY DUTY NEAT CUTTING OIL COMPOSITION

(57) Abstract: The invention discloses a broaching oil or heavy duty cutting oil composition with excellent extreme pressure, cutting and cooling properties. It has a kinematic viscosity (10-20 cSt at 40°C) and minimum quantity of active sulfur (0.2%), both of which play a crucial role for cutting and cooling properties. The oil shows excellent metal cutting (tapping efficiency), load properties (weld load) and cooling efficiency. The proposed composition or its suitable dilution can be used for other cutting operations e.g., gun drilling, tapping, broaching etc.

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A BROACHING OIL OR HEAVY DUTY NEAT CUTTING OIL COMPOSITION

FIELD OF THE INVENTION

[01] The present invention generally relates to broaching oil or cutting oil compositions, and in particular to an oil based neat broaching oil or heavy duty neat cutting oil composition comprising of natural fats/oils, synthetic ester, antiwear, extreme pressure additives, antioxidant and mineral oil. The composition according to the present invention can also be used for other heavy duty metal cutting applications e.g., tapping, boring, drilling, gear cutting etc as per the requirement of the application.

BACKGROUND OF THE INVENTION AND PRIOR ART

[02] Metal cutting process invariably generates heat. The heavier duty the cutting is, the amount of heat generated is correspondingly higher. For heavy duty metal cutting, heat generated is very high. Additionally, considerable amount of fine metal particles, dust etc., (collectively called swarf) is generated, which too must be removed along with the excessive heat generated. Though in certain cases machining can be conducted in dry condition, a cutting fluid is not only essential but mandatory in most metal cutting operations, and particularly for heavy duty metal cutting. It is very effective in improving overall machinability. A carefully selected fluid will reduce the coefficient of friction at the interfaces. This is the main object of lubrication. The ways in which a cutting fluid affects machining can be summarized and classified as follows:

- Reduce friction by functioning as a lubricant, thereby reducing the heat that is generated at the cutting tip.
- Function as a coolant because frictional heat cannot be completely eliminated.
- Act as an anti-weld to prevent welding of the work piece to the tool.

[03] Cooling down obviously increases the tool life and reduces thermal distortion. A reduction in the coefficient of friction lowers the machining force and power consumption. This also improves the surface finish greatly.

Cutting oil acts by cooling down the chip-tool-work zone by carrying away some of the generated heat and reducing the coefficient of friction at the chip-tool interface due to the formation of a weaker compound at the interface. Washing away of the chips is very important.

[04] An ideal cutting fluid should have following characteristics:

1) Low viscosity and low molecular size (to help rapid penetration to the chip-tool interface)
2) Inexpensive and easily available.

[05] The cutting fluids are mainly two types; namely, a) water based cutting fluid and b) neat cutting fluid. Neat cutting oils are fluids usually based on mineral oils and used for cutting without further dilution i.e. in the condition as supplied by the manufacturer. Fluids vary in suitability for metal working operations. For example, petroleum-based cutting oils are frequently used for drilling and tapping operations due to their excellent lubricity while water miscible fluids provide the cooling properties required for most turning and grinding operations. Neat cutting oils generally are blends of mineral oils and other additives. Neat oils can be used for applications from light machining to heavy-duty operations such as gear hobbing, broaching, turning, honing, drilling, tapping, gear cutting etc primarily to provide cooling and lubrication which lead to good tool life and appropriate surface finish of the components being machined. Neat cutting oils as opposed to soluble or synthetic cutting fluids provide high levels of lubrication to help reduce frictional heat as the cutting tool penetrates the metal or rubs against the swarf. Neat oils also save energy by reducing cutting forces.

[06] Depending upon the severity of the operation, type of metals and specific requirement of the application, the metal cutting operations are of several types starting from heavy duty operations e.g., broaching, tapping, reaming, gear cutting etc to light duty operations e.g., honing, lapping and other related metal super finishing operations etc.

[07] Broaching is one of the most severe metal cutting operations among the neat cutting operations. Broaching is a metal removal process that is performed on flat, round, or contoured substrates. The multi-toothed cutting tools used in broaching have teeth those are generally higher than the preceding tooth, each removing more material as it passes over the substrate.

[08] Cutting fluids have been used extensively in metal cutting operations for the last 200 years. In the beginning, cutting fluids consisted of simple oils applied with brushes to lubricate the machine tool. Occasionally, lard, animal fat or whale oil was added to improve the

lubricity of the oil. As the cutting operations became more severe, cutting fluid formulations became more complex. Today's cutting fluids are special blends of chemical additives, lubricants and base stock formulated to meet the performance demands of the metalworking industry.

[09] The neat cutting oil generally consists of base oil and additives. The additives are of several types e.g., extreme pressure (EP), lubricity, antioxidants, antifoam etc. The EP additives also are of several types. It may be chlorinated, sulfur, phosphorous containing additives. The sulfur additive performs an anti-wear function in cutting oils by forming a chemical bond between the cutting tool and work piece thereby keeping the tool from coming in direct contact with the metal being cut. There are two types of sulfur additives, active and inactive. The inactive compound is used for cutting the mild (low-carbon) steels and will not stain the softer materials. The active sulfur forms a stronger bond than the inactive but will stain soft metals. So oil containing active sulfur is recommended for cutting and broaching the harder varieties of steel only. The object of this chemical bond is to promote longer tool life and to keep the tool from welding itself to the work piece under the severe temperatures created in many metal cutting operations. The chlorine additive also works in the same fashion as the sulfur additive and tends to complement the sulfur by strengthening the chemical bond (film) around the tool. The lubricity additives may be fatty oils and esters. The fatty oils may be natural or animal fats. The fatty oil additive adds lubricity and makes oil "wetter" thereby lubricating and cooling the metal better than oil without this additive. This also allows better, cleaner cuts and promotes longer tool life. Synthetic metal wetting agents are also available which perform the same function as the fatty oil wetting agent, however they have two distinct advantages. It will not turn rancid with age and it leaves the metal coated with a rust and corrosion inhibitor. Sometimes antioxidants are also used in the formulation to avoid the rancidity problem of the cutting oil during use. The foaming is another problem in the metal working oil which may cause problem during application. This is because the starvation problem in the site of the application which may arise due to the foaming problem.

[10] Whereas different oil based neat broaching oil formulations with different additive systems are available in the market, there is a continuous need for new products. This is particularly so where the new products either present economic advantages and/or improvement of the performances. Performance advantages include overall improvement of the product properties. It can also include improvement in one or more of the properties of the lubricant. The

importance of this type of improvement is particularly effective if the achievement is without adversely affecting the other essential properties of the lubricant.

[11] Several disadvantages are associated and recognized with the known compositions based on the above patents. One such disadvantage is that although most of the formulations used different extreme pressure additives, none of them indicated the usefulness and minimum concentration of elemental sulfur alone in broaching oil or heavy duty cutting compositions. Yet another disadvantage is that although most of the patented formulations claimed the cooling effect of the broach or tool by extreme pressure additives/oil but none of the formulations mentioned the effect of viscosity of broaching oil on cooling of broach tool and finished product. Still further, the lubrication and cooling properties on the extended range of broaching and heavy duty cutting operation range of products and its dilutions were not covered by the patents as hereinafter motioned. Further, most of the patents avoided chlorine containing additives and their combinations with other EP additives.

[12] Due to rapidly increasing lubricant costs and the possibility of the critical shortage of lubricants, the usefulness of the lubricant can be increased if the same lubricant is used in multipurpose applications, in addition to its aimed specific application. In this case the lubricant is used as broaching oil as well as a concentrated product of other multiple heavy duty cutting applications. The application range can also be increased by diluting the concentrated product with suitable base oil/s as per requirement of the application. This improves the storage as well as inventory cost of the product and/or manpower saving.

[13] Formulations of cutting oils need specialization. Several phenomena e.g., metal cutting, lubrication, extreme pressure properties, cooling properties of the machined metals and cutting tools are associated and dependent on the cutting oil. The metals to be machined are also of various types e.g., stainless steel, ferrous metal, and yellow metals. The metal cutting operations start from heavy duty cutting operations e.g., broaching, tapping, reaming, drilling, gear cutting to light duty cutting operations e.g., honing, lapping and other related super-finishing operations. So it is not possible to use same type of oil for all metal cutting operations. Some of the additives may be corrosive to yellow metal, e.g., copper. The same additive is required for the cutting operations of other metals and it is not corrosive to those metals. But the additive may be required for both type of cutting operations. So the techniques require to find out the quantity and the threshold concentrations at which the additive will work for the required

cutting operations that will not stain the metal. The process requires proper dilution of the concentrated product for the required cutting operations. Removal of chips (flushing) after cutting operations is also an important requirement of cutting operations which enhance the cooling and surface property of the cutting surface and tool.

[14] Keeping in view of all the above properties of the cutting oil, cutting operations, metallurgy of the machined material, a development program was initiated at author's laboratory to formulate an efficient broaching oil and its use as multipurpose cutting oil concentrate for other heavy duty cutting operations.

[15] **US patent 5792728** describes a stable non-toxic coolant/lubricant suspension which is specifically designed for use in extremely high-load, high-stress machine operations, such as broaching. The composition of this coolant/lubricant includes about 1 to 15 wt% of molybdenum disulfide (MoS_2) powder; about 1 to 7 wt% of soap flakes; about 6 to 12 wt% of a liquid polytetrafluoroethylene suspension; and about 66 to 92 wt% water.

[16] **US patent 6562766** describes a metal working oil composition without a chlorine compound. The formulation can be used for low-speed cutting or heavy cutting operations such as broaching or gun-drilling operations and comparable to or better than those of chlorine compound-containing lubricant oil. The composition comprises 100 parts by weight of a lubricant base oil that constitutes from 0 to 30% by weight of (a) a mineral base oil and from 70% to 100% by weight of (b) a pi electron-containing synthetic base oil, from 0.1 to 25 parts by weight of (c) a sulfur-containing extreme-pressure agent, and from 0.1 to 7 parts by weight of (d) an alkali metal and/or alkaline earth metal sulfonate.

[17] **Chinese patent 1548507** discloses a water insoluble cutting oil which consists of base oil, grease, sulfide extreme pressure additive, lubricant agent, antioxidant and mist inhibitor mixed together. The product shows excellent extreme pressure lubricating performance, machining surface which enhances service life of cutting tool. It is used as common cutting oil for broaching and forming gear.

[18] **JP patent application JP2008013682A** discloses an improved composition of metal working fluid which contains phosphorus as extreme pressure agent. It further discloses that the kinematic viscosity of the base paraffinic mineral oil is 49.7 mm^2/S at 40°C, saturated content is 91.5% by mass, and content of the cyclic saturated component in the saturated content is 49.8% by mass. JP2008013682A claimed that the sulfur containing compound is about 0.05%.

[19] **US patent 4210544** describes dual-purpose cutting oils which serve as heavy duty cutting oils and machine lubricants in automatic screw machines. The oils contain a base oil, a combination of extreme pressure agents comprising primarily a di-tertiary alkyl polysulfide, a chlorinated paraffin, and a copper corrosion inhibitor comprising a sulfur scavenger such as a 2, 5-bis(n-alkyldithio) thiadiazole.

[20] **US patent 5726130** describes a cutting or grinding oil composition comprising (A) a base oil and (B) at least one compound selected from the group consisting of dibasic acids having 2 to 6 carbon atoms, tribasic acids having 3 to 6 carbon atoms, and ester derivatives of these acids; and a cutting or grinding oil composition comprising component (A) described above, component (B) described above, (C) a compound containing sulfur, and/or (D) at least one compound selected from the group consisting of perbasic alkali metal sulfonates and perbasic alkaline earth metal sulfonates are disclosed. The patent claims increase in working efficiency, suppressed wear of working tools and superior precision of a finished surface.

[21] US application **US 2004116309** discloses an oil composition for cutting and grinding by minimal quantity lubrication system and for sliding surface and comprises an ester and a sulfur compound and/or a phosphorus compound.

[22] The **PCT application WO0242397** describes a metal working fluid composition which comprises a base oil for a lubricating oil and, compounded therein, (a) an extreme-pressure additive, (b) at least one of an organic zinc compound and an organic molybdemum compound, and (c) an imide additive. The metal working fluid composition is free of a chlorine-containing additive, allows the heavy cutting of stainless steel, a titanium alloy etc.

[23] **Chinese patent 101255376(A)** discloses a water-based broaching liquor which comprises raw materials of specialized water-based broaching liquor and corresponding weight percentage are phytic acid 1.2-1.8%, sodium benzoate 3-5%, triethanolamine 5.5-6.5%, sodium carbonate 1,8-2.2%, hyposulfite of soda 0.8-1.2%, polyethyleneglycol 7-9%, glycyl alcohol 9-11%, sulfonated castor oil 2.5-3.5%, oleic acid 1.5-2.5%, alkyl phenol polyethenoxy ether 1.5-2.5%, 2-methyl-3(2H)-isothiazolone 0.4-0.6%, de-ionized water 56-62% for automobile clutch disk hub. Several advantages are claimed with the formulation e.g., reduced broaching temperature, force to maximum extent, improved processing efficiency of broaching, ensured broaching precision and surface quality, prolonged life of cutting tool, reduced cost, satisfying environmental protection requirement.

[24] **US patent 4416788** describes a lubricating composition useful for heavy duty cutting oil which comprises a major lubricating oil and a minor at least one sulfur–containing compound and effective amount of elemental sulfur. The sulfur containing compound and elemental sulfur present in such an amount which is soluble in oil and effective to improve the extreme pressure properties of the composition.

[25] **US patent 5792728** describes a stable non-toxic coolant/lubricant suspension, which is specifically designed for use in extremely high-load, high-stress machine operations, such as broaching. The composition of this coolant/lubricant includes about 1 to 15 wt% of molybdenum disulfide (MoS_2) powder; about 1 to 7 wt% of soap flakes; about 6 to 12 wt% of a liquid polytetrafluoroethylene suspension; and about 66 to 92 wt% water.

SUMMARY OF THE INVENTION

[26] An oil based neat broaching oil or heavy duty neat cutting oil composition disclosed in the present invention is an optimized composition of natural fats/oils, synthetic esters, extreme pressure additives, antiwear additive, antioxidants, mineral oil/s etc having the kinematic viscosity 10-20 cSt at 40°C and minimum 0.2% elemental sulfur. The oil may contain other sulfur, chlorine, phosphorus, zinc and calcium based extreme pressure and/or antiwear additive/s. The oil shows excellent metal cutting (tapping efficiency), load properties (weld load) and cooling efficiency. The oil can also be used for other heavy duty metal cutting operations (tapping, reaming, gear cutting, drilling etc) with or without any dilution.

DESCRIPTION OF THE INVENTION

[27] According to the present invention there is provided a broaching oil or heavy duty cutting oil composition which comprises a blend of natural fat(s)/oil(s), synthetic ester(s), extreme pressure and/or antiwear additive(s), antioxidant(s) and elemental sulfur optionally in the presence of mineral/synthetic oil(s). The composition additionally has a kinematic viscosity in the range of 10-20 cSt at 40°C. The concentration of natural fats/oils and synthetic esters in the composition should be in the range of 5-80% by wt, extreme pressure and/or antiwear additive(s) 5 to 50% by wt, antioxidant(s) 0.01 to 5% by wt, elemental sulfur at least 0.2% by wt

and mineral/synthetic oil(s) 0 to 85% by wt. The extreme pressure additive is selected from elemental sulfur, active or inactive sulfurized fat and/or ester. In one embodiment of the invention the extreme pressure additive is a chlorine-containing additive such as chlorinated paraffin or wax.

[28] According to the invention the extreme pressure and/or antiwear additive is selected from sulfur, phosphorus, chlorine, calcium and zinc based additives such as herein described either as a single component or a mixture thereof. The phosphorous containing additive is selected from phosphate ester and/or amine phosphate, the zinc-containing additive is ZDDP, calcium-containing additive is calcium petroleum sulphonate. The fat(s) are selected from all types of vegetable fats e.g. coconut, palm, rapeseed etc., animal fats from lard, tallow etc, synthetic esters from TMP ester, pentaerithritol ester, butyl stearate and butyl oleate etc and/or their possible mixtures. The mineral oil is selected from paraffinic or aromatic oils or their mixtures including all isomers thereof and the synthetic oil is selected from PAO and PEG/s etc.

[29] The minimum weld load of the composition is 600 kg and is suitable for use in heavy duty operations such as broaching, tapping, reaming, boring, gear cutting etc or light duty operations such as honing, lapping and other related metal super finishing operations etc on dilution. The invented composition also includes a multipurpose cutting oil package composition for different machining operations which comprises a composition diluted with a base oil. The invention further provides a method of heavy or light duty machining operations as applicable using the invented composition.

[30] According to one embodiment of the invention the oil based neat broaching oil or heavy duty neat cutting oil composition is an optimized composition of natural fats/oils, synthetic esters, extreme pressure additives, antiwear additive, antioxidants, mineral oil/s etc having the kinematic viscosity 10-20 cSt and minimum 0.2% elemental sulfur. The oil may contain sulfur, chlorine, phosphorus, zinc and/or calcium based extreme pressure and/or antiwear additive/s. The oil shows excellent metal cutting (tapping efficiency), load properties (weld load) and cooling efficiency. Superior cooling efficiency has been observed due to optimum kinematic viscosity of the oil composition as stated above during broaching or multipurpose cutting applications. The oil can also be used for other heavy duty metal cutting operations (tapping, reaming, gear cutting, drilling etc) with or without any dilution.

[31] According to another embodiment of the invention, the neat broaching oil or multipurpose neat cutting oil composition comprises natural fat(s)/oils and/or synthetic esters 5 to 80% by weight, extreme pressure and/or antiwear additives 5 to 50% by weight, minimum 0.2% elemental sulfur, antioxidant or mixtures of antioxidants 0.01 to 5% by weight and mineral oil or mixture of mineral oils 0 to 85% by weight.

[32] The fats/oils and esters are used as a lubricant and oiliness material in the oil base neat cutting oil. The above materials help to increase cutting operations and better surface finish. The natural fat used in the present invention is based on the vegetable fat/oil or animal fat/oil or synthetic ester/s or the mixture of any two or three. The vegetable fat includes palm, coconut, soybean, karanja, rapeseed etc having the fatty acid distribution of C-8 to C-22 with all possible isomers and/or its mixtures. The animal fats/oils include lard oil, tallow etc and/or the mixture of all possible combinations. The synthetic esters include butyl stearate, butyl oleate, methyl oleate, propylene glycol dioleate, trimethylol trioleate, etc individually or all the possible combinations. The animal and fats/oils synthetic esters include all the possible fatty acid distribution of C-8 to C-22 including its possible isomers, its mixtures including complex and self emulsifying esters. The kinematic viscosity of the fats/oils varies between 25 to 250 cSt at 40°C whereas the values for synthetic esters are generally 7 to 50 cSt.

[33] Extreme pressure and antiwear additives are used in the oil based neat cutting oil. These additives are used to enhance the tool life of the cutting machine, better cutting and surface finish. The additives selected and used in the present invention are based on sulphur, phosphorus, chlorine and zinc as single component or mixture of components of above. Examples of extreme-pressure and anti-wear agents are elemental sulfur, dilauryl phosphate, didodecyl phosphite, trialkylphosphate such as tri(2-ethylhexyl)phosphate, tricresylphosphate (TCP), zinc dialkyl(or diaryl) dithiophosphates (ZDDP), phospho-sulphurized fatty oils, zinc dialkyldithiocarbamate), mercaptobenzothiazole, sulphurized fatty oils, sulphurized terpenes, sulphurized oleic acid, alkyl and aryl polysulphides, sulphurized sperm oil, sulphurized mineral oil, sulphur chloride treated fatty oils, chlornaphta xanthate, cetyl chloride, chlorinated paraffinic oils, chlorinated paraffin wax sulphides, chlorinated paraffin wax, and zinc dialkyl(or diaryl) dithiophosphates (ZDDP), tricresylphosphate (TCP), trixylylphosphate (TXP), dilauryl phosphate, respectively.

[34] The natural fats and esters have a tendency to decompose to fatty acid with time, heating and hydrolyze during operation. Antioxidant is used to prevent the conversion of ester to the fatty acid. The antioxidants used in the present invention are amine and/or hindered phenolic based, their mixtures and isomers thereof.

[35] The base stock in the present formulation is used as a matrix and diluting the concentrated cutting/broaching oil. The base oil used is as single component or the mixture of more than one component. The base stock oil can be paraffinic or naphthenic, hydrocracked or mixture of these. The base oil typically has a viscosity from 2.2 to 58 cSt at 40°C. Viscosity of the formulation can be adjusted by mixing adequate quantity of the required different base oils. The flash point of the base oil should be greater than 120°C.

[36] For the preparation of the invented composition the required quantity of base oil is to be taken in the glass beaker and heated upto 40-45°C on the hot plate. The base oil is continued to be stirred with Remi stirrer for sometime till the base oil mixture is homogeneous and clear. The final broaching oil blend is prepared by adding the appropriate quantity of fats, EP additives and the antioxidants to the base oil one by one and stirring. Sufficient time is required to be given to mix the additive to the base oil before addition of the next additive. Throughout the blending procedure, the temperature is to be maintained between 40-45°C. After getting the final clear blend, the blend is to be removed from the stirrer and hot plate and allowed to reduce the temperature from 45°C to room temperature. Then the blend is to be stored in the glass bottle.

[37] The cutting oil blend is then subjected to various physicochemical and tribological performance tests. The physicochemical tests e.g., kinematic viscosity, TAN, pour point, flash point, copper corrosion etc are performed as per standard ASTM methods. Tapping efficiency and weld load are two suitable tribological tests correlating with the actual metal cutting operations and are selected for the evaluation of the candidate blends. All the tests are carried out on the neat oil system.

[38] The load carrying capacity of the lubricants can be measured by the weld load property. The value is an absolute one. The weld load of the formulations is evaluated by the IP-239 method. The tapping efficiency is a measure of cutting efficiency of the formulations and primary importance of the heavy duty cutting operations e.g., broaching, tapping, drilling, reaming etc. The tapping efficiency is always measured against a reference sample (assuming it

as 100%) and the experimental sample is reported against this reference. Here the reference used is one market established reputed commercial sample CASTROL ILOBROACH 11. Any sample having 100% tapping efficiency against this sample can also be used as a reference. Tapping efficiency was conducted as per ASTM D5619. The cooling properties measured with a standard industrial broaching machine in standard applications. The details of the broaching machine are as follows.

Make: H.M.T, Type: Medium Duty Horizontal, Filtration System: Wire mesh.

[39] The detail of the process of the invention are provided in the examples given below which are illustrative only and therefore should not be construed to limit the scope of the invention provided herein.

Experimental Data

Example-1

[40] 0.3% wt of elemental sulfur, 50% wt. of chlorine containing additive, 10% wt of palm oil, 0.5% wt of aminic antioxidant and 39.2% wt mixture of base stocks 1 and 2.

Example-2

[41] 0.8% wt of elemental sulfur, 0.5% inactive sulfur additive, 40% wt of rapeseed oil, 20% wt of lard oil, 15% wt of chlorine containing compound, 5% ZDDP, 1% hindered phenol type antioxidant and 17.7% wt mixture of base stocks 1 and 2.

Example-3

[42] 0.2% wt of elemental sulfur, 40% wt of Trimethylol propane ester , 1% wt of amine type antioxidant and 28.8% wt of base Stock-1 and 30% wt of base stock-3.

Example-4

[43] 90% wt of example-1 and 10% of base stocks as described in example-1.

Example-5

[44] 70% wt of example-2 and 30% wt of base stocks as described in example-2.

Example-6

[45] 50% wt of example-3, 50% wt of base stock mixtures as described in example-3.

Example-7

[46] 30% wt of example-5 and 70% base oils as described in example- 5.

Example-8

[47] 0.5% wt of sulfurized fat, 1.5% wt of phosphate ester, 3% coconut oil and 95% base stock-3.

Example-9

[48] Example No –1 having kinematic viscosity at 40°C = 17.5 cSt.

Example-10

[49] Example No-1 having kinematic viscosity at 40°C = 26.2 cSt.

Example-11

[50] Example No –2 having kinematic viscosity at 40°C = 13.1 cSt.

Example-12

[51] Example No-2 having kinematic viscosity at 40°C = 24.4 cSt.

Test Results:

Table-1: Weld Load Characteristics (Tribological Property)

S. No	Example No	Weld Load (Kg)	Suggested Application
1	1	800	Broaching, Reaming, Drilling, Milling Tapping, drilling and Gear Cutting
2	2	800	Broaching, Reaming, Tapping, Drilling and Gear Cutting
3	3	600	Tapping , Drilling, Boring
4	4	700	Tapping, Drilling, Boring

5	5	600	Tapping, Drilling, Boring.
6	6	300	Not suitable for heavy duty cutting operation.
7	7	250	Not suitable for heavy duty cutting operation.
8	8	180	Not suitable for heavy duty cutting operation.

Table-2: Tapping Efficiency (Cutting Operation)

Sl. No	Example No	% Tapping Efficiency (SAE 4140 Nut Blank, 500 rpm, Neat Oil)	Suggested Application
1	1	102.1	Broaching, Reaming, Drilling, Milling Tapping, drilling and Gear Cutting
2	2	100.2	Broaching, Reaming, Tapping, Drilling and Gear Cutting
3	3	98.2	Tapping , Drilling, Boring
4	4	99.1	Tapping, Drilling, Boring
5	5	98.5	Tapping, Drilling, Boring
6	6	97.5	N.A
7	7	95.6	N.A
8	8	95.0	N.A

Table-3: Cooling Characteristics during Broaching Operation

S. No	Example No	K.V, cSt @ 40°C	Auto Parts	Broach Temperature °C	Finished auto component Temperature °C
1	Example No-9	17.5	Rear Attachment and Rear wheel Hub of 3-wheeler	40- 45	44 - 49
2	Example No-10	26.2	-- do--	52-57	55 - 60
3	Example No-11	13.1	Brake Padel, Transmission Sleeve of 3-wheeler	37- 41	35-40
4	Example No-12	24.4	-- do --	44-49	46-52

[52] The embodiments disclosed herein are only illustrative in nature and there can be other possible embodiments as would be apparent from the practice of the invention. The full scope and spirit of the invention should be derived from the following claims.

CLAIMS:

1. A broaching oil or multipurpose heavy duty cutting oil composition with an optimum kinematic viscosity having super cooling properties, comprising a blend of natural fat(s)/oil(s), synthetic ester(s), extreme pressure and/or antiwear additive(s), antioxidant(s) and elemental sulfur, optionally in the presence of mineral/synthetic oil(s) (base oil), wherein at least 0.2% by wt elemental sulfur is present.

2. The composition as claimed in claim 1, wherein the optimum kinematic viscosity is in the range of 10-20 cSt at 40°C.

3. The composition as claimed in claim 1, wherein the concentration of natural fat(s)/oil(s) and synthetic ester(s) is in the range of 5 to 80% by wt, extreme pressure and/or antiwear additive(s) 5 to 50% by wt, antioxidant(s) 0.01 to 5% by wt, elemental sulfur at least 0.2% by wt and mineral/synthetic oil(s) 0 to 85% by wt.

4. The composition as claimed in claim 1, wherein the extreme pressure additive is selected from elemental sulfur, active or inactive sulfurized fat and/or ester or a chlorine containing additive.

5. The composition as claimed in claim 4, wherein the chlorine-containing additive is chlorinated paraffin or wax.

6. The composition as claimed in claim 1, wherein the extreme pressure/antiwear additive is selected from sulfur, phosphorus, chlorine, calcium and zinc based additives, either as a single component or a mixture thereof.

7. The composition as claimed in claim 6, wherein the phosphorus based additive is selected from phosphate ester and/or amine phosphate, the zinc-containing additive is ZDDP, and calcium-containing additive is calcium petroleum sulphonate.

8. The composition as claimed in claim 1, wherein the fat(s) are selected from vegetable fats from coconut, palm, rapeseed or the like, animal fats from lard, tallow or the like, synthetic esters from TMP ester, pentaerithritol ester, butyl stearate and butyl oleate or the like and/or their mixtures.

9. The composition as claimed in claim 1, wherein the mineral oil is selected from paraffinic or aromatic oils or their mixtures comprising all isomers thereof and the synthetic oil is selected from PAO and PEG/s or the like.

10. The composition as claimed in claim 1, which has a minimum weld load of 600 kg.

11. The composition as claimed in claim 1, which is suitable for use in heavy duty operations such as broaching, tapping, reaming, boring, gear cutting etc or light duty operations such as honing, lapping and other related metal super finishing operations on dilution of the concentrated formulation by suitable base oil/s.

12. A multipurpose cutting oil package composition for different machining operations comprising a composition of claims 1-11 diluted with a base oil.

13. A method of heavy or light duty machining operations characterized in that an oil composition of claims 1-12 as applicable is used.